LAWRENCE & MEMORIAL HOSPITAL

2011 OCT 25 A 11:40

COMPETITIVE SERVICE AT
HEALTH CARE ACCESS

OCT 25 2011
OFFICE OF
HEALTH CARE ACCESS

October 20, 2011

Ms. Kimberly R. Martone
Director of Operations
Department of Public Health
Office of Health Care Access
410 Capitol Avenue, MS#13HCA
P.O. Box 340308
Hartford, CT 06134-0308

Re: Certificate of Need Application

Dear Ms. Martone:

On behalf of Lawrence & Memorial Hospital, I am pleased to submit a Certificate of Need Application for the replacement of an aging CT scanner and mobile PET-CT scanner with a combined PET/CT Camera.

As requested, we have included an original and four hard copies in 3-ring binders along with electronic files in Adobe, MS Word and MS Excel. Also attached to this letter is a check with the filing fee of $500.00.

Please do not hesitate to contact me at (860) 442-0711, extension 2073, if you have any questions.

Sincerely,

Crista Durand
Vice President, Strategic Planning, Marketing and Business Development

Attachments

Lawrence & Memorial Hospital

Acquisition of Fixed PET-CT Scanner in Waterford

Certificate of Need Application

October 24, 2011

Lawrence & Memorial Hospital
265 Montauk Avenue, New London, CT 06320

Acquisition of Fixed PET-CT Scanner in Waterford

Table of Contents

Table of Contents (continued)

EXHIBIT I

CON CHECKLIST

Application Checklist

Instructions:

1. **Please check each box below, as appropriate; and**
2. **The completed checklist *must* be submitted as the first page of the CON application.**

☒ **Attached is the CON application filing fee in the form of a certified, cashier or business check made out to the "Treasurer State of Connecticut" in the amount of $500.**

For OHCA Use Only:

Docket No.: ~~31730~~ 11-31730 **Check No.:** 27437
OHCA Verified by: SD **Date:** 10/25/11

☒ **Attached is evidence demonstrating that public notice has been published in a suitable newspaper that relates to the location of the proposal, 3 days in a row, at least 20 days prior to the submission of the CON application to OHCA. (*OHCA requests that the Applicant fax a courtesy copy to OHCA (860) 428-7053, at the time of the publication)***

☒ **Attached is a paginated hard copy of the CON application including a completed affidavit, signed and notarized by the appropriate individuals.**

☒ **Attached are completed Financial Attachments I and II.**

☒ **Submission includes one (1) original and four (4) hard copies with each set placed in 3-ring binders.**

Note: A CON application may be filed with OHCA electronically through email, if the total number of pages submitted is 50 pages or less. In this case, the CON Application must be emailed to ohca@ct.gov.

Important: For CON applications(less than 50 pages) filed electronically through email, the singed affidavit and the check in the amount of $500 must be delivered to OHCA in hardcopy.

☒ **The following have been submitted on a CD**

1. **A scanned copy of each submission in its entirety, including all attachments in Adobe (.pdf) format.**
2. **An electronic copy of the documents in MS Word and MS Excel as appropriate.**

EXHIBIT II

COPY OF FILING FEE

VERIFY THE AUTHENTICITY OF THIS MULTI-TONE SECURITY DOCUMENT. CHECK BACKGROUND AREA CHANGES COLOR GRADUALLY FROM TOP TO BOTTOM.

LAWRENCE & MEMORIAL HOSPITAL
New London, CT 06320

51-57
119

DATE	CHECK NUMBER
10/17/11	272437

PAY FIVE HUNDRED 00/100

AMOUNT
*****$500.00

VOID OVER 60 DAYS

TO THE ORDER OF TREASURER, STATE OF CONNECTICUT

CITIZENS BANK

AUTHORIZED SIGNATURE

Details on back. Security Features Included

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EXHIBIT III

PUBLIC NOTICE EVIDENCE

PUBLISHER'S CERTIFICATE

009

State of Connecticut
County of New London, ss. New London

Personally appeared before the undersigned, a Notary Public within and for said County and State, Mary Labasi, Legal Adverising Clerk, of The Day Publishing Company Classifieds dept, a newspaper published at New London, County of New London, state of Connecticut who being duly sworn, states on oath, that the Order of Notice in the case of

12334 Lawrence & Memorial Hospital is applying for a Certi

A true copy of which is hereunto annexed, was published in said newspaper in its issue(s) of

09/30/2011, 10/01/2011, 10/02/2011

Cust: L&M HOSPITAL
Ad #: d00347699

12334
Lawrence & Memorial Hospital is applying for a Certificate of Need pursuant to Section 19a-638 of the CT General Statutes. The proposal includes the replacement of a mobile PET-CT and CT scanner with the acquisition and operation of a fixed PET-CT scanner at L&M Diagnostic Imaging at Crossroads located at 196 Parkway South, Waterford, CT-06385. The total capital expenditure for the project is $3,225,915.

Mary Labasi

Subscribed and sworn to before me
This Monday, October 03, 2011

Maryellen Jolinsky

Notary Public
My commission expires 5/31/14

EXHIBIT IV

HOSPITAL AFFIDAVIT

AFFIDAVIT

Applicant: **Lawrence & Memorial Hospital**

Project Title: **Acquisition of Fixed PET-CT Scanner in Waterford**

I, **Bruce D. Cummings** (Individual's Name), **President and CEO** (Position Title – CEO or CFO)

of **Lawrence & Memorial Hospital** (Hospital or Facility Name) being duly sworn, depose and state that

Lawrence & Memorial Hospital's (Hospital or Facility Name) information submitted in this Certificate of Need Application is accurate and correct to the best of my knowledge.

Signature

10/13/11
Date

Subscribed and sworn to before me on October 13, 2011

Karen M. Santacroce
Notary Public/Commissioner of Superior Court

My commission expires: September 30, 2012

Karen M. Santacroce
Notary Public, State of Connecticut
My Commission Expires Sept. 30, 2012

EXHIBIT V

CON APPLICATION

State of Connecticut
Office of Health Care Access
Certificate of Need Application

Instructions: Please complete all sections of the Certificate of Need ("CON") application. If any section or question is not relevant to your project, a response of "Not Applicable" may be deemed an acceptable answer. If there is more than one applicant, identify the name and all contact information for each applicant. OHCA will assign a Docket Number to the CON application once the application is received by OHCA.

Docket Number:	
Applicant:	**Lawrence & Memorial Hospital**
Contact Person:	**Ms. Shraddha Patel**
Contact Person's Title:	**Director of Business Development & Planning**
Contact Person's Address:	**365 Montauk Avenue, New London, CT 06320**
Contact Person's Phone Number:	**(860) 442-0711 ext. 5185**
Contact Person's Fax Number:	**(860) 446-3716**
Contact Person's Email Address:	**spatel@lmhosp.org**
Project Town:	**Waterford**
Project Name:	**Acquisition of Fixed PET-CT Scanner in Waterford**
Statute Reference:	**Section 19a-638, C.G.S.**
Estimated Total Capital Expenditure:	**$3,225,915**

1. **Project Description: Acquisition of Equipment**

   a. Please provide a narrative detailing the proposal.

Response:

Lawrence & Memorial Hospital (L&M Hospital) is an acute care hospital with 280 beds and 28 bassinets located at 365 Montauk Avenue in New London. L&M Hospital proposes to enhance imaging services at its outpatient L&M Diagnostic Imaging at Crossroads ("Crossroads") at 196 Parkway South in Waterford by replacing an aging computed tomography (CT) scanner as well as its mobile positron emission tomography – computed tomography (PET-CT) service with a new fixed PET-CT scanner. There are a number of factors that support this request. The current lease for the Crossroads CT scanner, a GE 16-slice Lightspeed (approved by OHCA in DN 05-30661 CON and 09-31413-CON), expired on June 30, 2011. The scanner is aging and must be replaced. As approved by OHCA in DN 01-565, PET-CT scanning is provided two days a week (on Tuesdays at the main L&M Hospital and on Saturdays at L&M Hospital's Pequot Health Center in Groton) through an agreement for mobile PET services with Alliance HealthCare Services. L&M Hospital's agreement with Alliance will expire on March 16, 2012. The mobile PET-CT does not offer all of the capabilities and safety features that are currently available in new, fixed units. In light of clinical limitations of the current equipment as well as the expiration of lease agreements, L&M Hospital strongly believes that replacement of both these scanners with one fixed PET-CT will ensure that its patients receive the safest and highest quality of imaging services in the most cost-effective manner. There has been significant focus on radiation safety by imaging providers, and this proposal, is also being pursued to improve radiation safety to L&M Hospital's patients.

The proposed fixed site PET-CT scanner will be installed at Crossroads and will be used for general diagnostic CT scanning as well as PET-CT scanning. Because the proposed scanner includes enhanced capabilities that are not available on the current scanners, it will result in improvements in patient safety, clinical care and service for patients. In addition, the proposed scanner will cost less to operate than the two separate existing scanners.

An additional factor supporting this request is L&M Hospital's development of an outpatient cancer center to be located less than two miles from Crossroads. The availability of PET/CT services in close proximity to the cancer center will be an important component

in the center's ability to deliver comprehensive, accessible care to oncology patients.

CT is an essential imaging modality that is frequently used in numerous inpatient and outpatient healthcare settings. It is a non-invasive radiographic method of imaging that provides important anatomical information for use in diagnosing various clinical conditions. CT is essentially an x-ray procedure that combines a series of x-ray images taken at many different angles with the aid of a computer to generate cross-sectional views of the body. These views, or slices, can be looked at individually by physicians, who can also perform additional visualization to make 3-D images. In general, the higher the number of slices provided by the scanner, the clearer and more precise the images. A CT scan is particularly appropriate to visualize the bones and soft tissues and is also useful for examining trauma patients and obtaining images of the brain. The injection of a contrast agent in patients can also help physicians identify blockages or other problems in a patient's blood vessels. Due to its numerous clinical applications and efficacy, use of CT has increased significantly in the past 20 years and it is one of the most frequently used imaging exams.

PET-CT is a nuclear medicine scan that historically has been predominantly used with oncology patients and more recently with neurology and cardiac patients. A PET-CT scan provides clinicians with both functional (PET component) and structural (CT component) imaging capabilities to accurately localize areas of increased metabolic activity, often indicative of cancer. A PET-CT scan uses the injection of positron-emitting radioactive isotopes attached to glucose molecules in patients. Tissues with elevated metabolic activity (such as tumors) absorb a disproportionate amount of glucose. In turn, the scanner detects the "signal" emitted from the isotopes in this area, providing physicians with an image that localizes the metabolic activity, while the CT component helps to precisely determine the exact anatomical location, shape and size of the tumor. PET-CT permits the non-invasive diagnosis and staging of cancer and offers support for radiation treatment planning and therapy monitoring. PET-CT is considered the standard of care for oncology imaging.

L&M Hospital's current PET-CT mobile unit, manufactured in 2006, is aging and does not offer the latest technological and patient safety features that differentiate the proposed state-of-the art PET-CT scanner. In addition to providing updated CT capability with more slices than the current CT scanner (40 slices compared to 16), the

proposed PET-CT scanner offers several clinical benefits that are not available on the current equipment, including:

- **Reduced radiation dose to patients;**
- **Ability to perform diagnostic CT and PET-CT scans simultaneously; and**
- **Enhanced images and improved diagnostic accuracy.**

b. Provide letters that have been received in support of the proposal.

Response:
Please see Attachment A for letters in support of the proposed PET-CT scanner.

c. Provide the Manufacturer, Model, Number of slices/tesla strength of the proposed scanner (as appropriate to each piece of equipment).

Response:
The proposed PET-CT scanner is a Siemens Biograph mCT S/X. The CT component is 40 slices.

d. List each of the Applicant's sites and the imaging modalities and other services currently offered by location.

Response:
L&M Hospital's sites, imaging modalities and other services by location are presented below.

Lawrence & Memorial Hospital Imaging Modalities & Other Services by Location					
	L&M Hospital, New London	Pequot Health Center, Groton	L&M Medical Office Building, Old Saybrook	L&M Diagnostic Imaging at Crossroads, Waterford	Stonington Walk-in Clinic, Stonington
Imaging Services					
Diagnostic Radiology (x-ray)	✓	✓	✓	✓	✓
CT	✓	✓	N/A	✓	N/A
MRI	✓	✓	N/A	✓*	N/A
Ultrasound	✓	✓	✓	✓	✓
Cardiovascular Ultrasound	✓	✓	N/A	✓	✓
Mammography	✓	✓	✓	✓	✓

Lawrence & Memorial Hospital Imaging Modalities & Other Services by Location					
	L&M Hospital, New London	Pequot Health Center, Groton	L&M Medical Office Building, Old Saybrook	L&M Diagnostic Imaging at Crossroads, Waterford	Stonington Walk-in Clinic, Stonington
Bone Density	N/A	✓	N/A	✓	✓
Nuclear Medicine	✓	N/A	N/A	N/A	N/A
Interventional Radiology	✓	N/A	N/A	N/A	N/A
PET-CT (mobile)	✓	✓	N/A	N/A	N/A
Other Services					
Laboratory	✓	✓	✓	N/A	✓
Inpatient Care	✓	N/A	N/A	N/A	N/A
Emergency Department Services	✓	✓	N/A	N/A	N/A

***effective FY 2012**

2. **Clear Public Need**

a. Explain why there is a clear public need for the proposed equipment. Provide evidence that demonstrates this need.

Response:

Several factors contribute to the clear public need for the proposed PET-CT equipment. These factors include:

- **The proposed PET-CT scanner will improve patient safety by reducing radiation exposure to patients;**
- **The lease agreements for the current scanners have expired or will expire;**
- **L&M Hospital's development of a cancer center in close proximity to Crossroads will require the full spectrum of oncology imaging services;**
- **The proposed PET-CT scanner provides improved patient care, in particular by allowing both a diagnostic CT and a PET/CT to be conducted in the same visit, which lowers motion and movement between studies and decreases radiation doses;**
- **The proposed equipment and location will offer enhanced and easier access for patients; and**
- **The proposed equipment is a more cost-effective approach.**

New PET-CT Scanner Improves Patient Safety by Reducing Radiation Exposure to Patients

One of the most compelling factors associated with the need for the proposed PET-CT scanner is that the scanner includes several advanced technological features that contribute to reduced radiation exposure for patients. These features, which are not available on the mobile unit, include Care kV, IRIS software and Adaptive Dose Shield, all of which meet national recommendations for reducing radiation dose in CT. Each of these components and their relevance is described below.

As discussed in the journal article "CT and Radiation: What Radiologists Should Know" (included as Attachment B), many efforts to reduce radiation dose in CT have focused on lowering x-ray tube peak kilovoltage (kV), among other strategies. As described in "Care kV: Automated Dose Optimized Selection of X-Ray Tube Voltage", included as Attachment C, lower levels of kV have been correlated with lower doses of radiation to patients; in one study, reducing the kV tube voltage from 120 kV to 100 kV was associated with a 53% reduction in radiation dose. Siemens' exclusive Care kV component addresses the issue of kV by determining the optimal scan settings and automatically suggesting the lowest possible kV for each individual patient in each scan. Use of Care kV ensures that the lowest dose and optimal image quality are achieved during each scan.

A second peer-reviewed study, "Strategies for CT Dose Optimization" (included in Attachment D), discusses the importance of radiation dose optimization in CT. The article also discusses the benefits of computer-simulated dose-reduction software, which can be found in Siemens' Iterative Reconstruction in Image Space (IRIS) software. By generating a master image so that raw data reconstruction is only applied once, IRIS reduces radiation doses by up to 60% while maintaining excellent image quality. The white paper "Iterative Reconstruction in Image Space", included as Attachment E, further explains the benefits of IRIS.

The proposed scanner also includes a proprietary Siemens feature that eliminates over-radiation pre- and post-spiral to the patient during CT. This feature, the Adaptive Dose Shield, moves shields into place on the x-ray tube to block any unnecessary doses of radiation. By dynamically opening at the beginning of a spiral range and then dynamically closing at the end, the Adaptive Dose Shield spares the patient all clinically irrelevant radiation doses. Please see the article in Attachment F, "Eliminating Over-Radiation with the Adaptive Dose Shield," for more information on this feature.

As described above, the very important technological improvements in the Siemens PET-CT scanner will have a direct, positive impact on patient safety. As a result of these patient safety features available on the proposed equipment, L&M Hospital cannot continue to operate the existing PET-CT equipment, which does not provide these features and consequently provides a higher radiation dose to patients.

Opportunity Presented by Need for New Agreements

As mentioned previously, the lease on the Crossroads CT scanner expired on June 30, 2011. The agreement with Alliance for mobile PET-CT services will expire on March 16, 2012, although L&M Hospital may terminate the lease six months ahead of schedule. The close timing of the expiration of both agreements presents L&M Hospital with an opportunity to consolidate the two pieces of equipment into one new scanner. In addition, because the proposed PET-CT scanner can also function as a diagnostic CT scanner, by consolidating imaging modalities and replacing both scanners at once, L&M Hospital will be able to assume the costs of just one new scanner instead of two.

The need for new CT and PET-CT agreements also overlaps with L&M Hospital's preparations for the installation of a new 3T MRI that will be added to Crossroads (as approved in DN 11-31682-CON). L&M Hospital is in the process of preparing adjacent space for the 3T MRI, so this construction can be coordinated with construction for the PET-CT scanner, ensuring that the space for both scanners is appropriately designed. The addition of both MRI and PET-CT at Crossroads will ensure that a comprehensive array of imaging services is available to patients, especially those being treated at the new cancer center.

Development of Cancer Center

L&M Hospital is planning to construct a comprehensive outpatient cancer center in Waterford, located approximately two miles from Crossroads, that is projected to open in the fall of 2013. The new center will provide comprehensive outpatient care for cancer patients such as radiation therapy, chemotherapy/infusion services, social work, nutrition services, patient education seminars, support groups, healthy lifestyle programs, tumor registry and a dedicated pharmacy and laboratory service in a comfortable, off-site environment. The center will also augment existing L&M Hospital oncology services with the addition of second opinion clinics, multidisciplinary/subspecialty clinics, clinical trials, survivorship, genetic counseling, patient navigator services, and expanded public

education sessions. Several of these augmented services will be offered this fiscal year. As discussed earlier, PET-CT is an essential imaging modality in diagnosing and monitoring treatment in cancer patients. As reported by the National Cancer Institute, the incidence of cancer in New London County is the highest among all the counties in Connecticut, and the availability of high quality, comprehensive cancer care, including a full range of oncology imaging services, to residents of L&M Hospital's service area is extremely important. Due to the close proximity of Crossroads and the new Cancer Center (less than two miles apart), the proposed PET-CT scanner will serve patients of the new Cancer Center.

Proposed PET-CT Scanner Provides Improved Patient Care

The proposed PET-CT equipment has capabilities that will improve the quality of patient care. First, the proposed scanner's diagnostic CT component is a 40-slice unit. By comparison, the existing CT scanner at Crossroads is a 16-slice unit. It is generally acknowledged that a CT scanner with a higher number of slices per rotation provides improved resolution and more detailed clinical information from each scan than a scanner with fewer slices. The proposed equipment will therefore result in more detailed and accurate image reconstruction and improved image quality.

A second important improvement to patient care from the proposed PET-CT scanner is its ability to perform a PET-CT and diagnostic CT exam simultaneously, which cannot be done on the mobile unit. For patients undergoing a PET-CT exam, the scanner produces clear PET and spiral CT images that reveal highly detailed anatomy and biological processes at the molecular level, along with high quality anatomic and metabolic images for optimal lesion detection and identification. Certain patients, however, require a full, diagnostic CT scan in addition to a PET-CT scan. Under the current arrangement, patients requiring both exams must obtain two separate tests: a PET-CT exam on the mobile unit and then a diagnostic CT on a separate CT scanner (possibly during a second appointment if the CT cannot be scheduled on the same day as the PET-CT). This is a more lengthy and cumbersome process for patients that exposes them to radiation during each exam. The proposed PET-CT scanner will allow patients to acquire both exams with a single scan in a single sitting, resulting in two images – a PET-CT and a diagnostic CT – acquired at the exact same time. This is clinically beneficial because it exposes patients to a lower dose of radiation from the combined PET-CT and CT exam. It also ensures that the patient is in the exact same position for both scans, which eliminates potential patient movement as an issue since both scans are performed on the same equipment at the same time. The reduction in the number of scans a

patient must receive also results in an improved experience for patients. Between September 2010 and September 2011, there were 342 patients at L&M Hospital that underwent separate PET/CT and diagnostic CT scans within 30 days of each other. With the proposed PET/CT scanner, these patients would have only had to undergo a single PET/CT exam, which would be a significant benefit to them and an improvement over the current approach.

Enhanced and Easier Access for Patients

The proposed PET-CT scanner, to be located in the state-of-the-art L&M Diagnostic Imaging at Crossroads center, will provide improved enhanced and easier access. The Crossroads center is conveniently located in a suburban location with ample parking in a building that houses the offices of several physicians on the L&M Hospital medical staff. The Crossroads location is easily accessible for a large percentage of service area residents due to its proximity to I-95, I395 and US1. Because the Crossroads imaging center offers several diagnostic modalities, patients in need of multiple radiology exams can obtain them all in the same location.

Adding the fixed PET-CT scanner to the Crossroads Center will also ensure a more comfortable atmosphere for patients. Rather than having to receive their PET-CT scan in a mobile van, patients will be scanned in a more spacious and comfortable fixed-site center. Accessing the PET-CT scanner in a mobile unit is suboptimal for patients. For example, in winter, patients have to exit the Hospital or Pequot facility and go outside to a tent-like enclosure, where they then enter the van, which is often cold inside. To reach the mobile van, patients must climb a flight of stairs, which can be challenging in icy or snowy weather, or they must be lifted up on a trailer unit to the mobile van if they are not able to climb the stairs. In rainy weather, the mobile van enclosure sometimes leaks, and in the winter, ice can develop. In addition, due to the mobile unit's small size, obtaining a PET-CT scan can be problematic for claustrophobic patients. All of these issues will be eliminated by the improved environment of the fixed PET-CT unit, which will be located within the Crossroads center.

For patients who require a PET-CT and a diagnostic CT scan, they currently have to obtain two scans and may have to travel to two separate locations. This is burdensome and confusing to patients. The proposed scanner will simplify the imaging process for many patients and minimize their travel and time spent obtaining necessary imaging scans.

Currently, PET-CT scanning is available to L&M Hospital patients on a limited basis (two days a week). The limited access to PET-CT is problematic for patients. The process of reaching a diagnosis of cancer is a stressful and frightening time, and a delay in obtaining all necessary diagnostic imaging procedures can exacerbate the stress faced by patients. As described in the Health Care Advisory Board technology briefing on hybrid PET-CT, included as Attachment G, "Prompt service is a cornerstone of successful PET-CT programs. Ease of scheduling and consistent, timely interpretation are the two primary factors that draw continued referral business". With the increased accessibility of the proposed PET-CT scanner, which will be available five days a week, patients can obtain a PET-CT scan more promptly (such as a next-day appointment), which will provide a great emotional benefit to them and their families. The proposed schedule for the PET-CT scanner at Crossroads will offer five PET-CT appointments a day and eleven CT appointments a day, as shown below.

Proposed PET-CT Schedule- Crossroads, Monday - Friday	
Time	Service
7:30 am	CT
8:00 am	PET-CT
8:30 am	CT
9:00 am	PET-CT
9:30 am	CT
10:00 am	PET-CT
10:30 am	CT
11:00 am	PET-CT
11:30 am	CT
12:00 pm	PET-CT
12:30 pm	CT
1:00 pm	CT
1:30 pm	CT
2:00 pm	CT
2:30 pm	CT
3:00 pm	CT
3:30 pm	CT

The split between PET-CT appointments and CT appointments will be adjusted accordingly as needed based on future demand.

<u>More Cost-Effective Approach than Current Arrangement</u>

The proposed scanner represents a more cost-effective approach for L&M Hospital. Over the course of the first three years operating the

proposed PET-CT, L&M Hospital will improve the net income on this service by more than $500,000. The CT lease expense along with the mobile PET-CT costs totaled more than $700,000 per year. The operating expenses will be reduced substantially with the fixed scanner.

As described above, there are several compelling reasons for acquiring the proposed PET-CT in place of the two existing scanners.

b. Provide the utilization of existing health care facilities and health care services in the Applicant's service area.

Response:
Utilization of PET-CT and CT services at Backus Hospital is as follows:

	Total Scans, FY 2010 (Inpatient and Outpatient)
PET Scans	819
CT Scans	33,349

Source: PCR

Utilization of CT services at The Westerly Hospital and the Westerly Hospital Imaging Center is not available. They do not offer PET-CT. There are no other known providers of CT or PET-CT services in L&M Hospital's service area.

c. Complete **Table 1** for each piece of equipment of the type proposed currently operated by the Applicant at each of the Applicant's sites.

Response:
Please see Table 1 for each CT and PET-CT scanner owned and/or operated by L&M Hospital. L&M Hospital does not presently own a PET-CT scanner, but leases one.

Table 1: Existing Equipment Operated by the Applicant

Provider Name Street Address Town, Zip Code	Description of Service *	Hours/Days of Operation **	Utilization ***
L&M Hospital 365 Montauk Ave. New London, CT 06320	1 64-slice CT 1 16-slice CT	64 slice: Monday – Sunday, 24 hours/day 16 slice: Monday – Friday, 7:00 am to 3:30 pm	FY 2011: 20,573 scans
Pequot Health	1 16-slice CT	Monday – Sunday,	FY 2011: 8,419

Provider Name Street Address Town, Zip Code	Description of Service *	Hours/Days of Operation **	Utilization ***
Center 52 Hazelnut Hill Road Groton, CT 06340		7:00 am to 11:00 pm	scans
L&M Diagnostic Imaging at Crossroads 196 Parkway South Waterford, CT 06385	16-slice CT	Monday – Friday, 7:30 am to 4:00 pm	FY 2011: 2,309 scans
L&M Hospital 365 Montauk Ave. New London, CT 06320	Mobile PET-CT (with 16-slice CT)	Due to the upgrade of the oxygen farm on the hospital campus during FY 2011, the scanner has only been at Pequot this fiscal year.	FY 2011: N/A Due to the upgrade of the oxygen farm on the hospital campus during FY 2011, the scanner has only been at Pequot this fiscal year.
Pequot Health Center 52 Hazelnut Hill Road Groton, CT 06340	Mobile PET-CT (with 16-slice CT)	Tuesday &Saturday, 7:00 am to 4:00 pm	FY 2011: 434 scans

* Include equipment strength (e.g. slices, tesla strength), whether the unit is open or closed (for MRI)
** Days of the week unit is operational, and start and end time for each day; and
*** Number of scans/exams performed on each unit for the most recent 12-month period (identify period).

d. Provide the following regarding the proposal's location:

i. The rationale for locating the proposed equipment at the proposed site;

Response:

The proposed site, L&M Diagnostic Imaging at Crossroads in Waterford, is a state-of-the-art outpatient imaging center that provides enhanced access to L&M Hospital's high quality imaging services in a convenient, off-site location with ample on-site parking. In addition, the Crossroads location is less than two miles from L&M Hospital's planned Cancer Center in Waterford and is in the same building as several oncology and cardiology physicians on the L&M Hospital medical staff. The Crossroads location is easily accessible for a large percentage of service area residents due to its proximity to I-95, I395 and US1

L&M Hospital's selection of Crossroads for the proposed PET-CT scanner was also based on the fact that the main Hospital campus does not have sufficient space to accommodate the larger footprint of the PET-CT scanner or the lead-lined quiet rooms the scanner requires. As a result, it will be more practical

and convenient for patients to visit the full-service Crossroads imaging center for all their imaging needs.

PET-CT is an integral modality for oncology care and its presence in close proximity to the new Cancer Center is critical.

ii. The population to be served, including specific evidence such as incidence, prevalence, or other demographic data that demonstrates need;

Response:

The population to be served includes residents of L&M Hospital's primary and secondary service area towns, consisting of Bozrah, Colchester, East Lyme, Franklin, Griswold/Lisbon, Groton, Ledyard, Lyme/Old Lyme, Montville, New London, North Stonington, Norwich, Old Saybrook, Preston, Salem, Stonington, Voluntown and Waterford, Connecticut, as well as Westerly, Rhode Island. Current and projected population by town for the service area, as provided by Claritas, a leading provider of demographic data, is shown below:

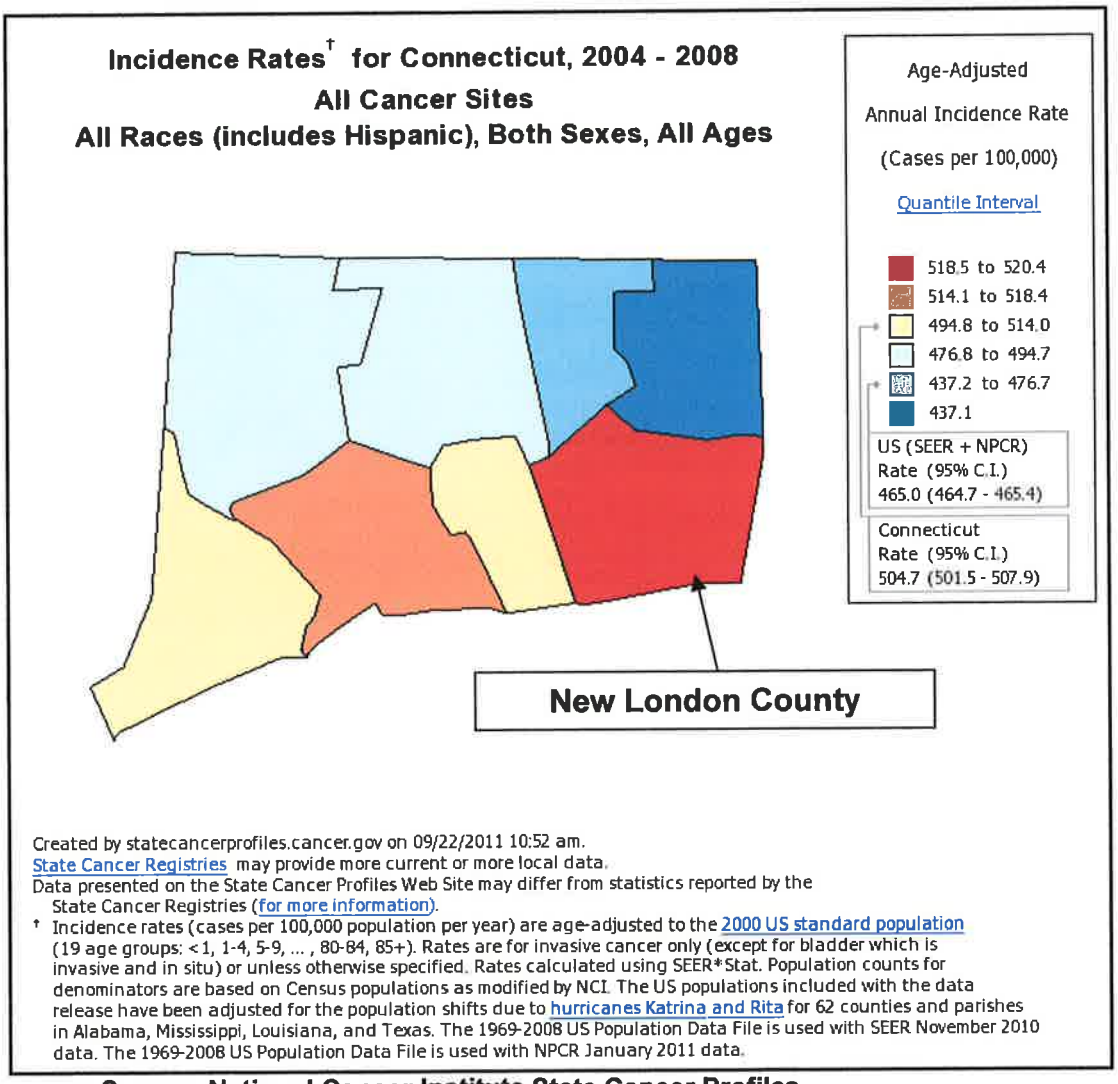
	2009 Population	2014 Population	Change, 2009 - 14	Change, 2009 - 14, %
Primary Service Area				
East Lyme	19,164	19,761	597	3.1%
Groton	47,204	48,850	1,646	3.5%
Ledyard	14,885	15,029	144	1.0%
Lyme/Old Lyme	9,305	9,258	(47)	-0.5%
Montville	19,655	20,324	669	3.4%
New London	25,665	25,667	2	0.0%
North Stonington	5,172	5,271	99	1.9%
Stonington	14,174	14,218	44	0.3%
Waterford	19,203	19,304	101	0.5%
Total, PSA	174,427	177,682	3,255	1.9%
Secondary Service Area				
Bozrah	2,589	2,627	38	1.5%
Colchester	16,383	16,881	498	3.0%
Franklin	1,865	1,884	19	1.0%
Griswold/Lisbon	15,541	15,899	358	2.3%
Norwich	36,350	36,424	74	0.2%
Old Saybrook	10,546	10,684	138	1.3%
Preston	4,886	4,986	100	2.0%
Salem	4,140	4,255	115	2.8%
Voluntown	2,624	2,660	36	1.4%
Westerly (RI)	21,717	21,848	131	0.6%
Total, SSA	116,641	118,148	1,507	1.3%
Total, All Towns	**291,068**	**295,830**	**4,762**	**1.6%**

Source: Claritas

As previously mentioned, PET-CT scans are predominantly used in cancer patients. Cancer is the second leading cause

of death and has an increased prevalence in the elderly population. The American Cancer Society report, "Cancer Facts and Figures 2011" (included as Attachment H) states that there will be an estimated 21,440 new cancer cases in Connecticut this year, and an estimated 6,800 cancer deaths.

The following map from the National Cancer Institute depicts the age-adjusted annual incidence rates of cancer by county in Connecticut for 2004 to 2008. New London County is clearly shown as having the highest incidence of cancer in the state (518.5 to 520.4 cases per 100,000, compared to incidence rates of 504.7 for Connecticut and 465.0 for the United States).



Source: National Cancer Institute State Cancer Profiles

The table below also shows cancer incidence in New London County compared to the other counties in the state. The data

clearly show that the residents of New London County, which encompasses the majority of L&M Hospital's service area towns, are afflicted with cancer at higher rates than the rest of the state.

Incidence Rates(†) for Connecticut, 2004 - 2008 All Cancer Sites All Races (includes Hispanic), Both Sexes, All Ages						
County	Annual Incidence Rate Over Rate Period Cases per 100,000 (95% confidence interval)	Lower 95% Confidence Interval	Upper 95% Confidence Interval	Average Annual Cases	Rate Period	Interval Range
Connecticut(3)	504.7	501.5	507.9	19,484	2004 - 2008	N/A
US (SEER + NPCR)(1)	465	464.7	465.4	§	2004 - 2008	§
New London County(7)	520.4	508.6	532.3	1,515	2004 - 2008	518.5 - 520.4
New Haven County(7)	518.4	511.9	525.1	4,851	2004 - 2008	514.1 - 518.4
Fairfield County(7)	514	507.5	520.5	4,938	2004 - 2008	494.8 - 514.0
Middlesex County(7)	503.2	488.9	517.8	958	2004 - 2008	494.8 - 514.0
Hartford County(7)	494.7	488.5	501	4,913	2004 - 2008	476.8 - 494.7
Litchfield County(7)	487.1	474.1	500.4	1,103	2004 - 2008	476.8 - 494.7
Tolland County(7)	476.7	460.6	493.2	686	2004 - 2008	437.2 - 476.7
Windham County(7)	437.1	420.2	454.4	520	2004 - 2008	437.1 - 437.1

Source: National Cancer Institute State Cancer Profiles
(†)Incidence rates (cases per 100,000 population per year) are age-adjusted to the 2000 US standard population (19 age groups: <1, 1-4, 5-9, ... , 80-84, 85+). Rates are for invasive cancer only (except for bladder which is invasive and in situ) or unless otherwise specified. Rates calculated using SEER*Stat. Population counts for denominators are based on Census populations as modified by NCI. The US populations included with the data release have been adjusted for the population shifts due to hurricanes Katrina and Rita for 62 counties and parishes in Alabama, Mississippi, Louisiana, and Texas. The 1969-2008 US Population Data File is used with SEER November 2010 data. The 1969-2008 US Population Data File is used with NPCR January 2011 data.
(1) Source: CDC's National Program of Cancer Registries Cancer Surveillance System (NPCR-CSS) November 2010 data submission and SEER November 2010 submission.
(3) Source: SEER November 2010 submission. State Cancer Registry also receives funding from CDC's National Program of Cancer Registries.
(7) Source: SEER November 2010 submission
(§) Because of the impact on Louisiana's population for the July - December 2005 time period due to Hurricanes Katrina/Rita, SEER excluded Louisiana cases diagnosed for that six month time period. The count has been suppressed due to data consistency issues. [http://seer.cancer.gov/data/hurricane.html]

iii. How and where the proposed patient population is currently being served;

Response:
The proposed patient population is currently being served by the CT scanner at L&M Diagnostic Imaging at Crossroads and by

L&M Hospital's mobile PET-CT service, which is available to patients on a limited basis and located on the main campus which is difficult to navigate to and from I-95 and other major roadways.

iv. All existing providers (name, address) of the proposed service in the towns listed above and in nearby towns;

Response:
Backus Hospital provides CT, PET and PET-CT scanning at its main hospital campus at 362 Washington Street in Norwich. It also provides CT scanning at the Norwich Backus Outpatient Care Center, 111 Salem Turnpike, Norwich and at the Colchester Backus Health Center, 163 Broadway, Colchester.

The Westerly Hospital provides CT scanning at its main campus at 25 Wells Street in Westerly, RI and at The Westerly Hospital Imaging Center at 16 Granite St. in Westerly.

v. The effect of the proposal on existing providers; and

Response:
This proposal represents a replacement of a CT scanner that is at the end of its lease and a leased mobile PET-CT service with a new state-of-the-art fixed PET-CT scanner. The replacement of the current equipment will provide enhanced imaging quality and safety, service and access to the Hospital's current patients. As a result, it is not expected to have an effect on any existing providers.

vi. If the proposal involves a new site of service, identify the service area towns and the basis for their selection.

Response:
The proposed PET-CT is expected to serve L&M Hospital's service area as identified in response to question 2d ii. It is expected that the PET-CT at Crossroads in Waterford will draw from the hospital's traditional service area towns, particularly because of the attractiveness of the advanced PET-CT technology and the site's easy access to major highways and roadways.

e. Explain why the proposal will not result in an unnecessary duplication of existing or approved health care services.

Response:
This proposal replaces two separate scanners: an aging CT scanner whose lease has expired and a mobile PET-CT unit provided by an

outside company, whose agreement with L&M Hospital will expire in the near future. The consolidation of these two scanners into one fixed PET-CT scanner will provide enhanced patient safety, imaging quality and service to L&M Hospital's current patients. As a result, the replacement of existing equipment does not represent a duplication of existing health care services.

3. **Actual and Projected Volume**

a. Complete the following tables for the past three fiscal years ("FY"), current fiscal year ("CFY"), and first three projected FYs of the proposal, for each of the Applicant's existing and proposed pieces of equipment (of the type proposed, at the proposed location only). In Table 2a, report the units of service by piece of equipment, and in Table 2b, report the units of service by type of exam (e.g. if specializing in orthopedic, neurosurgery, or if there are scans that can be performed on the proposed scanner that the Applicant is unable to perform on its existing scanners).

Response:

Please see Table 2a for CT and PET-CT volume for inpatient, outpatient and Emergency Department patients at L&M Hospital, Pequot Health Center and L&M Diagnostic Imaging at Crossroads. Table 2b provides CT and PET-CT volume for all patients by type of exam.

Table 2a: Historical, Current, and Projected Volume, by Equipment Unit

	Patient Type	Actual Volume (Last 3 Completed FYs)			CFY Volume*	Projected Volume (First 3 Full Operational FYs)**			
		FY 2008	FY 2009	FY 2010[1]	FY 2011[2]	FY 2012	FY 2013	FY 2014	FY 2015
CT Scans									
L&M Hospital[3]	Inpatient	4,203	4,178	4,172	4,084	4,084	4,084	4,084	4,084
	Outpatient	4,546	5,391	5,033	4,570	4,570	4,570	4,570	4,570
	ED	11,666	11,874	12,038	11,919	11,919	11,919	11,919	11,919
	Total	20,415	21,443	21,243	20,573	20,573	20,573	20,573	20,573
Pequot Health Center	Inpatient	12	4	10	11	11	11	11	11
	Outpatient	6,744	5,342	4,521	4,872	4,872	4,872	4,872	4,872
	ED	2,983	2,676	3,189	3,536	3,536	3,536	3,536	3,536
	Total	9,739	8,022	7,720	8,419	8,419	8,419	8,419	8,419
L&M Diagnostic Imaging at Crossroads	Outpatient	0	0	1,737	2,309	2,662	3,025	3,399	3,784

[1] L&M Hospital's fiscal year runs from October 1 to September 30
[2] Fiscal Year 2011 volume represents 12 months (October to September)
[3] Please note that volume for the two CT Scanners at L&M Hospital cannot be broken out separately and is presented in aggregate

	Patient Type	Actual Volume (Last 3 Completed FYs)			CFY Volume*	Projected Volume (First 3 Full Operational FYs)**			
		FY 2008	FY 2009	FY 2010[1]	FY 2011[2]	FY 2012	FY 2013	FY 2014	FY 2015
Total, CT (All Sites)	Inpatient	4,215	4,182	4,182	4,095	4,095	4,095	4,095	4,095
	Outpatient	11,290	10,733	11,291	11,751	12,104	12,467	12,841	13,226
	ED	14,649	14,550	15,227	15,455	15,455	15,455	15,455	15,455
	Total	30,154	29,465	30,700	31,301	31,654	32,017	32,391	32,776
PET-CT Scans									
L&M Hospital	Inpatient	5	0	4	2	0	0	0	0
	Outpatient	297	154	237	0	0	0	0	0
	Total	302	154	241	2	0	0	0	0
Pequot Health Center	Outpatient	380	389	269	434	218	0	0	0
L&M Diagnostic Imaging at Crossroads	Outpatient	0	0	0	0	218	496	555	570
Total, PET-CT (All Sites)	Inpatient	5	0	4	2	0	0	0	0
	Outpatient	677	543	506	434	436	496	555	570
	Total	682	543	510	436	436	496	555	570

* For periods greater than 6 months, report annualized volume, identifying the number of actual months covered and the method of annualizing. For periods less than six months, report actual volume and identify the period covered.

** If the first year of the proposal is only a partial year, provide the first partial year and then the first three full FYs. Add columns as necessary.

*** Identify each scanner separately and add lines as necessary. Also break out inpatient/outpatient/ED volumes if applicable.

**** Fill in years. In a footnote, identify the period covered by the Applicant's FY (e.g. July 1-June 30, calendar year, etc.).

Table 2b: Historical, Current, and Projected Volume, by Type of Scan/Exam

	Actual Volume (Last 3 Completed FYs)			CFY Volume*	Projected Volume (First 3 Full Operational FYs)**			
	FY 2008	FY 2009	FY 2010[4]	FY 2011[5]	FY 2012	FY 2013	FY 2014	FY 2015
Service type***								
CT Scans								
Abdomen only	856	782	794	805	827	849	873	896
Abdomen & pelvis	11,860	11,024	11,486	12,112	12,206	12,302	12,402	12,504
Chest	6,137	6,293	6,846	6,874	7,018	7,166	7,319	7,476
Extremities	236	249	352	327	333	340	347	354
Head	7,820	8,009	8,013	7,979	8,027	8,077	8,128	8,181
Lung	80	56	96	74	74	74	74	74
Neck	569	539	666	701	714	726	740	753

[4] L&M Hospital's fiscal year runs from October 1 to September 30

[5] Fiscal Year 2011 volume represents 12 months (October to September)

	Actual Volume (Last 3 Completed FYs)			CFY Volume*	Projected Volume (First 3 Full Operational FYs)**			
	FY 2008	FY 2009	FY 2010[4]	FY 2011[5]	FY 2012	FY 2013	FY 2014	FY 2015
Pelvis only	172	203	167	192	195	198	201	204
Spine	1,465	1,582	1,697	1,656	1,662	1,668	1,675	1,682
All Other	959	728	583	581	598	615	633	651
Total, CT	30,154	29,465	30,700	31,301	31,654	32,017	32,391	32,776
PET-CT Scans								
Breast	95	61	65	35	35	35	39	39
Cardiac	0	0	0	0	0	60	75	90
Colon	44	35	70	45	45	45	50	50
Esophageal	24	18	35	26	26	26	29	29
Head	13	14	30	24	24	24	26	26
Lung	324	263	233	242	242	242	266	266
Lymph	106	98	59	52	52	52	57	57
All Other	76	54	18	12	12	12	13	13
Total, PET-CT	682	543	510	436	436	496	555	570

* For periods greater than 6 months, report annualized volume, identifying the number of actual months covered and the method of annualizing. For periods less than six months, report actual volume and identify the period covered.
** If the first year of the proposal is only a partial year, provide the first partial year and then the first three full FYs. Add columns as necessary.
*** Identify each type of scan/exam (e.g. orthopedic, neurosurgery or if there are scans/exams that can be performed on the proposed piece of equipment that the Applicant is unable to perform on its existing equipment) and add lines as necessary.
**** Fill in years. In a footnote, identify the period covered by the Applicant's FY (e.g. July 1-June 30, calendar year, etc.).

b. Provide a breakdown, by town, of the volumes provided in Table 2a for the most recently completed full FY.

Response:
Total FY 2011 CT and PET-CT scan volume by town is shown below.

CT Volume by Town	
Town	**FY 11 Cases**
Groton	8,340
New London	6,263
Waterford	4,319
East Lyme	3,083
Ledyard	2,038
Montville	1,664
Stonington	1,011
Lyme/Old Lyme	676
Norwich	668
North Stonington	411
Salem	220
Westerly, RI	196
Griswold/Lisbon	192
Preston	169
Old Saybrook	111
Colchester	98
Bozrah	50
Voluntown	36
Franklin	16
All Others	1,740
TOTAL	**31,301**

PET/CT Volume by Town	
Town	**FY 11 Cases**
Groton	99
New London	60
Waterford	45
East Lyme	42
Stonington	39
Ledyard	35
Westerly, RI	23
Montville	21
Norwich	10
North Stonington	10
Lyme/Old Lyme	6
Griswold/Lisbon	4
Old Saybrook	4
Preston	2
Salem	1
Colchester	-
Bozrah	-
Voluntown	-
Franklin	-
All Others	35
TOTAL	**436**

c. Describe existing referral patterns in the area to be served by the proposal.

Response:
Clinically appropriate patients that live and/or work in L&M Hospital's service area are referred to the Hospital's CT and PET-CT service by their physician (including oncologists, internists, cardiologists, neurologists, surgeons and many other specialists). Referring physicians have existing relationships with L&M Hospital's radiologists.

d. Explain how the existing referral patterns will be affected by the proposal.

Response:
Because the proposal involves the replacement of two existing scanners, and will serve an existing patient base, no changes in referral patterns are expected.

e. Explain any increases and/or decreases in volume seen in the tables above.

Response:
Outpatient PET-CT volume at L&M Hospital was negatively impacted in Fiscal Year 2011 due to the need to move the entire mobile PET-CT service to the Pequot Health Center in order to perform construction at the L&M Hospital campus (replacement of the special procedures room followed by the replacement of the Hospital's oxygen farm and

then the cardiac catheterization laboratory). This construction is expected to be completed by November, at which point the mobile PET-CT service will resume operations at L&M Hospital one day a week.

f. Provide a detailed explanation of all assumptions used in the derivation/ calculation of the projected volume by scanner and scan type.

Response:

PET-CT volume is expected to stabilize in Fiscal Year 2012. This expectation is as a result of the addition of a new oncologist, Dr. Youval Katz, to the New London Cancer Center oncology practice in April 2011. Volume projections for the PET-CT service reflect the addition of new members of the L&M Hospital medical staff (one oncologist and one cardiologist); the new Cancer Center (for which the recruitment of two new oncologists is planned); new procedures (rubidium cardiac and fluoride 18 bone scan); and the expanded availability of PET-CT scans to L&M Hospital patients.

Specific volume projections incorporated into this application are very conservative. Projections are outlined below:

- **CT Volume: Inpatient and Emergency Dept. - Projected to remain flat.**
- **CT Volume: Outpatient – Projected to increase 3% per year and increased volume is projected to occur at the Crossroads site.**
- **PET-CT Volume: Volume will remain flat in FY 2012 and increase by 60 cardiac scans in FY 2013. In FY 2014 when the new Cancer Center opens, PET-CT oncology volume projected to increase 10% along with 75 cardiac scans. FY 2015 will maintain the oncology increase from the previous year and 15 more cardiac scans (total of 90) will be achieved.**

Cardiac scan volume has been conservatively projected and as noted in letters of support from two cardiologists, these volumes can easily be achieved.

Despite these very conservative projections, this proposal is financially feasible and represents a more cost effective approach to offer PET-CT services.

g. Provide a copy of any articles, studies, or reports that support the need to acquire the proposed scanner, along with a brief explanation regarding the relevance of the selected articles.

Response:
Several clinical studies document the improved clinical benefits of new PET-CT technology, particularly its ability to deliver a reduced radiation dose to patients. Some selected highlights from the attached articles are listed below; all of the clinical features referenced below are included in the proposed Siemens Biograph mCT S/X PET-CT scanner. Please see Attachment I for full copies of these articles.

Article	Selected Highlighted Points
Effects of Adaptive Section Collimation on Patient Radiation Dose in Multisection Spiral CT	• Adaptive dose shield can reduce radiation dose to patients by up to 37%
Comparison of Image Quality and Radiation Dose Between Combined Automatic Tube Current Modulation and Fixed Tube Current Technique in CT of Abdomen and Pelvis	• When used in CT of the abdomen and pelvis, the automatic tube current modulation "substantially reduced radiation dose while maintaining image quality"
Radiation Dose of Non-enhanced Chest CT can be Reduced 40% by Using Iterative Reconstruction in Image Space	• The use of iterative reconstruction in image space (IRIS) can maintain or improve image quality on non-contrast chest CT image reconstruction while reducing radiation dose by 40%
Hybrid Imaging Can Accurately Predict Cardiac Events	• Combining perfusion and anatomical data in a PET-CT scan has predictive value in assessing coronary artery disease and serves as a "predictive gatekeeper"

4. **Quality Measures**

a. Submit a list of all key professional, administrative, clinical, and direct service personnel related to the proposal. Attach a copy of their Curriculum Vitae.

Response:
Key personnel related to the proposal are listed below. Their Curriculum Vitae are included as Attachment J.

- **Bruce D. Cummings, President and Chief Executive Officer**

- **Daniel Rissi, MD, Vice President and Chief Medical & Clinical Operations Officer**
- **Todd M. Blue, MD, Chair, Department of Radiology**
- **John Sorrentino, MD, Section Head, Nuclear Medicine**
- **Lugene Inzana, MBA, CPA, Vice President and Chief Financial Officer**
- **Donna-Marie Blakely, Administrative Director, Radiology**
- **Robert Brouillette, Manager, Nuclear Medicine/PET CT Services**
- **Marci Gwiazdowski, Manager, CT/MRI**

b. Explain how the proposal contributes to the quality of health care delivery in the region.

Response:
As mentioned previously, the proposed PET-CT scanner will positively impact the quality of health care delivery in the region by reducing the radiation dose to patients undergoing a CT or PET-CT scan. It also improves clinical quality by improving the accuracy and image quality of scans and by reducing the need for separate CT and PET-CT scans by patients. This is accomplished with the new features offered and more CT slices which will lead to improved resolution and image quality and ultimately in better diagnosis, especially of smaller lesions.

L&M Hospital maintains the highest standards for its diagnostic imaging equipment and staff. Its technologists are all licensed and registered by the State of Connecticut and the American Registry of Radiographers. In addition, all technologists are required to pass specialty boards by the ARRT in computed tomography, and all of L&M Hospital's CT scanners are accredited by the American College of Radiology (ACR).

5. Organizational and Financial Information

a. Identify the Applicant's ownership type(s) (e.g. Corporation, PC, LLC, etc.).

Response:
L&M Hospital's ownership type is a Corporation.

b. Does the Applicant have non-profit status?
☒ Yes (Provide documentation) ☐ No

Response:
Please see Attachment K for proof of L&M Hospital's non-profit status, as shown by its Department of Public Health licensure status.

c. Provide a copy of the State of Connecticut, Department of Public Health license(s) currently held by the Applicant and indicate any additional licensure categories being sought in relation to the proposal.

Response:
A copy of L&M Hospital's Department of Public Health license is included as Attachment K. No additional licensure is being sought in relation to the proposal.

d. Financial Statements

i. If the Applicant is a Connecticut hospital: Pursuant to Section 19a-644, C.G.S., each hospital licensed by the Department of Public Health is required to file with OHCA copies of the hospital's audited financial statements. If the hospital has filed its most recently completed fiscal year audited financial statements, the hospital may reference that filing for this proposal.

ii. If the Applicant is not a Connecticut hospital (other health care facilities): Audited financial statements for the most recently completed fiscal year. If audited financial statements do not exist, in lieu of audited financial statements, provide other financial documentation (e.g. unaudited balance sheet, statement of operations, tax return, or other set of books.)

Response:
A copy of L&M Hospital's audited financial statements for Fiscal Year 2010 is on file with OHCA.

e. Submit a final version of all capital expenditures/costs as follows:

Response
Please see Table 3 for all proposed capital expenditures and costs.

Table 3: Proposed Capital Expenditures/Costs

Medical Equipment Purchase	**$161,450**
Imaging Equipment Purchase	**$2,168,286**
Non-Medical Equipment Purchase	**$296,179**
Land/Building Purchase *	
Construction/Renovation **	**$600,000**
Other Non-Construction (Specify)	
Total Capital Expenditure (TCE)	**$3,225,915**
Medical Equipment Lease (Fair Market Value) ***	
Imaging Equipment Lease (Fair Market Value) ***	
Non-Medical Equipment Lease (Fair Market Value) ***	
Fair Market Value of Space ***	
Total Capital Cost (TCC)	
Total Project Cost (TCE + TCC)	**$3,225,915**
Capitalized Financing Costs (Informational Purpose Only)	
Total Capital Expenditure with Cap. Fin. Costs	**$3,225,915**

* If the proposal involves a land/building purchase, attach a real estate property appraisal including the amount; the useful life of the building; and a schedule of depreciation.
** If the proposal involves construction/renovations, attach a description of the proposed building work, including the gross square feet; existing and proposed floor plans; commencement date for the construction/ renovation; completion date of the construction/renovation; and commencement of operations date.
*** If the proposal involves a capital or operating equipment lease and/or purchase, attach a vendor quote or invoice; schedule of depreciation; useful life of the equipment; and anticipated residual value at the end of the lease or loan term.

Medical equipment associated with the proposal includes a ceiling-mounted injector, EKG unit, Infusion system, triage procedure chairs and a patient lift system. Non-medical equipment includes furniture, furnishings and equipment, telephone and data system equipment/software and a closed-circuit television system.

The proposed implementation of a PET-CT scanner at the L&M Diagnostic Imaging Center at Crossroads includes renovation to approximately 2,700 gross square feet of existing space to accommodate the installation of the PET-CT unit and the required patient and support spaces. These spaces include the PET-CT treatment room, PET-CT equipment room, PET-CT control room, patient changing/injection rooms, patient holding room, patient toilets, hot lab, staff work area, clean supply and soiled holding and staff support spaces.

A floor plan depicting the existing spaces and their current use at the Crossroads center is included as Attachment L. The proposed PET-CT space will occupy space currently utilized by a CT scanner, CT scan control and empty spaces that were planned for an additional CT scanner and the addition of an MRI unit at the time of the original construction of the building. Neither the second CT scan unit nor the MRI unit were installed at the time of the opening of the center and have not been added since that time.

A schematic floor plan depicting the proposed layout and space configuration is also included as Attachment M. The schematic plan also indicates the spaces being allocated to the installation of a fixed-site 3T MRI unit (previously approved in DN 11-31682-CON). The 1,500 gross square feet of renovations to support the MRI installation is not included in the proposed PET-CT scope of work. The proposed schedule for the implementation of this project is as follows:

Construction/Renovation commencement date*	**Feb. 20, 2012**
Equipment lead time*	**Feb. 20 to March 30, 2012**
Construction/Renovation completion date	**March 30, 2012**

Equipment installation commencement date	**April 2, 2012**
Equipment installation completion date	**April 27, 2012**
PET-CT applications commencement date	**April 30, 2012**
PET-CT applications completion date	**May 4, 2012**
Commencement of operations	**May 7, 2012**
***Contingent on CON approval**	

Please see Attachment N for a copy of the quote from Siemens for the proposed equipment.

f. List all funding or financing sources for the proposal and the dollar amount of each. Provide applicable details such as interest rate; term; monthly payment; pledges and funds received to date; letter of interest or approval from a lending institution.

Response:
The proposal will be funded out of applicant's equity.

g. Demonstrate how this proposal will affect the financial strength of the state's health care system.

Response:
As previously stated, this proposal reduces L&M Hospital's operating expenses for providing CT and PET-CT services and therefore is a most cost efficient model of care.

6. Patient Population Mix: Current and Projected

a. Provide the current and projected patient population mix (based on the number of patients, not based on revenue) with the CON proposal for the proposed program.

Table 4a: Patient Population Mix - CT

	Current** FY ***	Year 1 FY ***	Year 2 FY ***	Year 3 FY ***
Medicare*	33.2%	33.2%	35.2%	36.5%
Medicaid*	16.3%	16.3%	15.4%	14.8%
CHAMPUS & TriCare	6.5%	6.5%	6.0%	5.7%
Total Government	**56.0%**	**56.0%**	**56.6%**	**57.0%**
Commercial Insurers*	40.8%	40.8%	40.5%	40.3%
Uninsured	3.2%	3.2%	2.9%	2.7%
Workers Compensation	In Commercial			
Total Non-Government	**44.0%**	**44.0%**	**43.4%**	**43.0%**
Total Payer Mix	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Table 4b: Patient Population Mix – PET-CT

	Current** FY ***	Year 1 FY ***	Year 2 FY ***	Year 3 FY ***
Medicare*	46.9%	Same as above		
Medicaid*	10.2%			
CHAMPUS & TriCare	3.1%			
Total Government	**60.2%**			
Commercial Insurers*	38.8%			
Uninsured	1.1%			
Workers Compensation	In Commercial			
Total Non-Government	**39.9%**			
Total Payer Mix	**100.0%**			

* Includes managed care activity.
** New programs may leave the "current" column blank.
*** Fill in years. Ensure the period covered by this table corresponds to the period covered in the projections provided.

b. Provide the basis for/assumptions used to project the patient population mix.

Response:
Historical payor mix was analyzed for CT and PET-CT and changes are projected based on the projected volumes of each modality.

7. **Financial Attachments I & II**

a. Provide a summary of revenue, expense, and volume statistics, without the CON project, incremental to the CON project, and with the CON project. **Complete Financial Attachment I.** (Note that the actual results for the fiscal year reported in the first column must agree with the Applicant's audited financial statements.) The projections must include the first three full fiscal years of the project.

Response:
Please see Attachment O for Financial Attachments I & II.

b. Provide a three year projection of incremental revenue, expense, and volume statistics attributable to the proposal by payer. **Complete Financial Attachment II.** The projections must include the first three full fiscal years of the project.

Response:
Please see Attachment O for Financial Attachments I & II.

c. Provide the assumptions utilized in developing **both Financial Attachments I and II** (e.g., full-time equivalents, volume statistics, other expenses, revenue and expense % increases, project commencement of operation date, etc.).

Response:
Please see Attachment P for the assumptions used in developing Financial Attachments I and II.

d. Provide documentation or the basis to support the proposed rates for each of the FYs as reported in Financial Attachment II. Provide a copy of the rate schedule for the proposed service(s).

Response:
Please see Attachment Q for the rate schedule for the proposed service.

e. Provide the minimum number of units required to show an incremental gain from operations for each fiscal year.

Response:
The minimum number of units required to show an incremental gain from operations for each fiscal year is shown below:

Breakeven per year				
	2012	**2013**	**2014**	**2015**
CT & PET-CT	(3)	259	220	215

f. Explain any projected incremental losses from operations contained in the financial projections that result from the implementation and operation of the CON proposal.

Response:
Not applicable. There are no projected incremental losses from operations.

g. Describe how this proposal is cost effective.

Response:
This proposal is cost effective because it consolidates two separate scanners into one single fixed PET-CT scanner, which will allow patients to receive two separate scans in one sitting (PET-CT and CT simultaneously). As previously stated, it also is more cost effective for L&M Hospital to assume the costs of one scanner than to continue to operate two separate scanners.

L&M Hospital PET/CT CON

List of Attachments

Attachment	Item
A	**Letters of support** • **Valerie Popkin, MD** • **Todd Blue, MD** • **Louis Mazzarelli, MD** • **Arun Basu, MD** • **Richard Hellman, MD** • **Roshanak Bagheri, MD** • **Jon Gaudio, MD** • **Mithlesh Govil, MD, MS; Stephen Lattanzi, MD; Youval Katz, MD, MS** • **Paul Licata, DO**
B	**CT and Radiation: What Radiologists Should Know**
C	**Care kV: Automated Dose Optimized Selection of X-Ray Tube Voltage**
D	**Strategies for CT Dose Optimization**
E	**Iterative Reconstruction in Image Space**
F	**Eliminating Over-Radiation with the Adaptive Dose Shield**
G	**Health Care Advisory Board technology briefing on PET/CT**
H	**Cancer Facts and Figures 2011**
I	**Clinical Journal Articles:** • **Effects of Adaptive Section Collimation on Patient Radiation Dose in Multisection Spiral CT** • **Comparison of Image Quality and Radiation Dose Between Combined Automatic Tube Current Modulation and Fixed Tube Current Technique in CT of Abdomen and Pelvis** • **Radiation Dose of Non-enhanced Chest CT can be Reduced 40% by Using Iterative Reconstruction in Image Space** • **Hybrid Imaging Can Accurately Predict Cardiac Events**
J	**Curriculum Vitae** • **Bruce D. Cummings, President and Chief Executive Officer** • **Daniel Rissi, MD, Vice President and CMO** • **Todd M. Blue, MD, Chair, Department of Radiology** • **John Sorrentino, MD, Section Head, Nuclear Medicine** • **Lugene Inzana, MBA, CPA, Vice President and Chief Financial Officer** • **Donna-Marie Blakeley, Administrative Director, Radiology** • **Robert Brouillette, Manager, Nuclear Medicine/PET CT Services** • **Marci Gwiazdowski, Manager, CT/MRI**
K	**Department of Public Health license**
L	**Floor plan – existing**
M	**Floor plan – proposed**
N	**Siemens quote for PET/CT**

O	**Financial Attachments I & II**
P	**Assumptions for FA I & II**
Q	**Rate schedule**

Attachment A

Letters of Support

Eastern Connecticut
Cardiology Group, P.C.

September 20, 2011

Brian S. Ehrlich
MD FACC

Peter S. Milstein
MD FACC

Richard P. Fazio
MD FACC

Francis J. Mirecki
MD FACC

Mark N. Fiengo
DO FACC FSCAI

Valerie B. Popkin
MD FACC

Mark J. Somers
MD FACC

C. W. Andrias
MD FACC

Joseph J. Brennan
MD FSCAI

Brian C. Cambi
MD

Robert J. Kupis
MS PA-C

Kim Chemacki
MHS, PA-C

Ms. Jeannette DeJesus
Deputy Commissioner
Department of Public Health
Office of Health Care Access
410 Capitol Avenue, MS#13HCA
P.O. Box 340308
Hartford, CT 06134-0308

Re: L&M Hospital's Replacement of Mobile PET-CT with a Fixed PET-CT Scanner

Dear Deputy Commissioner DeJesus:

I am writing in support of Lawrence and Memorial (L&M) Hospital's certificate of need application to replace the mobile PET-CT and an older CT scanner, with one fixed PET-CT scanner. I am a general cardiologist on staff at L&M, and have been in practice in this area for more than eleven years. I feel strongly that this community would be better served with the updated equipment.

Due to the mobile nature of the current PET system, cardiac PET imaging is underutilized in this area. PET-CT scanning fills a specific niche in cardiac imaging, one that is very helpful in making treatment decisions regarding our patients. It is an excellent way of diagnosing coronary artery disease non-invasively. Cardiac PET-CT provides additional viability information that is of tremendous use when determining whether patients would benefit from revascularization either with percutaneous intervention or bypass surgery versus continuing with more conservative medical therapies.

A unique feature of PET-CT scanning is its versatility. The equipment is not only used for cardiac patients, but is very valuable in other fields as well. The new equipment is also particularly beneficial for imaging obese patients with high body mass indexes. L&M's plan to place the equipment in Waterford, CT makes it accessible not only to my patients, but to all of the patients in our catchment area.

I strongly encourage you to approve L&M's application for the CON for this equipment. I feel it will significantly improve the quality and scope of medical care that can be provided in this area. Thank you for your attention to this matter.

Sincerely,

Valerie B. Popkin, MD FACC

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Telephone (860) 443-4383 Fax (860) 443-3980

481 Gold Star Highway, Suite 101 Groton, Connecticut 06340
Telephone (860) 446-2167 Fax (860) 446-2523

Ocean Radiology Associates, P.C.

Lawrence & Memorial Hospital
365 Montauk Avenue
New London, Connecticut 06320
Phone: (860) 444-5151
Fax: (860) 444-6851

September 14, 2011

Ms. Jeannette DeJesus
Deputy Commissioner
Department of Public Health
Office of Health Care Access
410 Capitol Avenue, MS#13HCA
P.O. Box 340308
Hartford, CT 06134-0308

Re: Lawrence & Memorial Hospital Replacement of Mobile PET-CT and CT with a Fixed PET-CT Scanner

Dear Deputy Commissioner DeJesus:

I am writing this letter in support of Lawrence & Memorial Hospital's Certificate of Need (CON) application to replace two existing pieces of imaging equipment (mobile PET-CT and an older Fixed CT Scanner) with a new Fixed PET-CT at Lawrence & Memorial Hospital's Waterford imaging center. The Waterford imaging center already offers a wide array of diagnostic imaging services at a site that is easily accessible and convenient for many of the patients that choose Lawrence & Memorial Hospital and its affiliated physicians for their health care needs. In my opinion, this is a perfect site for this state-of-the-art technology.

The proposed replacement PET-CT will be a significant upgrade to the services it is intended to replace. Both the PET portion and the CT portion of the unit have significant advances over their stand-alone predecessors. This will allow radiation reduction for patients receiving PET-CT scans and also conventional CT Scans. The unit will improve spatial resolution and image contrast allowing for improved sensitivity. This in turn will allow for greater diagnostic accuracy in not only our oncologic patients, but also in patients being evaluated for cardiac and neurologic diseases. Aside from these improvements, a fixed unit will allow for greater flexibility and ease of scheduling examinations which also improves overall care.

In summary, the proposed Fixed PET-CT unit will allow Lawrence & Memorial Hospital to continue to provide quality health care to the patients of Southeastern Connecticut. I hope you will strongly consider approval of the CON application. Thank you in advance for your time and effort.

Sincerely,

Todd Blue MD

Todd Blue, MD
Chairman, Radiology Department

Ocean Radiology Associates, P.C.

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New London, Connecticut 06320
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September 13, 2011

Ms. Jeannette DeJesus
Deputy Commissioner
Department of Public Health
Office of Health Care Access
410 Capitol Avenue, MS#13HCA
P.O. Box 340308
Hartford, CT 06134-0308

Re: Lawrence & Memorial Hospital Replacement of Mobile PET-CT and CT with a Fixed PET-CT Scanner

Dear Deputy Commissioner DeJesus:

I am writing in strong support of Lawrence and Memorial's Certificate of Need application for a fixed site PET CT scanner. The PET CT scanner is intended to replace an older CT scanner previously located at the hospital's Waterford imaging center as well as the mobile PET CT scanner which has precedently served the hospital. The proposed fixed site PET CT scan represents a significant technical upgrade to the previous services, markedly improving quality of care and accessibility. The scanner is intended to serve our hospital's oncology, cardiac and neurology patients through an array of high quality clinical applications with vastly improved sensitivity. Patients will be able to undergo valuable clinical exams in a much more expeditious fashion with PET CT services provided on a daily basis. The proposed scanner employs radiation reduction techniques which allow for both decreased dose and elimination of irrelevant dose. Vastly improving patient comfort by means of shorter imaging time and a larger bore size , the proposed system accommodates concomitant diagnostic and PET CT imaging, allowing for a single comprehensive exam rather than multiple visits and additional radiation dose. Spatial resolution and image contrast will be significantly enhanced allowing for greater diagnostic accuracy. The fixed site will be located at a convenient location with a high ease of access and in close proximity to the hospital's forthcoming oncology center. Furthermore, continued development of molecular imaging techniques will allow for state of the art patient care for the southeastern Connecticut region and the easy upgrade-ability of the proposed scanner will obviate any short term obsolescence.

I strongly support Lawrence and Memorial's CON application to replace the current mobile PET CT and CT scanner with a fixed unit and urge you to approve the CON application.

Sincerely,

Louis Mazzarelli, MD

Ocean Radiology Associates, P.C.

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Phone: (860) 444-5151
Fax: (860) 444-6851

Ms. Jeannette DeJesus
Deputy Commissioner
Department of Public Health
Office of Health Care Access
410 Capitol Avenue, MS#13HCA
PO Box 340308
Hartford, CT 06134-0308

September 26, 2011

RE: Lawrence and Memorial Hospital Replacement of Mobile PET/CT and CT with single Fixed PET/CT

Dear Deputy Commissioner DeJesus:

This letter is in reference to the pending application for Lawrence and Memorial Hospital's Certificate of Need to replace two existing scanners (mobile PET/CT and fixed CT) with a single fixed PET/CT scanner. The proposed replacement scanner would allow for lower radiation doses, combination of contrast enhanced scanning with PET and increase diagnostic accuracy over the current equipment. The fixed scanner would also provide improved patient access as the mobile scanner is only available for use twice a week which has proved to be a significant impediment for patient care. This would significantly elevate delivery of patient care to this region. While the application of PET/CT for oncologic imaging is widely known the improvement in applications for both cardiac imaging and neurologic imaging are quickly growing and we hope to provide our community with such tools as well.

Thank you for your time and consideration in this matter.

Sincerely,

Arun Basu, MD

Oncology & Hematology Associates

Jason R. Haldas, M.D.
Richard M. Hellman, M.D.
Vanessa M.P. Johnson, M.D., M.P.H.
Benjamin R. Newton, M.D.
Board Certified in Medical Oncology & Hematology
Luanne C. Hespeler, M.P.A.S., PA-C.

September 12, 2011

Ms. Jeannette DeJesus, Deputy Commissioner
Department of Public Health, Office of Health Care Access
410 Capitol Avenue MS #13 HCA
P.O. Box 340308
Hartford, CT 06134-0308

RE: Lawrence & Memorial Hospital replacement of mobile PET-CT and CT with a fixed PET-CT scanner.

Dear Deputy Commissioner DeJesus:

I am writing this letter in support of Lawrence & Memorial Hospital's certificate of need (CON) application to replace two items of imaging equipment - a mobile PET-CT and an older CT scan with one fixed PET-CT scan.

The proposed PET-CT scanner will be located in Waterford, Connecticut at Lawrence & Memorial Hospital's Imaging Center which is a comprehensive imaging center, which is easily accessible and convenient for my patients. In fact many of my patients currently receive other imaging studies at the Waterford location.

CT and PET-CT scanning are both critical in diagnostic and staging modalities for my cancer practice and I use both frequently. The current mobile PET-CT is only available two days per week which is limiting my patient's access and can delay obtaining important diagnostic information. The proposed PET-CT will offer services five days a week as well as superior technology as well as lower doses of radiation. I believe these are significant benefits to my patients.

I strongly support Lawrence & Memorial Hospital CON application to replace the mobile PET-CT and CT scanner with a fixed PET-CT scanner. I urge you to approve this CON application.

Please do not hesitate to contact me if any additional information is needed.

Sincerely,

Richard Hellman

Richard M. Hellman, M.D.

Roshanak Bagheri, MD, FACC
Lawrence & Memorial Cardiology
492 Montauk Ave
New London, Connecticut 06320
(860)443-0282

September 16, 2011

Ms. Jeannette DeJesus
Deputy Commissioner
Department of Public Health
Office of Health Care Access
410 Capitol Avenue, MS#13HCA
P.O. Box 340308
Hartford, CT 06134-0308

Re: Lawrence & Memorial Hospital Replacement of Mobile PET-CT and CT with a Fixed PET-CT Scanner

Dear Deputy Commissioner DeJesus:

I am writing this letter in support of Lawrence and Memorial Hospital's Certificate of Need ("CON") application to replace two pieces of imaging equipment, a mobile PET-CT and an older CT scanner, with one fixed PET-CT scanner. The proposed PET-CT scanner will be located at Lawrence and Memorial Hospital's Waterford imaging center, a comprehensive imaging center that is easily accessible and convenient for my patients.

PET-CT can provide tremendous information in terms of diagnosis and treatment of cardiology patients. Currently it is used for obstructive coronary artery disease and cardiomyopathies causing heart failure. In Lawrence and Memorial Hospital we are using SPECT studies for detection of significant coronary artery disease. Very frequently and especially in overweight patients the images could be suboptimal and result in further unnecessary testing or treatment. With PET-CT we could reduce the number of testing and unnecessary treatments.

I strongly support Lawrence and Memorial Hospital's CON application to replace a mobile PET-CT and a CT scanner with a fixed PET-CT scanner. I urge you to approve this CON application.
Thank you for your time and attention.

Sincerely,

R Bagheri

Roshanak Bagheri, MD, FACC

Jon C. Gaudio MD, FACC
Lawrence & Memorial Cardiology
492 Montauk Ave
New London, Connecticut 06320
(860)443-0282

Ms. Jeannette DeJesus
Deputy Commissioner
Department of Public Health
Office of Health Care Access
410 Capitol Avenue, MS#13HCA
P.O. Box 340308
Hartford, Ct 06314-0308

Re: Lawrence & Memorial Hospital Replacement of Mobile PET-CT and Ct with a fixed PET-CT Scanner

Dear Deputy Commissioner DeJesus:

I write to give my wholehearted support of Lawrence and Memorial Hospital's Certificate of Need ("CON") application for one fixed PET-CT scanner which will replace two antiquated pieces of imaging equipment, a mobile PET-CT and an older CT scanner. The proposed PET-CT scanner will be located at Lawrence and Memorial Hospital's Waterford imaging center, a comprehensive imaging center that is easily accessible and convenient for my patients and one where my patients already receive other imaging studies at the Waterford location. The daily availability of PET-CT will be a tremendous benefit to my patients who require cardiac studies.

PET-CT provides significant benefits to my patients by aiding the diagnosis and localization of coronary artery disease and to help determine if a patient requires revascularization or can be treated with less aggressive therapy. It is particularly beneficial for obese patients with a high BMI-something of increasing value given the prevalence of obesity in the patients I treat. Additionally it can assess the effectiveness of revascularization attempts.

Since 30% of the US population is considered overweight or obese, I would estimate that the number of PET-CT tests we would order would be approximately 20% of the current number of nuclear stress tests we order. This is obviously a very conservative number.

In summary, I urge you to approve Lawrence and Memorial Hospital's CON application to replace a mobile PET-CT and a CT scanner with a fixed PET-CT scanner.

Anticipatory thanks for your consideration.

Sincerely,

Jon C. Gaudio, M.D., F.A.C.C

September 26, 2011

Ms. Jeannette DeJesus
Deputy Commissioner
Department of Public Health
Office of Health Care Access
410 Capitol Avenue, MS#13HCA
P.O. Box 340308
Hartford, CT 06134-0308

Re: Lawrence & Memorial Hospital Replacement of Mobile PET-CT and CT with a Fixed PET-CT Scanner

Dear Deputy Commissioner DeJesus:

I am writing this letter in support of Lawrence and Memorial Hospital's Certificate of Need ("CON") application to replace two pieces of imaging equipment, a mobile PET-CT and an older CT scanner, with one fixed PET-CT scanner.

The proposed PET-CT scanner will be located at Lawrence and Memorial Hospital's imaging center at the Crossroads Professional Building in Waterford. As oncologists practicing in the Crossroads Professional Building, we can attest to the importance of PET-CT scanning in the management of patients with cancer. The availability of a state-of-the-art PET-CT scanner in our building will be of great benefit to cancer patients in our practice and in the entire community.

CT and PET-CT scanning are both important diagnostic and staging modalities for our oncology practice and are used routinely. The current mobile PET-CT is available only two days per week, which is limiting to our patients and can delay obtaining important diagnostic information. The proposed PET-CT scanner will offer services five days per week. In addition, the new scanner offers higher-quality images with lower doses of radiation, providing significant benefits to patients. For patients who require both a PET/CT and a diagnostic CT scan, the new scanner allows for both studies to be done in the same sitting, resulting in lower radiation doses and more accurate comparisons between studies.

We strongly support Lawrence and Memorial Hospital's CON application to replace a mobile PET-CT and a CT scanner with a fixed PET-CT scanner, and we urge you to approve this CON application. Thank you very much for your consideration.

Sincerely,

Mithlesh Govil, M.D., M.S.

Stephen C. Lattanzi, M.D.

Youval Katz, M.D., M.S.

GOLD COAST PULMONARY & SLEEP ASSOCIATES, LLC
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www.goldcoastpsa.com

053

September 26, 2011

Dear Deputy Commissoner DeJesus:

I am writing in strong support of Lawrence and Memorial's Certificate of Need application for a fixed site PET-CT scanner. The PET CT scanner is intended to replace an older CT scanner previously located at the hospital's Waterford imaging center as well as the mobile PET CT scanner which has precedently served the hospital. The proposed fixed site PET CT scan represents a significant technical upgrade to the previous services, markedly improving quality of care and accessibility. The scanner is intended to serve our hospital's oncology, cardiac and neurology patients through an array of high quality clinical applications with vastly improved sensitivity. As a Pulmonologist, the PET CT is an important part of a cancer work up. In the current situation patients are limited with available appointments often delaying their diagnosis or further work up. The proposed scanner employs radiation reduction techniques which allow for both decreased dose and elimination of irrelevant dose. Vastly improving patient comfort by means of shorter imaging time and a larger bore size, the proposed system accommodates concomitant diagnostic and PET CT imaging, allowing for a single comprehensive exam rather than multiple visits and additional radiation dose. Spatial resolution and image contrast will be significantly enhanced allowing for greater diagnostic accuracy. The fixed site will be located at a convenient location with a high ease of access and in close proximity to the hospital's forthcoming oncology center. Furthermore, continued development of molecular imaging techniques will allow for state of the art patient care for the southeastern Connecticut region and the easy upgrade-ability of the proposed scanner will obviate any short term obsolescence.

I strongly support Lawrence and Memorial's CON application to replace the current mobile PET CT and CT scanner with a fixed unit and urge you to approve the CON application.

Thanks you for your time.

Paul J. Licata, D.O.

Attachment B

CT and Radiation: What Radiologists Should Know

CT and radiation: What radiologists should know

Courtney A. Coursey, MD, and Donald P. Frush, MD

It is estimated that >60 million computed tomography (CT) examinations were performed in the United States in 2005.[1] With a current U.S. population of just >300 million, this equates to 1 CT per year for 20% of the U.S. population, or, over the course of 5 years (with stable population numbers) 1 CT for every U.S. citizen. As faster CT scanners with increasing numbers of detector arrays are developed and dual energy/dual source technologies are increasingly available (along with the new CT protocols that are necessary), we are constantly challenged to find methods for CT dose reduction (such as tube current modulation). In addition, the use of CT may outpace science, which shows that the technology actually has a cost-effective benefit. In short, there is increasing pressure to depend on CT for diagnosis and a lack of guidance for how to best perform this examination.

Therefore, the fundamental goal of this article is to help radiologists make thoughtful decisions about radiation dose—ie, the quantity of radiation delivered to a patient with a given CT examination—just as a primary care physician would think about the dose of antibiotic prescribed or as a radiologist would think about the dose of intravenous contrast delivered.[2] This understanding of dose then can serve as a guide when deciding about ranges of acceptable image quality.

Dr. Coursey is a Radiology Resident, and Dr. Frush is a Professor of Radiology and Pediatrics and the Director of the Division of Pediatric Radiology, Department of Radiology, Duke University Medical Center, Durham, NC.

To this end, this article reviews scanner-based CT radiation dose estimations and why CT radiation dose is generally of more concern than dose delivered by other diagnostic imaging modalities, presents a summary of the cancer risk of radiation doses delivered by CT, outlines parameters contributing to CT radiation dose, and describes techniques for reducing CT radiation dose. While the material applies to young adults, these objectives will be illustrated primarily through pediatric CT. Furthermore, most of the discussion will focus on illustrations of multidetector CT (MDCT), although many principles will apply to all clinical CT technology.

Scanner-based CT radiation dose estimation

Two related measures of CT radiation dose are available on CT consoles: the CT dose index (CTDI) and the dose length product (DLP)[3,4] (Figure 1). The CTDI represents the radiation dose of a single CT slice and is determined using acrylic phantoms.[3] These acrylic phantoms are cylinders of a standard length and are generally in diameters of 16 cm and 32 cm.

As defined by the Food and Drug Administration (FDA) in 1984, the original incarnation of the CTDI was based on an axial CT scanner.[4] This original defintion of CTDI represented the dose from the primary beam plus scatter from surrounding slices. Several variations of the CTDI have since been defined. For example, the $CTDI_{100}$ reflects the dose contribution from a 100-mm range centered on the index slice. The weighted CTDI ($CTDI_w$) reflects the weighted sum of two thirds peripheral dose and one third central dose in a 100-mm range in acrylic phantoms. The volume CTDI ($CTDI_{vol}$), defined as $CTDI_w$ divided by the beam pitch factor, is the most commonly cited index for modern MDCT equipment.[4]

The dose length product (DLP) is the $CTDI_{vol}$ multiplied by the scan length (slice thickness × number of slices) in centimeters. It should be noted that the DLP is independent of what is actually scanned. In other words, the reported DLP is the same whether a 10-lb infant or a 100-lb teenager is scanned if the scan length and other scan parameters are the same. Conversion factors can be used to estimate what the effective dose equivalent would be. However, these conversion factors are problematic in that they are only estimates of dose and do not represent the full range of pediatric sizes.

In order to determine a more accurate effective dose equivalent, individual organ doses would have to be determined, which would be impossible during clinical MDCT. The effective dose equivalent is the sum of the product of organ doses (in mGy or cGy, the magnitude of CT organ doses) multiplied by a corresponding weighting factor.[5] The effective dose equivalent, therefore, represents a total body dose. For regional exposures, the effective dose equivalent is the equivalent dose to the whole body, for example, approximately 2.0 to 3.0 mSv for a head CT. In conclusion, the DLP

Exam Description: CT BRAIN

Dose Report

Series	Type	Scan Range (mm)	CTDIvol (mGy)	DLP (mGy-cm)	Phantom cm
1	Scout	-	-	-	-
2	Axial	131.000-S106.525	13.57	193.46	Head 16
			Total Exam DLP:	193.46	

FIGURE 1. This dose report was generated by a LightSpeed 64-slice CT scanner (GE Healthcare, Waukesha, WI) during the performance of a routine noncontrast brain CT scan in a 4-month-old child. Note the volume CT dose index ($CTDI_{vol}$)(arrow) and dose length product (DLP) (asterisk). Scan parameters: mAs 150, kVp 120, rotation time 0.6 sec. Effective dose in mSv = DLP × conversion factor: 193.46 mGy-cm × 0.02185 mSv/mGy-cm-1 (conversion factor) = 4.23 mSv. (Conversion factor courtesy T. Yoshizumi, Duke Medical Center, modified from Shrimpton http:// www.drs.dk/guidelines/ct/quality/Page032.htm.)

method for estimating dose is problematic and offers only an approximation. However, this method is of value from the standpoint of ease of use and as a gauge for dose in one's practice.

Why is CT radiation dose potentially so high?

There are several reasons why CT radiation dose is potentially high: 1) there is no dose penalty for relatively high radiation dose examinations; 2) CT doses are intrinsically high radiation dose examinations; 3) there are "hidden" dose penalties that occur with CT; and (4) there is no binding regulation for CT practice.

There is no compromise in image quality for relatively high-dose CT examinations. Compare this to the setting of film screen radiography (and even, to some extent, digital radiography), in which an overexposed film (and therefore an "overdosed" patient) is relatively straightforward to identify—the film is too black. However, with CT technology, patients can receive extremely high doses of radiation without a dramatic change in image quality that would signal to the radiologist that the patient has been overexposed or "overdosed." However, in most cases, this information is available to the radiologist in the form of image annotations (eg, tube current) and information provided on the CT console (eg, the DLP) (Figure 1).

CT radiation doses can be quite high. While doses, especially in pediatric CT, can be <1.0 mSv, doses can be >30 mSv as well (unpublished data, CL Hollingsworth, MD, Durham, NC; Radiological Society of North America 2004). The effective dose of a chest CT (eg, 5 mSv) is nearly 100 times the effective dose from a frontal and lateral chest radiographic series (0.06 mSv) in an adult.[6] When settings are not adjusted for size, CT doses are higher in small children. For example, the effective dose of a chest CT in an infant can be 2 to 3 times the effective dose of a chest CT in an adult if the settings are not adjusted for size.[7] The potential doses delivered by newer CT technologies can be quite high. For example, using a 5-year-old anthropomorphic phantom on a 64-slice CT scanner and maximizing settings to deliver the highest dose possible, we were able to perform an abdomen and pelvis CT examination that resulted in a dose of slightly less than 120 mSv (unpublished data; Donald P. Frush, MD, Duke University Medical Center, Durham, NC). This dose is beyond the range of low-level radiation dose and is at or approaching medium-level exposure, at which there is a clear connection with cancer risk.

In the United States, the data regarding the overall contribution of CT to radiation exposure are compelling. Traditionally, it has been thought that approximately 80% of all radiation exposure comes from background sources and 15% is from medical radiation, with up to 67% due to CT (or roughly 10% of the total radiation dose). However, the contribution from CT to the total radiation dose to the U.S. population has probably been underestimated. Given a background radiation dose of approximately 3.0 mSv per year, if 10% is due to CT, it should contribute roughly 0.375 mSv per person per year. However, we can also approach this from the standpoint of CT examinations performed currently. Assuming that there are 60 million CT examinations performed annually in the United States with a population of approximately 300 million people, 1 CT is performed for every 5 individuals. If we assume that a single CT, irrespective of the region scanned, delivers 6.0 mSv (head and chest CT may be <5.0 mSv, whereas abdomen scanning is often >8.0 mSv), then 1 in 5 individuals (20% of the population) will receive twice the annual background dose of 3.0 mSv in a single CT examination. Spreading this out, 100% of the population, on average, will receive an additional 40% of background dose per year, or an additional 1.2 mSv. Contrast this to the previous estimate of 0.375 mSv, and the amount actually received from CT alone is larger by a factor of 3.2; and the relative contributions to exposure are 66% as a result of background and 26% as a result of CT alone. At the April 2006 National Council on Radiation Protection and Measurement Annual Meeting in Washington, D.C., preliminary data suggested that the contribution of CT to total radiation dose exposure could be approximately 50%.[8]

"Hidden doses" of radiation also add to the dose delivered by CT. For example, each time an additional phase is performed, it results in an additional dose. In addition, as the effective beam becomes larger (eg, currently 40 mm for some scanners), there is some dose that is not accounted for in image formation since some gantry rotation must be completed before there are sufficient data to begin

image formation. For a small range scanned (eg, a child), this can result in a higher dose than displayed.[9] Moreover, the CTDI and DLP do not account for newer scan technologies with larger effective beam widths.[10,11] Basically, the scatter radiation now extends well beyond the measurement range and is therefore not accounted for in calculations of the CTDI and DLP. In support of this, we found an underestimation using the DLP method of effective dose by as much as 35% in certain body MDCT protocols in the adult female.[12]

Despite the potentially high radiation doses CT can deliver, there is no regulation of CT practice in the United States. Regulation is up to the individual practitioner. While the American College of Radiology has a CT accreditation program, which includes upper limits of doses for CT, participation in this accreditation is voluntary at this point in time. This is in contrast to other countries and regions. In the United Kingdom, medical exposure ionizing radiation regulations were initiated in 2000.[13] As part of this regulation, it is the responsibility of radiologists to perform only those examinations that are thought to be justified, and radiologists are granted the authority to refuse any studies that are not appropriate.[14]

Cancer: The bioeffect of concern with CT

Two points about cancer risk and low-level radiation dose, such as that from CT, are worth mentioning. First, whether or not radiation doses at levels delivered by CT produce cancer remains a controversial topic. Second, radiation dose is a greater concern in children.

Regarding the first point, there is strong support for a linear, nonthreshold model of radiation dose in which any radiation dose is thought to increase one's risk of developing cancer.[15] On the other hand, others argue that low doses of radiation (including the levels delivered by CT) are harmless or may actually be therapeutic (eg, stimulate the immune system). This is the concept of hormesis through stimulation of the immune system.[16]

While most of the emphasis on the potential radiation dose dangers is in the pediatric population, the issue applies to adults as well. In one example in support of cancer risk and CT, Brenner et al[17] looked at screening CT in adults using a linear model based on atomic bomb survivor data in the specific scenario of a 45-year-old man who undergoes a screening chest, abdomen, and pelvis CT every year for 30 years and computed an estimated lifetime attributable cancer mortality risk of approximately 0.08% for a single examination and of about 1.9% for 30 examinations; radiation-induced lung cancer was the dominant cause of cancer mortality.[17]

Breast radiation dose is also worth mentioning, given the association between breast radiation dose and breast cancer. It has been estimated that a dose of 0.01 Gy (1.0 cGy) to the breast of a woman <35 years of age increases her risk of breast cancer by approximately 14% over the expected spontaneous rate for the general population.[18] A recent investigation by Hurwitz et al[19] reported breast doses of 4 to 6 cGy for a standard pulmonary embolism protocol CT (140 kVp, 380 mA, 0.8-sec rotation, 16 × 1.25 collimation), 1 to 2 cGy for a standard appendicitis protocol CT (140 kVp, 340 mA, 0.5-sec rotation, 16 × 0.625 collimation), and 150 μGy for a standard renal calculus protocol CT (140 kVp, 160 mA, 0.5-sec rotation, 16 × 0.625 collimation) using metal oxide semiconductor field effect transistor (MOSFET) detector technology and a female-configured anthropomorphic phantom.[19] As the use of chest CT is increasing (including evaluation for pulmonary embolism and cardiac evaluation or screening) and the use of CT increases in younger populations, these radiation doses will need to be carefully considered as a factor in the complex risk-benefit balance.

The second point is that CT dose and potential risk is of special importance in pediatric patients because of their much larger increase in lifetime risk per unit radiation dose, greater sensitivity of organs and tissues, and relatively greater dose deposition compared with adults from similar CT settings.[20-23] For example, Brenner et al[24] estimated a lifetime cancer mortality risk attributable to a single CT (with relatively high dose) of 0.18% for an abdomen pelvis CT and 0.07% for a head CT protocol performed in a 1-year-old child.

Table 1. CT parameters and effect on CT radiation dose

Variable	Relationship to dose*
Tube current	Direct, linear
Gantry cycle time	Direct, linear
Kilovoltage	Direct, nonlinear
Pitch	Indirect, linear

*Relationship to dose when other variables are held constant.

Parameters contributing to CT radiation dose

The principal selectable parameters that contribute to radiation dose are tube current (mA), peak kilovoltage (kVp), pitch, and gantry cycle time (in seconds) (Table 1). The relationship between tube current and radiation dose is linear. Decreasing tube current by 50% will essentially decrease radiation dose by 50%.[25] In contrast to the relationship between tube current and dose, the relationship between kilovoltage and dose is nonlinear.[26] For example, when all other parameters were held constant with a single-slice CT scanner, when kVp was increased from 120 to 140 (a 17% increase), the $CTDI_w$ increased by 37.5% for a head phantom and 39% for a body phantom.[26]

Pitch (defined as table distance traveled in one 360° rotation/total collimated width of the X-ray beam) is inversely proportional to patient dose. Larger pitches lower the radiation dose. The relationship between pitch and radiation dose is linear. Specifically, increasing the pitch from 1.0 to 1.5 will reduce the patient dose by 33%.[5] Most body CT scanning, especially in children, is performed at pitches between approximately 1.0 to 1.5.

Decreasing gantry rotation time decreases radiation dose in a linear fashion.[27]

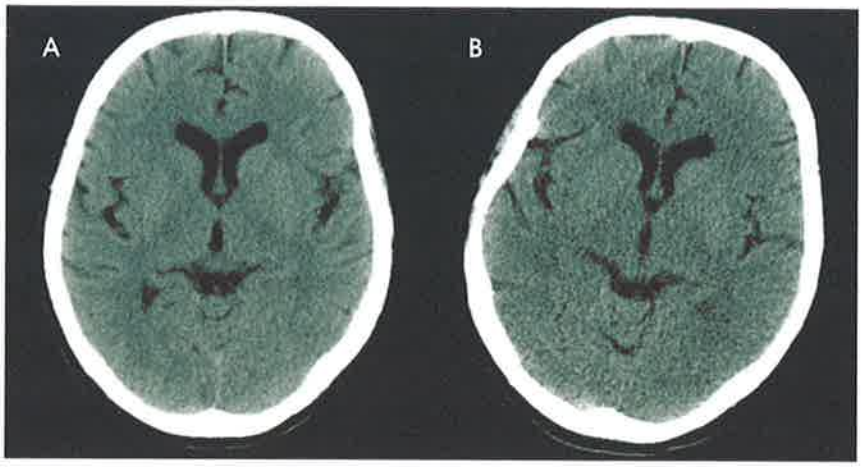

FIGURE 2. The image noise increases when the tube current decreases. (A) The initial adult CT examination was obtained with kVp 140, mA 280, slice thickness 5 mm, rotation time 1 sec. (B) Thirteen days later, the patient returned for a repeat scan on the same CT scanner. This scan was acquired using a tube current of 140 mA (all other scan parameters constant). Note the increased noise in this image. (Window 80, level 40 in both images.)

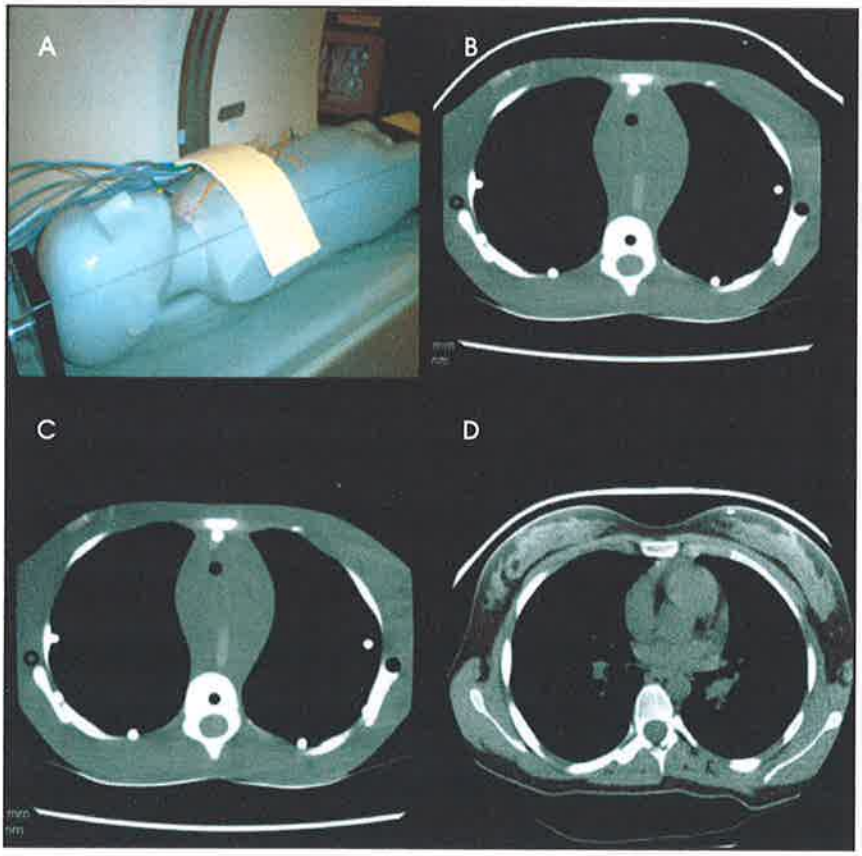

FIGURE 3. A bismuth breast shield in use. (A) A 2-ply bismuth breast shield (arrow) (F&L Medical Products, Vandergrift, PA) in place on a 5-year-old anthropomorphic phantom (CIRS Inc., Norfolk, VA). (B) A CT image of a phantom with the same shield (arrow). 120 kVp, 65 mAs, 1.375 pitch, 16 x 1.25 effective collimation, 0.5-sec rotation time, average image noise 9.7 SD HU for entire scan. (C) A CT image of the phantom without the shield (using the same CT parameters). Average image noise 8.7 SD HU for entire scan. (D) A breast shield (arrow) in clinical use with a 16-year-old patient (120 kVp, 90 mA, 1.375 pitch, 16 x 1.25 effective collimation, 0.5-sec rotation time).

The faster the gantry rotation, the lower the dose. Increasing the cycle speed of rotation from 1.0 to 0.5 seconds per 360° rotation reduces the dose essentially by 50%. Of course, when these variables are adjusted to decrease dose, the trade-off is an increase in image noise. The increase in noise that resulted when tube current was decreased from 280 to 140 mA is illustrated in Figure 2.

Techniques for decreasing radiation dose

Most efforts at reducing dose through selectable parameters are focused on tube current (including using tube current modulation) and kVp. Additional strategies include minimizing multiphase scanning, limiting the range of coverage, and using in-plane shielding. As always, optional imaging modalities that do not expose the individual to radiation or provide additional substantive risks, such as magnetic resonance imaging or sonography, should be considered.

Extensive work has been done, primarily in the pediatric population, to develop CT protocols that are based on the patient's size. For example, pediatric guidelines have been published that discuss size-based, lower-dose scanning for specific applications.[2,28-31] There are also investigations that support the use of relatively lower tube currents for pediatric CT of the brain,[32-34] sinuses,[35,36] tracheobronchial tree,[37] chest,[38-40] pelvis,[41] skeletal system,[42] and colon (colonography).[43] Rogalla et al[39] concluded that age-adjusted tube currents from 25 to 75 mA (using a 1-second gantry rotation time) were of diagnostic quality.

In a study of CT examinations submitted for review at a tertiary care center in the southeastern United States, Paterson et al[44] reported that many referring physicians were not adjusting scan parameters for pediatric patients. Prompted by increased awareness of the detrimental effects of radiation on pediatric patients and information that CT parameters were not being adjusted for pediatric patients, in 2002 the FDA issued a Public Health Notification entitled "Reducing radiation risk from computed

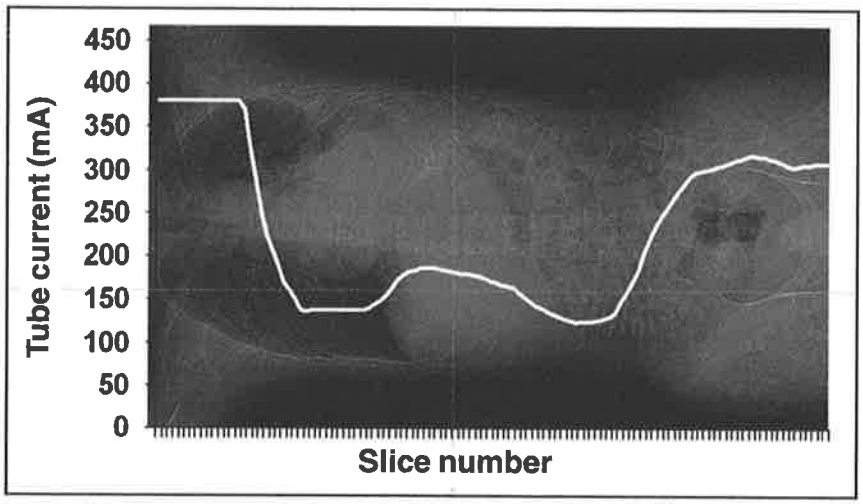

FIGURE 4. Tube currents delivered with automatic tube current modulation in an older teenager using a 16-slice CT scanner (LightSpeed CT scanner, GE Healthcare, Waukesha, WI), which modulates tube current along the z-axis (kVp 140, pitch 1.375:1, slice thickness 5 mm). Note the relatively higher tube currents through the shoulders and pelvis and the lower tube currents through the midthorax and lower abdomen.

tomography for pediatric and small adult patients," which encouraged optimizing CT settings (reducing tube current, increasing pitch, and developing a chart of tube current settings based on patient size and anatomical region of interest), reducing the number of multiple scans with contrast material (for example, eliminating unnecessary precontrast scans), and eliminating inappropriate referrals for CT when other modalities, such as ultrasound or MRI, could be performed instead of CT.[45]

Recent data suggests that practice patterns are, in fact, changing. In April 2007, data was presented at the Society for Pediatric Radiology annual meeting that represented a 5-year–interval survey of pediatric body MDCT use by the membership. Approximately 40% of respondents indicated using a kVp of <110 in 2006 versus <5% in 2001 (P <0.0001). In addition, the mean mA for CT in the 0-to-4-year age group decreased from >120 mA to approximately 70 mA in abdomen CT and from approximately 110 mA to 50 mA in chest CT. Both of these changes in MDCT mA practice are also statistically significant.

Whenever possible, multiphase scanning should be eliminated. When settings are not adjusted, each study will result in a dose that is a multiple of the number of phases performed. In our practice, multiphase scanning is not part of our routine protocols, should be performed on a case-by-case basis, and should account for up to only roughly 5% of pediatric body CT protocols.

Other techniques for dose reduction include bismuth shielding and automatic tube current modulation (ATCM). Bismuth shielding has been shown to reduce radiation dose while still producing diagnostic quality images (Figure 3). Bismuth breast shields have been shown to reduce breast dose by 26.9% to 52.4% in the adult population depending on the thickness of the shield.[46] Similarly, bismuth breast shields have been shown to reduce breast dose by 29% in pediatric patients.[47] Bismuth shielding has also been shown to reduce direct radiation dose to the orbits by 34%.[48] At our institution, bismuth breast shields are generally used when scanning women <50 years of age when breast tissue is included in the range of scanning and in select cases in pediatric scanning. Our experience is that 2-ply shields can be used in girls who have not yet undergone breast development, after which 4-ply shielding is more appropriate. Pediatric breast shields are now available.[49]

Automatic tube current modulation also can be used to decrease radiation dose. The 3 primary means of ATCM include angular (x- and y-axis), longitudinal (z-axis), and combined (x-, y-, and z-axis) modulation. With angular modulation, relatively higher tube currents are delivered through the thicker region of an ellipse (eg, mediolateral abdomen) as compared with the thinner dimension (eg, anteroposterior abdomen). With z-axis modulation, tube current is altered along the craniocaudal dimension of the patient delivering lower tube currents through less attenuating structures (eg, the lungs) and relatively higher tube currents through more attenuating structures (eg, the shoulders). The technical basis that determines the modulation varies by manufacturer and was recently summarized by McCollough et al.[50] Figure 4 illustrates the use of one manufacturer's tube current modulation technique (Auto mA and GE LightSpeed 16-slice CT, GE Healthcare, Waukesha, WI); the modulation along the z-axis is based on the density of tissues seen on the topogram (scout image). As seen in Figure 4, relatively higher tube currents are delivered through the shoulders (peak 381 mA) and pelvis (peak 318 mA). Relatively lower tube currents are delivered through the lungs (nadir 137 mA) and lower abdomen (nadir 125 mA). For this type of modulation, the technologist selects a noise target. Tube currents are then modulated (within a selected maximum and minimum range) to maintain the selected noise index.

Dose savings with ATCM can be quite substantial. In the setting of pediatric chest CT, Greess et al[51] found dose reductions of 26% to 43% when ATCM was used (dose decrease depended on the patient's geometry and weight) as compared with standard weight-adapted protocols. In the setting of adult chest CT, z-axis ATCM has been shown to decrease radiation dose by 18% to 26% when the selected noise indices were 10.0 and 12.5 HU, respectively.[52] For adult abdomen pelvis CT, z-axis ATCM has been shown to reduce mean tube

current-time product by 31.9% (range 18.8% to 87.5%) as compared with fixed tube current scanning.[53] Combined ATCM (x-, y-, and z-axis modulation) in the setting of adult abdomen pelvis CT has been shown to decrease dose by 43%.[54]

In our work investigating ATCM with Auto mA and the LightSpeed 16-slice CT scanner and 2-ply bismuth pediatric breast shields (F & L Medical Products, Vandergrift, PA) in the setting of pediatric chest MDCT, the highest dose saving (52%) was achieved when the shield was placed after the scout image was performed.[49] When the shield was present in the scout radiograph, ATCM compensated for the presence of the shield by increasing tube current through the level of the shield, minimizing dose savings through that region. Despite this increase, doses in the scans using ATCM and breast shields were still lower than in scans performed with the standard, age-based protocol.

How are these variables reconciled into practical CT protocols? There are a few simple guidelines that can be followed. Thin adults can be scanned at lower tube currents than heavier adults. This principle applies to pediatric scanning, where a variety of sources provide recommendations for size-based scanning parameters.[2,29-31] Higher contrast regions or organs lend themselves to both lower tube current and lower kVp.[55,56] These regions include lung parenchyma, skeletal system, and some CT angiography. Tube current modulation, when properly applied, is useful for dose reduction and should be used when doses will not be higher than when a nonmodulated examination is performed. This necessitates familiarity with the specific technology used in one's practice. In short, to lower the radiation dose (assuming the CT examination is indicated and the scanning range is properly defined), one should always consider lowering the tube current and the kVp, scanning with a relatively large pitch, and using shielding when appropriate. Finally, educational and regulatory efforts are important venues for balancing radiation dose and image quality. Many of these efforts and additional recommendations were recently outlined in the ACR White Paper on Radiation Dose in Medicine.[57]

Image quality considerations

The goal of dose management should not always be dose reduction. A balance must be struck between dose and image quality. The image quality portion of this balance is much more intangible in nature than the dose side. Basically, image quality has physical, or objective, properties—such as mottle, contrast, or artifacts—and subjective properties. The objective properties related to the parameters discussed above are measurable. Subjective qualities also define the diagnostic yield of a CT scan. These subjective factors often take into account the structure or region being assessed. For example, higher mottle may be tolerated in relatively high contrast areas such as lung parenchyma or the skeletal system. Desired image quality also depends on the nature of the disorder being addressed. Assessment for trauma might lend itself to higher mottle than evaluation of small hepatic metastases. In an investigation of adults with acute abdominal pain reported at the 2007 ARRS Meeting, Udayasankar et al[58] reported that very ("ultra") low-dose CT (120 kVp, 25 to 100 mAs with tube current modulation) resulted in both a sensitivity and negative predictive value of 93%. Ultra-low-dose CT was shown to have a sensitivity of 92.8% with a negative predictive value of 92.6% in adults in the setting of abdominal pain. Image quality also depends on individual preferences, which may be based on experience (ie, training) in addition to institutional, community, national, and medical specialty societal or organizational guidelines.[59]

Conclusion

It has been estimated that 1 CT scan was performed for every 5 Americans in 2005, and this number is expected to continue to increase. While the issue of whether or not radiation doses at levels delivered by CT can cause cancer is debated, the ALARA (As Low As Reasonably Achievable) principle is not. Extensive work in the pediatric radiology community has shown that we do not need to and, in fact, should not be performing CT examinations of infants with the same scan parameters as CT examinations of teenagers. Substantially lower tube current settings, and lower kVp, for example, can be used in smaller patients and still yield diagnostic quality images with dose savings. Likewise, in adult radiology, we do not need to image a small adult with the same scan parameters we use for a large or obese adult to obtain diagnostic quality images. However, work in the small, medium, and large categories in adult CT has yet to be as pervasive as the size-based scanning in children.

In addition to size/weight-based protocols, automatic tube current modulation and bismuth breast shields have each been shown to decrease radiation dose. Because there are no federal regulations as of yet in the United States regarding CT imaging and radiation dose, it is up to individual radiologists and radiology departments to control the radiation dose that patients receive. As radiologists, we have the responsibility to properly "dose" our patients. Ignoring this responsibility is, in the authors' estimation, medical error.

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Products used

- Isovue 300 (Bracco Diagnostics, Princeton, NJ)
- VCT and LightSpeed 16-slice CT (GE Healthcare, Waukesha, WI)
- Definition (dual source) (Siemens Medical Solutions, Malvern, PA)
- 5-year-old anthropomorphic phantom (CIRS Inc., Norfolk, VA)
- 2-ply bismuth pediatric breast shields (F&L Medical Products, Vandergrift, PA)

Attachment C

Care kV: Automated Dose Optimization Selection of X-Ray Tube Voltage

063

CARE kV

Automated Dose-Optimized Selection of X-ray Tube Voltage

White Paper

Katharine Grant, PhD, and Bernhard Schmidt, PhD

www.usa.siemens.com/healthcare

SIEMENS

Conventional dose modulation approaches, such as CARE Dose4D™, modulate only the X-ray tube current (mAs), while the X-ray tube voltage (the kV setting) is left unchanged. However, there exists a large potential for dose reduction in optimizing the X-ray tube kV setting.[1-7]

For example, in a study conducted by Siegel et al (2004), reducing the tube voltage from 140 kV to 80 kV resulted in a 78% decrease in radiation dose to pediatric patients. In another study on cardiac patients, PROTECTION 1[8], the use of 100 kV tube voltage was associated with a 53% reduction in radiation dose compared to conventional 120 kV scan protocols. In a busy environment, the technologists and reading physicians often have insufficient time to assess the attenuation of each patient.

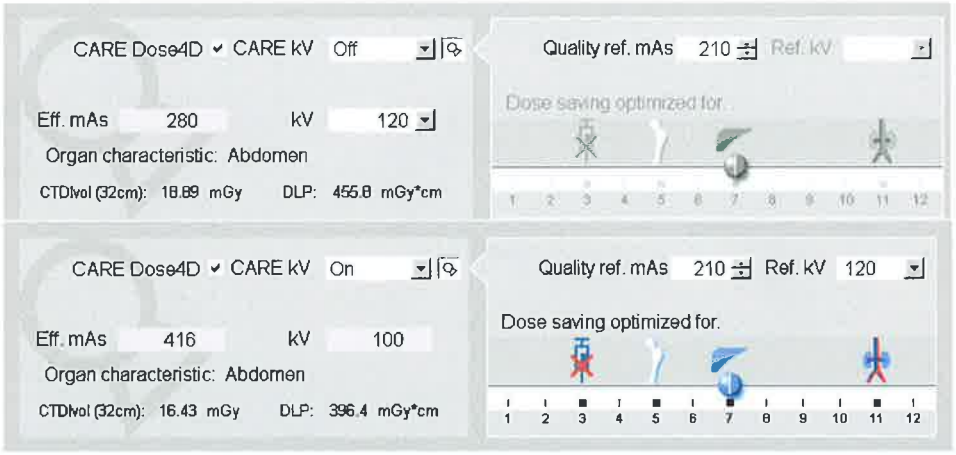


Figure 1.
Example image of the CARE kV user interface. The top panel illustrates the CARE kV tool in the "Off" position; no automatic dose optimization will occur and the user-provided Quality Reference mAs and Reference kV will be used for the exam. In addition, CARE Dose4D will operate as usual. With the CARE kV tool turned "On", the Quality Reference mAs and Reference kV of the specific exam are used to determine and maintain image quality for each exam, in conjunction with the CARE kV slider, which is used to indicate the type of exam being performed, allowing the tool to optimize dose for each specific exam. The optimal kV and mAs settings are now shown on the left panel and will be implemented in the scan. There also exists a "Semi" mode, in addition to off and on, which allows the user to force a specific kV but still allows for some dose optimization.

In addition, determining the optimal scan settings for individual patients is time-consuming and challenging given the interrelationship among kV, mAs, dose, contrast, and noise. Given these barriers, it is not surprising that in routine scanning tube voltage (kV) is rarely optimized to the patient and the indication. To utilize this significant unused possibility in aiding dose reduction, Siemens has developed a tool, CARE kV, that automatically recommends the optimal kV setting for each individual patient for each specific exam. CARE kV uses information gathered by the topogram and provided by the user in the slider bar, to optimize kV and mAs so that a user-chosen contrast-to-noise ratio is maintained, and thus optimal image quality and lowest dose are achieved.

The main goal behind CARE kV is to keep the contrast-to-noise ratio, the key parameter for image quality, the same. For each patient exam, the topogram and the corresponding attenuation information is used to determine the optimal kV to achieve the optimal dose efficiency for the entire length of the scan. In other words, patient-specific mAs curves are calculated for all kV levels (Figure 2) based on the given scan range, patient anatomy, and user-selected contrast behavior (identification of scan type or tissue of interest) necessary to deliver the desired image quality. The estimated dose is then calculated based on these kV-specific mAs curves for all of the kV levels to determine the optimal dose efficiency (Figure 2). Once the

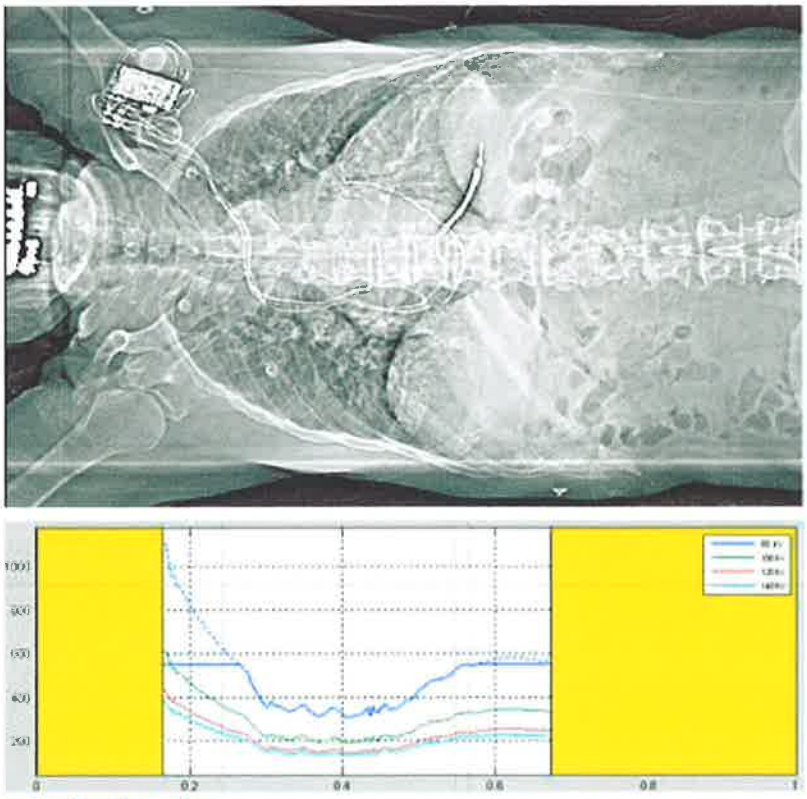


Figure 2.
The contents of this figure illustrate how kV-specific mA curves are calculated based on the attenuation from a specific patient topogram along the z-axis, given user-provided protocol and contrast information. The yellow opaque areas block out the mA curves outside the user-selected scan range, while the dotted lines of the mA curves indicate those portions of the curve that cannot be achieved due to system limitations (i.e., tube current limits) or due to the duration of the scan. In this exam, 100 kV (as indicated by green line) would be the optimal setting given the user-provided protocol and contrast information. Given slight adjustments to scan range or pitch, for example, a lower dose may be achieved.

optimal settings are determined, the tool checks the system to see if the optimal setting is possible (due to tube current limits, pitch settings, scan range, etc.). If this setting is not possible, the next best kV setting is suggested (Figure 3).

For a given image sharpness (spatial resolution) and slice thickness, the quality of CT images is mainly characterized by two parameters: contrast and noise. Improving either or both of these parameters will render a better image and enable the reading physician to make a more precise diagnosis. For example, if the contrast increases but the noise remains unchanged, the image quality improves.

Often, iodine contrast agent is administered to improve contrast and the visibility of the organ structures in CT images (particularly in CT angiographies). Image contrast increases with lower X-ray tube voltage since low energy X-rays are more strongly absorbed by iodine than by the surrounding tissue. However, in order to maintain low noise levels at low voltages, the tube current usually requires an upward adjustment. Most importantly, for a constant contrast-to-noise ratio in CT angiographic studies, the radiation dose can be significantly reduced by choosing 80 kV or 100 kV tube voltages instead of 120 kV.

kV	mAs	Pitch	CTDI
80	462	1.00	—
100	297	1.00	-20%
120	210	1.00	11.00
140	147	1.00	+5%

Figure 3.
Example table of the parameters considered by CARE kV. In this example exam, 120 kV at 210 mAs with a pitch of 1.0 was the routine protocol, and the user selected a "Liver" contrast setting along the slider bar. The information gathered from the topogram, along with the user-provided contrast information, allowed the optimal kV to be selected for this patient and exam. The kV selection in light blue (100 kV) allows for a 20% dose reduction. The white selection (80 kV) could be achieved under different parameters, such as lower pitch, but at the current settings is not possible.

For larger patients who have higher X-ray attenuation, the output current of the X-ray tube at lower kV settings may not be sufficient to produce the required contrast-to-noise ratios. For these patients, higher X-ray tube voltages will be necessary, despite a resulting reduction in iodine contrast. The benefit to larger patients will be improved image quality without a significant increase in radiation.

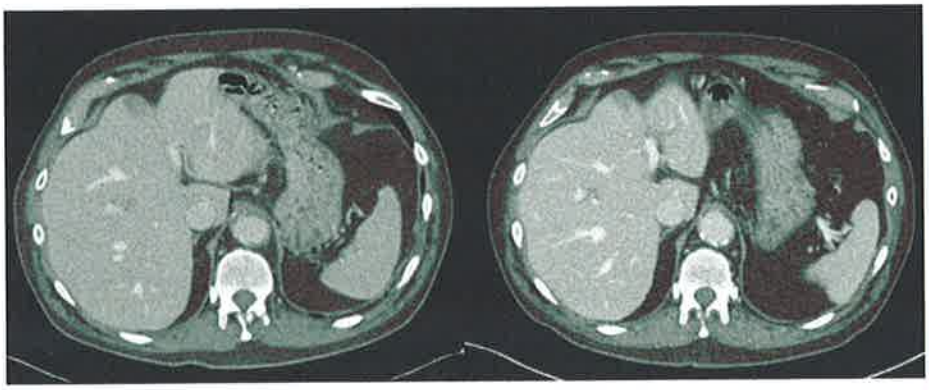


Figure 4.
Images showing dose savings of 14% using CARE kV on a patient with a prior CT exam on the same scanner for comparison. Original image on left (120 kV, eff. mAs 199), ref. mAs 240, CTDI 15.31 mGy. CARE kV on right (100 kV, eff. mAs 324) ref. mAs 337, CTDI 13.33 mGy. Images Copyright 2010, Mayo Foundation for Medical Education and Research.

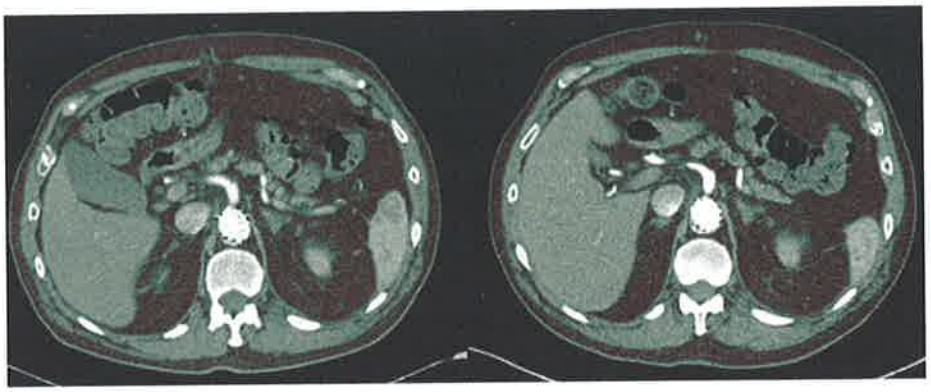


Figure 5.
CTA exam: Images illustrate the improvement in image quality between the original routine exam settings (Left: 120 kV, ref. mAs 250, CTDIvol 18.52 mGy), in comparison to the CARE kV provided exam settings (Right: 100 kV, ref. mAs 337, CTDIvol 14.32 mGy). Images Copyright 2010, Mayo Foundation for Medical Education and Research.

In order to maintain the same noise level at lower kVs, a significant increase in mAs is necessary. However, in high contrast exams, the effective mAs can actually be dropped resulting in a decreased dose. The most obvious results (and most significant dose reductions) are apparent in conducting a CT angiogram since the CT values of iodine-enhanced vessels at 80 kV are approximately two times higher than at 140 kV. Thus, the noise level can be twice as high while still maintaining the original contrast-to-noise ratio, allowing for acquisition at a significantly reduced dose. In non-contrast exams, there is no additional benefit gained from contrast improvement at lower kV. However, the CARE kV tool will still work to optimize the scan settings to the individual patient.

Several clinical sites internationally have tested the CARE kV prototype tool. These sites have already experienced significant dose reductions for a multitude of exams types and patient sizes.

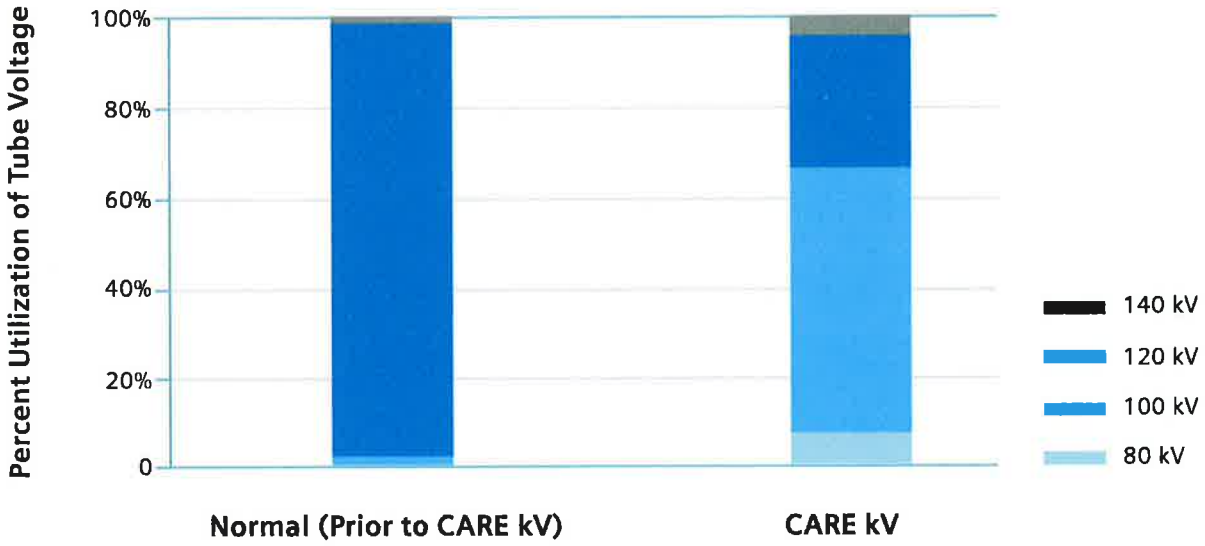
CARE kV is most beneficial in contrast exams such as CT angiograms, CT enterographies, CT urograms, routine abdomen/pelvis imaging, and cardiac and pediatric examinations. In a pilot study conducted by Fletcher et al (RSNA 2010) assessing the potential for dose reduction by adapting the kV, the dose was reduced by approximately 20% on average in patients who underwent either a CT enterography or a CT urogram. In this study of 60 patients, two blinded radiologists compared image quality across similarly sized patients (30 images

The main goal behind CARE kV is to keep the contrast-to-noise ratio, the key parameter for image quality, the same.

with the original protocol and 30 using the kV and mAs settings recommended by CARE kV). Researchers assumed that the original protocol was at the lowest possible dose level prior to using CARE kV. Dose savings were calculated based on the estimated CTDIvol both before and after CARE kV was used to adapt kV and mAs settings. Image noise and quality did not significantly differ between the control and test group.

CARE kV requires that CARE Dose4D be turned on and works simultaneously with the dose modulation provided by CARE Dose4D: the optimized kV is held constant but the mAs is still modulated. This tool can be especially beneficial in optimizing and reducing dose at sites that do not have a dedicated physicist on staff. CARE kV is yet another tool that allows Siemens CT users to improve and individualize patient care.

As found in the graph below, early experience with CARE kV at 6 different customer testing sites shows a remarkable shift away from traditional scanning at 120 kV, which is used for over 97% of scans when CARE kV is not applied. These sites included academic institutions and community hospitals, with a wide range of clinical specialties including cardiac, neuro, vascular, body, pediatric, and ER imaging. All sites experienced a consistent shift toward lower kV and lower doses. In the first three months of CARE kV use, 71% of patients scanned on the scanners equipped with CARE kV were scanned at a setting other than 120 kV, with 67% below 120 kV.



Several clinical sites internationally have tested the CARE kV prototype tool. These sites have already experienced significant dose reductions for a multitude of exam types and patient sizes.

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Attachment D

Strategies for CT Dose Optimization

Special Review

Radiology

Strategies for CT Radiation Dose Optimization[1]

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Review

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[2] **. Multiple body systems

Recent technologic advances have markedly enhanced the clinical applications of computed tomography (CT). While the benefits of CT exceed the harmful effects of radiation exposure in patients, increasing radiation doses to the population have raised a compelling case for reduction of radiation exposure from CT. Strategies for radiation dose reduction are difficult to devise, however, because of a lack of guidelines regarding CT examination and scanning techniques. Various methods and strategies based on individual patient attributes and CT technology have been explored for dose optimization. It is the purpose of this review article to outline basic principles of CT radiation exposure and emphasize the need for CT radiation dose optimization based on modification of scanning parameters and application of recent technologic innovations.

Owing to the ongoing technologic boom during the past 10 years, there has been a corresponding notable increase in the number of computed tomographic (CT) examinations being performed around the world. The broadened use of CT in clinical practice has raised concerns about mounting radiation exposure, thus emphasizing the need for appropriate strategies to optimize and thereby, if possible, reduce radiation dose due to CT. In the present review, we will present data that document the magnitude of CT radiation exposure and discuss the important safety issues. Various technologic and patient-based strategies proposed by radiologists, physicists, and the CT industry for radiation dose optimization will be discussed.

CT SCANNING: DATA AND RISK PROJECTION

There has been a remarkable increase in use of CT since its inception in the early 1970s. The average annual rate of CT scanning per 1,000 people increased from 6.1 in 1970–1979 to 44.0 in 1985–1990 (1). For 1985–1990, the annual rate in the United States was 14.5 CT examinations per 1,000 people; in Australia, 30 per 1,000; in Germany, 35 per 1,000; in Belgium, 50 per 1,000; and in Japan, 97 per 1,000 (1). Surveys performed in the United States reveal that the annual number of CT examinations has increased almost 10-fold in less than 2 decades, from 3.6 million in 1980 to 33 million in 1998 (2,3). An estimated 2.7 million CT studies were performed in children under the age of 15 years in 2000 (4).

While CT accounts for only 11% of x-ray–based examinations in the United States, it delivers over two-thirds of the total radiation dose associated with medical imaging (5). In the United Kingdom, the population-averaged effective dose comprises x-ray procedures in hospitals (87%), nuclear medicine examinations (11%), mammography screening (1.5%), and extramural dentistry (0.2%) (6). The contribution of CT to the collective effective dose from medical exposure to the population increased to an estimated 40% in 1999, in comparison with 20% in 1990. Similarly, in Poland the number of CT examinations increased from 170,000 in 1995 to 460,000 in 1999, accounting for a fourfold increase in collective effective radiation dose and nearly a threefold increase in CT examinations in this period (7). In the Netherlands, the annual effective dose from diagnostic medical exposure in 1998 increased to 0.59 mSv per capita, reflecting an increase of 26% since the previous inventory in the Netherlands a decade earlier (8). The increase in patient dose was attributed to the upsurge in frequency of CT examinations and vascular radiologic procedures. The United Nations Scientific Committee on the Effects of Atomic Radiation 2000 report on medical radiation exposure stated that, worldwide, CT constitutes 5% of radiologic examinations and contributes 34% of the collective dose (9).

Owing to the burgeoning application of CT, there is an emergent need for radiation dose reduction to avoid a reversal of the risk-benefit ratio associated with this imaging modality (10). Risks associated with radiation exposure can be considered with regard to two main categories: namely, deterministic effects or stochastic effects. Deterministic risk results from cell death and is quantified in terms of radiation dose to a particular region that has a threshold level beyond which these effects generally occur. Deterministic risks are rarely seen with diagnostic x-ray–based examinations, including CT, because radiation doses typically do not reach the threshold level. Indeed, the main risks to the subject undergoing a diagnostic x-ray–based examination are due to stochastic effects, which may result in cancer, and genetic effects, which occur in the offspring of the irradiated subject. The probability of stochastic effects depends on the amount of absorbed dose. In an American College of Radiology publication, Gray (11) emphasized the need for radiation reduction in the following manner:

> The estimated risk of cancer death for those undergoing CT is 12.5/10,000 population for each pass of the CT scan through the abdomen. This risk compares with 12 cancer deaths/10,000 population from 1 year of smoking in a similar population (however, one should take into account that the risk of smoking may be much greater when considered throughout a lifetime, in which case the risks from CT examinations become much smaller than those from smoking).

In addition, an International Commission on Radiological Protection Special Task Force report on CT radiation exposure (10) stated that CT radiation doses are relatively high. The radiation doses from CT to tissues can often approach or exceed the levels known to increase the probability of cancer. Indeed, Brenner et al (12) projected an increased risk of cancer mortality in children as a result of CT radiation exposure. They estimated the lifetime cancer mortality risks attributable to CT radiation exposure in a 1-year-old to be 0.18% (for abdominal CT) and 0.07% (for head CT), which represents a small increase in cancer mortality over the natural background rate. In the United States, where 600,000 abdominal and head CT examinations are performed annually in children younger than 15 years, an estimated 500 of those scanned may ultimately die of cancer attributable to CT radiation (12).

IMPORTANT CT SCANNING PARAMETERS

Regardless of model, all CT scanners have a gantry, an x-ray source, and detectors. On passage through the body part, the incident beam is attenuated in a manner dependent on the local tissue composition (greater attenuation for bones, lesser for soft tissues). The signals generated by the attenuated beam in the detectors are used to reconstruct the image. X-ray beam energy (determined by tube potential) and photon fluence (determined by the product of tube current and time) are important factors that affect radiation exposure to the patient (13,14).

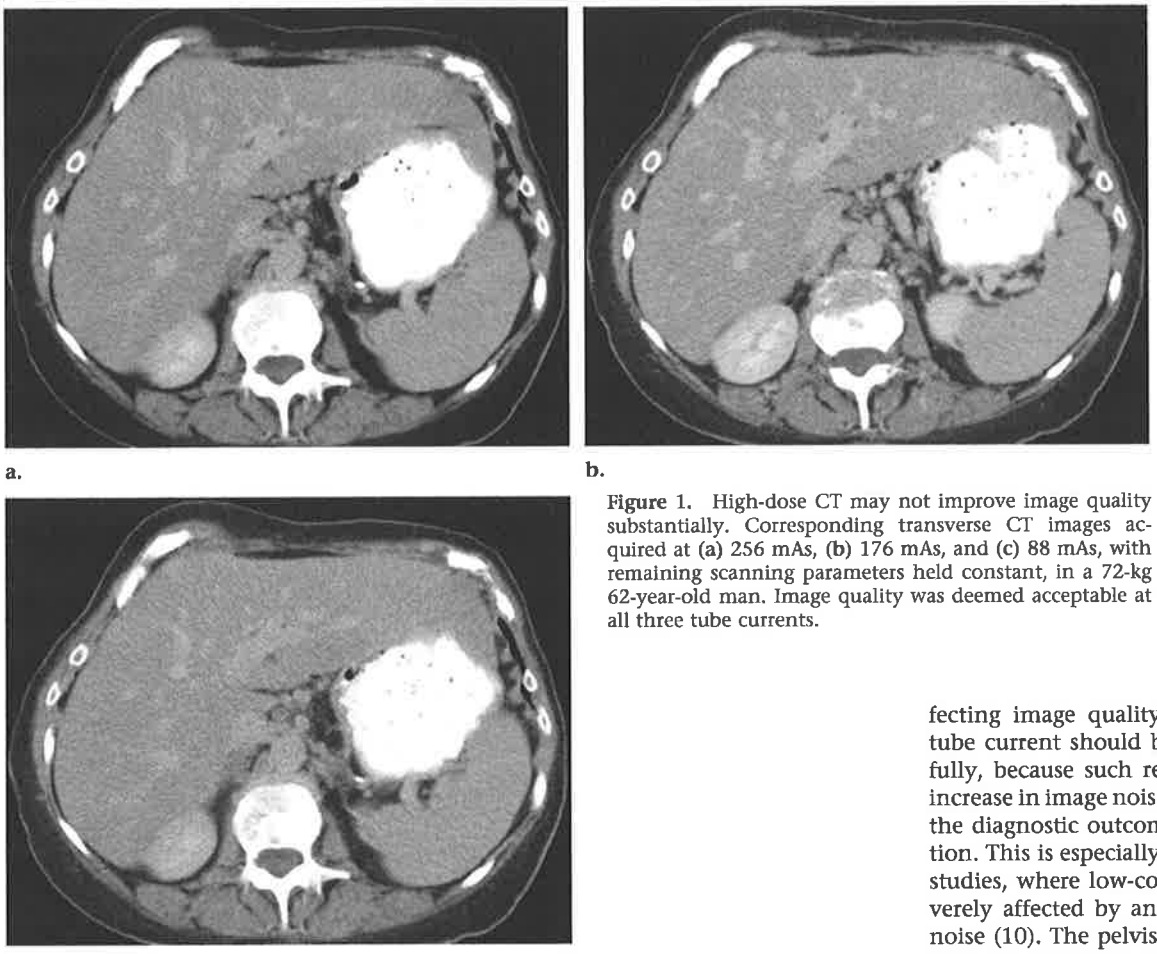
In conventional radiography, radiation dose decreases continuously from the beam's entrance into the body to its exit, whereas in CT the dose is distributed more uniformly across the scanning plane because the patient is equally irradiated from all directions. In a head CT examination, for instance, the dose is uniform across the field of view. In larger objects such as the abdomen, the dose is equally distributed around the periphery of the scanned object and decreases by a factor of only two near the center of the object. Hence, dose comparisons between CT and conventional radiography in terms of skin dose are not appropriate. Furthermore, the radiation energy delivered by CT is not fully contained within the scanning volume. Scattered radiation, divergence of the radiation beam, and limits to the efficiency of beam collimation all contribute to the radiation exposure beyond the boundaries of the scan volume. In the case of the multiple scan acquisitions required to image some length of a patient's anatomy, it becomes essential to consider the effect of the radiation dose delivered beyond the boundaries of a single scan.

The radiation dose descriptor known as the CT dose index, or CTDI, integrates the radiation dose delivered both within and beyond the scan volume. CTDI is the principle dose descriptor in CT. The average across the field of view to take into account variations in absorbed dose from the periphery to the center of the object results in a dose descriptor known as the weighted CTDI, or $CTDI_w$. $CTDI_w$ represents the average dose in the scan volume for contiguous CT scans.

In the case when there is either a gap or an overlap between sequential scans, $CTDI_w$ must be scaled accordingly, resulting in the dose descriptor volume CTDI, or $CTDI_{vol}$. $CTDI_{vol}$ represents the average dose within a scan volume (relative to a standardized CT phantom) and is now required to be displayed on the user interface of the CT scanner. $CTDI_{vol}$ is presented in milligrays. While it is not the dose to any specific patient, it is a standardized index of the average dose delivered from the scanning series. Intuitively, a longer series imparts a higher total radiation dose to the patient than does a shorter series. The term *dose length product* is used to represent the integrated dose and is equal to the average dose within the scanning volume ($CTDI_{vol}$) times the total scan length (in centimeters). This parameter is also displayed on some CT systems.

Image noise, an important determinant of CT image quality, is inversely related to the x-ray beam energy. Although a decrease in tube current or tube voltage results in a reduction in radiation dose, such a decrease is also associated with an increase in image noise, which may compromise the image quality to a variable extent. Thus, while CT radiation dose reduction is a crucial issue given the risks of radiation exposure, it is equally essential to realize the benefit of a "quality CT examination" that adequately addresses pertinent clinical issues affecting patient care (10). Therefore, radiation dose reduction, although prudent when appropriate, must not compromise the diagnostic outcome of a clinically relevant examination. It is worthwhile to remember that in most circumstances, strategies should be directed toward radiation dose optimization rather than dose reduction per se, so that the image quality maintains a diagnostic standard. For instance, high radiation dose may not necessarily provide substantially improved image quality and increased lesion conspicuity in comparison with standard or even low-dose scanning (Fig 1). Research on dose reduction must, therefore, focus on image quality and standard practice. The challenge to practitioners is to identify acceptable thresholds of image quality so that the minimum radiation doses needed to achieve these can be determined. Definition of image quality must extend to issues of lesion detection so that the goal of radiation dose optimization can be achieved. The challenge to CT scanner manufacturers is to improve the dose efficiency of CT systems and to provide features that allow practitioners to further reduce the dose needed while achieving the required diagnostic confidence.

The scanning parameters that affect CT radiation dose include scanner geometry;



a. b. c.

Figure 1. High-dose CT may not improve image quality substantially. Corresponding transverse CT images acquired at (a) 256 mAs, (b) 176 mAs, and (c) 88 mAs, with remaining scanning parameters held constant, in a 72-kg 62-year-old man. Image quality was deemed acceptable at all three tube currents.

tube current and voltage; scanning modes, length, and collimation; table speed and pitch; gantry rotation time; and shielding. The technologist monitoring the examination can control most of these parameters and modulate them to obtain the desired image quality.

Scanner Geometry

The distance between the focal spot of the x-ray tube and the isocenter of the scanner depends on scanner geometry, since single– or multi–detector row helical CT scanners can have a long or a short geometric configuration. According to the inverse square law, radiation intensity varies with the inverse of the squared distance between radiation source and patient. Thus, if all other scanning parameters are identical, a short-geometry scanner can produce more interaction of radiation with the patient and lower image noise than a long-geometry scanner can. This underscores the fact that the "transfer" of scanning parameters from one scanner type to another should be performed with caution, so that image quality can be maintained with identical or reduced radiation dose, depending on scanner geometry and other attributes (eg, reconstruction algorithms) (15).

Tube Current and Potential

Reduction in tube current is the most practical means of reducing CT radiation dose. A 50% reduction in tube current reduces radiation dose by half. The beam energy and photon fluence of an x-ray beam varies with the tube potential and the current used during the particular examination. Tube current–time product settings are proportional to the number of photons in the defined exposure time (photon fluence). Authors of previous studies (16–25) on CT of the head, neck, chest, abdomen, and pediatric pelvis have suggested that it is possible to reduce tube current without markedly affecting image quality. Any decrease in tube current should be considered carefully, because such reduction causes an increase in image noise, which may affect the diagnostic outcome of the examination. This is especially true in abdominal studies, where low-contrast areas are severely affected by an increase in image noise (10). The pelvis, however, with its greater inherent contrast is usually not noticeably affected. According to a recent review of scanning protocols (24), diagnostic-quality abdominal CT scans can be obtained at lower tube currents with a four–detector row scanner.

Tube potential (peak voltage) determines the incident x-ray beam energy, and variation in tube potential causes a substantial change in CT radiation dose. The effect of tube voltage on image quality is more complex, since it affects both image noise and tissue contrast. An important outcome that may be associated with decreased tube voltage is a notable increase in image noise. This occurs if the patient is too large or the tube current is not appropriately increased to compensate for the lower tube voltage. The dose change is approximately proportional to the square of the tube voltage change (ie, square of the ratio of final and initial peak voltage), and the noise change is approximately inversely proportional to the tube voltage change (10).

Image quality ramifications of a decrease in tube voltage to reduce radiation exposure must be carefully examined before this strategy is implemented. For

most patients, abdominal CT can be optimally performed at 120 kVp instead of 140 kVp, resulting in a 20%–40% reduction in radiation dose (24). For very large patients, a higher tube voltage is generally more appropriate. There is a need for further research on the use of lower tube voltage for dose advantages, because of the complex relationship between tissue contrast, image noise, and radiation dose that depends on patient size. According to preliminary results reported by Lieberman et al (26), head CT performed in children at a substantially reduced tube voltage (if performed with increased tube current) may result in the lowest possible patient dose with no decrease in image contrast-to-noise ratio. However, further studies should precede such a reduction in the tube voltage used to acquire CT scans.

Scanning Modes

Use of a multi–detector row CT scanner results in some amount of unused radiation extending beyond the beginning and end of the imaging region (27). This occurs because, at the start of the acquisition, only the first detector row is contributing to the image. As the acquisition proceeds, additional detector rows enter the imaging region until all rows are contributing. A similar effect occurs in reverse at the end of the acquisition. As a result, it is generally more dose efficient to use a single helical scan rather than multiple helical scans if there are no overriding clinical considerations, such as breath holding, for the patient. The need to prescribe multiple contiguous helical scans should be infrequent with modern high-speed multi–detector row scanners.

Scanning Length

With the widespread availability of helical CT scanners, there is a general tendency to increase the area of coverage (to include regions beyond the actual area of interest in the chest, abdomen, or pelvis), which increases effective radiation dose to the patient (10). Therefore, it is essential to draw the attention of referring physicians and radiologists to dose consequences and to establish scanning protocols that restrict the examination to what is absolutely essential.

Collimation, Table Speed, and Pitch

For helical CT scanners, pitch is defined as the ratio of table feed per gantry rotation to the nominal width of the x-ray beam. An increase in the pitch decreases the duration of radiation exposure to the anatomic part being scanned. With helical CT scanners, beam collimation, table speed, and pitch are interlinked parameters that affect the diagnostic quality of an imaging study.

Faster table speed for a given collimation, resulting in higher pitch, is associated with a reduced radiation dose (especially if other scanning parameters, including tube current, are held constant) because of a shorter exposure time, whereas narrow collimation with slow table speed, resulting in a longer exposure time, is associated with a higher radiation dose. This is not true for scanners that use an *effective milliampere-second* setting (defined as milliampere seconds divided by pitch) and maintain a constant value for effective milliampere seconds. In such scanners, the effective milliampere-second level is held constant irrespective of pitch value, so that radiation dose does not vary as pitch is changed. For a given collimation, an increase in table speed increases the pitch and reduces the radiation dose by 1 divided by the pitch (10,28–30). Modern multi–detector row scanners may automatically recommend the appropriate tube current adjustment to maintain a given image noise level when pitch is changed.

Although scanning at a higher pitch is generally more dose efficient, it also tends to cause helical artifacts, degradation of the section-sensitivity profile (section broadening), and decrease in spatial resolution. Hence, alterations in pitch can have varying effects on image quality in different situations. For instance, in CT colonoscopy image quality and reconstruction artifacts are less affected by pitch than by beam collimation, so that a higher pitch with narrow beam collimation may be preferable for reducing radiation dose (31,32). However, in situations such as imaging of metastatic liver lesions or pancreatic lesions, which generally require thin collimation, an increased pitch may affect detectability because lesions may be missed owing to degradation of the section-sensitivity profile (10). We have not noted any marked difference in the image quality of scans obtained at a pitch of 1.5:1 relative to images obtained at a pitch of 0.75:1. Hence, at our institution we acquire most abdominal scans with a pitch of 1.5:1, which results in up to 50% radiation dose saving in comparison with the dose with a pitch of 0.75:1, with other scanning parameters unchanged.

Owing to "overbeaming" in multi–detector row CT, some amount of the x-ray beam is incident beyond the edge of the detector rows (27,30). Generally, thicker beam collimation in multi–detector row CT results in a more dose-efficient examination, because overbeaming constitutes a smaller proportion of the detected x-ray beam. Depending on the scanner type, however, thick collimation limits the width of the thinnest sections that can be reconstructed. On the other hand, although thin collimation increases the proportion of overbeaming x rays, it allows reconstruction of thinner sections. Hence, beam collimation and pitch must be carefully selected to address specific clinical requirements. For instance, a thicker collimation and a pitch greater than 1:1 is usually sufficient for screening examinations such as CT colonography and CT for urinary tract calculus. However, CT scanning for certain clinical situations, such as liver resection or transplantation work-up, is frequently performed with thin collimation and a pitch of less than 1:1.

Gantry Rotation Time

There has been a dramatic decrease in tube rotation times with recent technologic innovations, most notably with the development of four–, eight–, and, recently, 16–detector row CT scanners. Whereas a four-row scanner with a 0.8-second rotation time requires a 16-second breath hold to scan the entire abdomen, an eight-row scanner covers this length in 8 seconds. If the tube rotation time is decreased (faster gantry rotation), the radiation exposure decreases, and tube current may thus have to be increased to maintain constant image quality (10). Modern 16-row scanners are capable of high scanning speeds and submillimeter section thicknesses. Thin collimation can lead to a higher dose, especially if tube current is increased to maintain image noise at a level similar to that of thicker sections. The contrast resolution of small lesions improves because of reduced partial volume effects; hence, greater noise on thinner sections may often be acceptable (33). In addition, submillimeter-collimation scans can usually be reconstructed as thicker sections, which reduces inherent noise. Thus, it is important to optimize beam collimation for different multi–detector row scanners on the basis of the clinical situation in question.

Shielding

Protection of radiosensitive organs, such as the breast, eye lenses, and go-

nads, is particularly relevant in pediatric patients and young adults, because these structures frequently lie in the beam pathway (10,34). Beaconsfield et al (35) studied the effect of shielding regions of the body that are not included in the direct path of the x-ray beam during CT. They reported that with lead protection, thyroid and breast radiation doses were reduced by an average of 45% and 76%, respectively, in 110 patients undergoing routine head CT. Therefore, external shielding may be helpful in reducing radiation exposure to parts that are not included in the examination field. In examinations where the gonads are included in the field but are not the organs of clinical concern, some form of shielding should be used. Hidajat et al (34) showed that in abdominal CT examinations, the testis capsule is an important instrument for reducing the dose absorbed by the testes (by up to 95%), whereas the lead apron is not appropriate for dose reduction to the ovaries (due to their inconstant position). Hein et al (36) reported that the use of a shield for protection of eye lenses in paranasal sinus CT is a suitable and effective means of reducing surface radiation dose by 40%.

RADIATION DOSE REDUCTION AND JUDICIOUS PRACTICES

Requests for CT scanning must be generated only by qualified medical practitioners and justified by both the referring doctor and the radiologist. Establishment of clinical guidelines to advise referring doctors and radiologists about the appropriateness and acceptability of CT examinations helps eliminate inappropriate requests for CT. In addition, CT examinations should not be repeated without clinical justification (10,14). It is also important to triage patients toward the correct imaging test and, if necessary, eliminate inappropriate CT referrals. Procedures with no radiation exposure, such as ultrasonography and magnetic resonance (MR) imaging, should be used for appropriate clinical indications when equal or greater diagnostic information can be obtained. For instance, the benign condition responsible for the largest cumulative radiation dose from CT is complicated acute pancreatitis, and it may be possible to substitute MR imaging for CT in these patients (especially if the medical condition allows a longer examination period). Similarly, although CT in pregnant women is not contraindicated in emergency settings, scanning in pregnant women often raises concern. When CT is necessary in these patients, it is imperative to limit scanning to the area of interest (14).

CT images are often acquired before, during, and after intravenous administration of contrast material. When medically appropriate, multiple exposures may be reduced by eliminating precontrast imaging. This may be especially relevant in the evaluation of liver and bowel wall conditions, where precontrast images can frequently be omitted without affecting the interpretation of the imaging study. As recommended by the International Commission on Radiological Protection, all CT performed for research purposes but without immediate benefit to the individual undergoing the examination should be subject to critical evaluation, since the doses can be markedly higher than those of conventional radiography (10). A critical step toward uniform optimization of CT radiation dose is the establishment of uniform protocols for all examinations on the basis of patient attributes (dimension, weight) and/or scanning features (image noise, automatic modulation of tube current). This will ensure that diagnostic quality images are acquired by using radiation doses that are reduced to the lowest levels possible.

MODULATION OF CT PARAMETERS FOR DOSE REDUCTION

Most radiation dose optimization strategies involve modulation of scanning parameters, especially tube current, on the basis of patient weight and cross-sectional abdominal dimensions.

Weight

Several investigators have suggested that tube current settings can be substantially reduced for CT of the chest in both adults and children (20,21,37–40). Image quality identical to that in adults can be obtained in pediatric patients by using markedly reduced radiation exposure. For abdominal CT, Donnelly et al (25) described modulation of scanning parameters in children on the basis of weight. They documented that patient weight can be used to select an appropriate tube current that is much lower than the adult settings used earlier for pediatric abdominal CT. In addition, Donnelly et al suggested the use of a substantially reduced tube current for children weighing 4.5–68.0 kg. Recent studies have shown that for adult patients, too, radiation exposure from abdominal CT can be reduced substantially. For abdominal CT in adults, tube current can be reduced on the basis of patient weight (22). The quality of abdominal CT images obtained with a four–detector row scanner at a 50%-reduced radiation dose was compared with that of images obtained with a standard dose. Although standard-dose images were less noisy and more visually pleasing in patients weighing less than 81.6 kg, image quality at 50%-reduced tube current was acceptable. In contrast, for patients weighing more than 81.6 kg, reduced-dose CT images were found to be too noisy, and image quality was not acceptable. It follows that lighter patients should be evaluated with reduced radiation by changing the tube current according to the patient's weight.

Cross-sectional Dimensions

Attenuation of the incident x-ray beam in CT depends on the size of the body portion being evaluated; that is, greater exposure is required in corpulent patients to attain image quality equal to that in slimmer patients (41). Selection of CT parameters on the basis of a patient's weight can lead to large variations in image quality between, for instance, two persons with the same weight but different height. Scanning parameters can, therefore, be modified on the basis of cross-sectional body dimensions to optimize radiation exposure from CT.

Haaga et al (42) reported that image noise was related to cross-sectional dimensions and advocated the use of cross-sectional measurements for optimizing scanning parameters and CT radiation dose. A new method has recently been reported (43), in which radiation dose is varied to achieve similar levels of image noise for patients with various abdominal diameters, thereby minimizing radiation dose in most cases. This method results in substantial radiation dose reduction for these patients. Modulation of scanning parameters by using the diameter of the anatomic cross section being evaluated resulted in a reduction in dose of up to 45%. The results suggest a potential for reduction of radiation exposure in slim patients on the basis of cross-sectional abdominal diameter. Similarly, a significant correlation has been reported (22) between reduced-dose image quality and abdominal cross-sectional parameters such as abdominal circumference, cross-sectional area, and anteroposterior and transverse diameters of the abdomen. At 50%-reduced tube current

(half the radiation dose), image quality was acceptable in patients with a cross-sectional area of less than 800 cm^2, a circumference of less than 105 cm, a root mean square diameter of less than 44 cm, an anteroposterior diameter of less than 28 cm, and a transverse diameter of less than 34.5 cm. Conversely, image quality with reduced–tube current CT was unacceptable in patients with larger abdominal dimensions (ie, exceeding the aforementioned measurements).

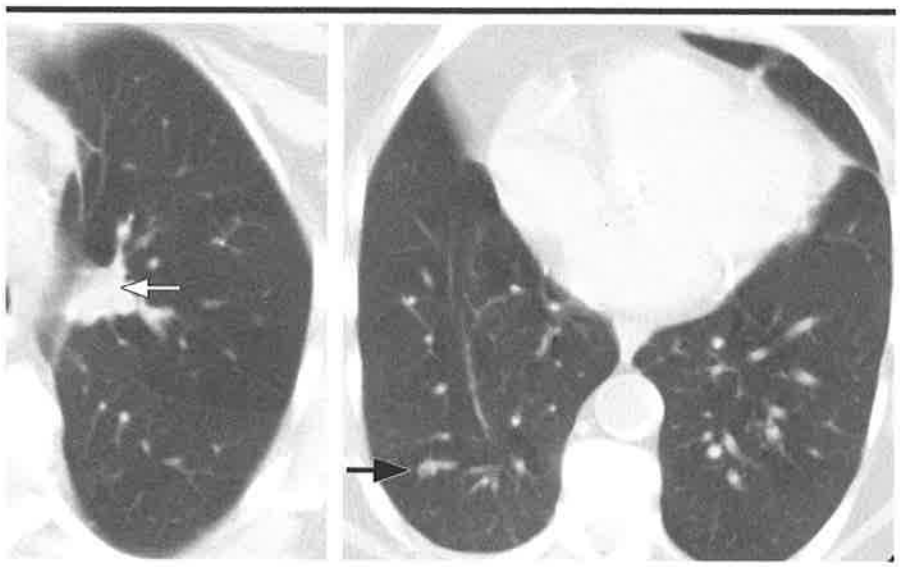
These dimensions can be easily calculated before the examination with a simple measuring caliper. Alternatively, the technologist can directly measure these dimensions at the CT console monitor by using a fixed landmark on a scout image, a single precontrast image, or automated bolus-tracking images. McCollough et al (44) evaluated the use of size-based CT technique charts for reducing radiation dose to pediatric and small patients and for improving image quality in large patients. They reported that modifications of tube current in proportion to patient width are feasible and result in a two- to fourfold dose reduction for small patients.

LITERATURE ON CT RADIATION REDUCTION

Several studies (16–21,38–40) have shown that certain CT examinations can be performed with low tube current resulting in substantial reduction in radiation dose. CT performed for screening purposes, where risk versus benefit proportions are critical for justification of the examination, must be performed at the lowest acceptable radiation dose. These screening examinations include CT colonography for detection of polyps in a population with a high risk of colon cancer. Many studies (16–21,38–40) have been performed to determine the possibility of reducing CT radiation doses for specific clinical indications. These include investigations of chest CT, CT in pediatric populations, CT colonography, and CT for urinary tract calculi.

Chest CT Scanning

Dose requirements for CT of the chest are much smaller than those for the abdomen because of low x-ray absorption in the lungs (14). As a consequence, chest CT can be performed at a lower tube current than abdominal CT can. For chest CT, Prasad et al (37) documented acceptable image quality for evaluation of normal anatomic structures with a 50% reduction in tube current. Low-dose CT with reduced tube current has been reported to be as effective as standard-dose CT performed with a higher tube current for demonstration of pathologic findings in the lung and mediastinum (20). Therefore, low-dose CT should be considered as a viable alternative to standard-dose CT, especially in young patients with benign disease (38).



a. b.

Figure 2. Low-dose chest CT scan obtained at 60 mA and 120 kVp for lung cancer screening in a 75-kg 70-year-old man. Transverse images show **(a)** spiculated mass (arrow) in the upper lobe of the left lung and **(b)** nodule (arrow) in the lower lobe of the right lung.

Low-dose CT has been recommended for screening for lung cancer (Fig 2). Promising results have been shown with very low tube currents (38,45,46). Similarly, studies have shown that pulmonary nodules can be detected with equal effectiveness at low-dose CT performed with substantially reduced tube current (38). For detection of benign asbestos-related pleural-based plaques and thickening, Michel et al (47) have reported that low-dose high-resolution CT of the chest can give results that are equivalent to those of scans obtained with a standard higher radiation dose.

CT in Pediatric Patients

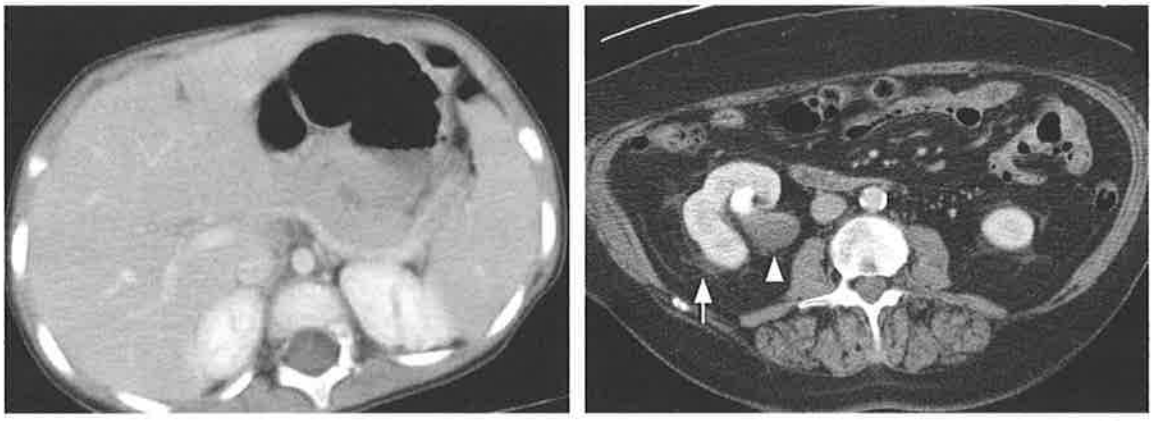
X-ray beam attenuation is exponentially related to the distance traveled by the beam. Radiologists and technologists can reduce the appropriate scanning parameters, most notably tube current, for children and slim patients (Fig 3) (10,22).

CT Colonography

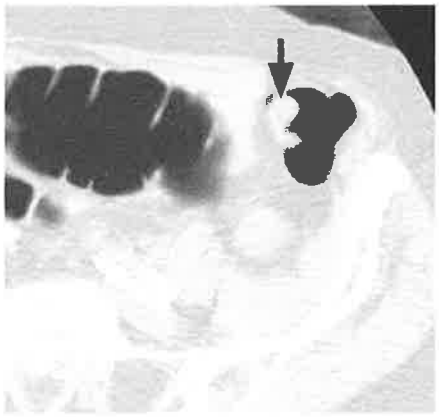
High inherent contrast at the air–soft-tissue interface in a distended colon allows for marked reduction in radiation exposure (48–50). Cohnen et al (50) reported that multi–detector row CT colonographic images obtained with a 12-fold reduction in radiation exposure compare well with images from a standard-dose examination. Similarly, van Gelder et al (48) reported that despite decreased image quality when tube current is very low, polyp detection in patients at high risk for colorectal cancer remains unimpaired. At our institution, multi–detector row CT colonography is performed at substantially reduced tube current and tube potential, in comparison with those parameters used in other abdominal CT examinations (Fig 3). One of the disadvantages is that the detection of abnormalities outside the colon may be affected at low-dose CT colonography.

CT for Urinary Tract Calculi

Unenhanced CT scans for evaluation of acute flank pain that are obtained with reduced radiation dose (low tube current) can give excellent diagnostic information with radiation exposure at least 50% lower than that of excretory urography (51,52). Spielmann et al (53) used an anthropomorphic torso phantom and reported unimpaired visualization of renal calculi on images obtained with markedly reduced tube current on single– and multi–detector row CT scanners, with a dose reduction of more than 75%. Similarly, some investigators have reported using unenhanced reduced-radiation-



a. b.



c.

Figure 3. Low-dose transverse CT scans of the abdomen. **(a)** Reduced-dose (120-kV, 60-mAs) scan in a 23-kg 4-year-old boy with abdominal pain. **(b)** Low-dose (96-mAs) scan in a 67-kg 43-year-old man shows perirenal fat stranding (arrow) and dilated right renal pelvis (arrowhead). **(c)** CT colonography (40 mAs, 140 kVp) in a 78-kg 68-year-old woman demonstrates a sessile polyp (arrow) in the sigmoid colon.

dose helical CT with a pitch of 2 or greater and obtaining satisfactory results in cases of suspected renal colic (Fig 3) (54,55).

TECHNOLOGIC ADVANCES FOR RADIATION REDUCTION

A wide range of technical advances that aim to decrease radiation dose from CT have been developed, and many others are at an experimental stage. The majority of technologic innovations address the issue of radiation optimization by improving scanning efficiency and image quality, thus aiding in acquisition of image information with reduced radiation exposure. These innovations include prepatient collimation of x-ray beams, use of better filters and image processing algorithms, automatic tube current modulation, and efficient detector configuration.

X-ray Beam Utilization

Prepatient tracking, or control of x-ray tube focal spot motion and beam collimation, enhances scanner efficiency (by decreasing z-axis beam collimation) and thus reduces radiation exposure. With this technique, overbeaming is reduced by means of measurement of the beam position every few milliseconds and continual repositioning of a source aperture to hold a narrow beam fixed on the detector. Thus, the beam is stabilized on the detectors, allowing an x-ray exposure profile that is narrower than the detected x-ray profile, and the radiation dose associated with multi–detector row CT is reduced in comparison with that of systems with no focal spot tracking.

X-ray Filtration

X-ray filters decrease the "soft x rays" that constitute absorbed radiation that never reaches the detectors and thus does not contribute to the image. Efficient x-ray filters selectively remove these soft x rays and thus decrease absorbed radiation. Itoh et al (56) compared radiation exposure with an aluminum filter (5.8 mm thick at the center) and that with a conventional filter in a phantom and patient study. They noted a 17% reduction in radiation exposure and a 9% decrease in noise at very-low-dose CT with the new filter. Bow-tie filters or beam-shaping filters reduce the surface radiation dose by 50% compared with the dose with flat filters (27). Bow-tie and beam-shaping filters minimize radiation exposure in the thinner portions of patient anatomy, thus providing better noise consistency within the image while saving substantial amounts in radiation dose.

Automatic Modulation of Tube Current

Tube current modulation is a technical innovation that can substantially reduce radiation dose. The concept of automatic tube current modulation is based on the premise that pixel noise on a CT scan is attributable to quantum noise in the projections. By adjusting the tube current to follow the changing patient anatomy, quantum noise in the projections can be adjusted to maintain a desired noise level on the image and to improve dose efficiency.

There are two methods used on CT scanners today: z-axis modulation and angular (x- and y-axis) modulation. Both methods have a complementary role in minimizing patient dose. In z-axis modulation, tube current is adjusted to maintain a user-selected quantum noise level in the image data. Noise is regulated on the final image to a level desired by the user. In this sense, z-axis modulation is the CT equivalent of the autoexposure control systems used for many years with conventional x-ray systems. z-Axis modulation is an attempt to render all images with similar noise, independent of patient size and anatomy. The dose savings with z-axis modulation are expected to be greater than those with fixed–tube current methods, since the tube current will be automatically reduced for smaller patients and anatomic regions.

z-Axis modulation has been recently introduced for multi–detector row CT scanners (AutomA; GE Medical Systems, Waukesha, Wis). Tube current modulation is determined from the attenuation and shape of scout scan projections in the patient just prior to the CT examination. Clinical results of this technique have not yet been published in the literature.

Angular modulation has a different objective than z-modulation. In angular modulation, the tube current is adjusted to minimize x rays in projections (angles) that have less importance for the reduction of overall image noise content. In anatomy that is highly asymmetric (eg, the shoulders), x rays are much less attenuated in the anteroposterior direction than in the lateral direction (57–60). Thus, the overwhelming abundance of anteroposterior x rays can often be reduced dramatically without a marked effect on overall image noise. Angular modulation was first introduced on single–detector row scanners in 1994 (HiLight Advantage; GE Medical Systems) (61,62). Dose reductions of up to 25% were reported at that time, with virtually no change in image noise. On these early systems, both lateral and anteroposterior scout scans were required to determine angular modulation. More recently, angular tube current modulation has been introduced on multi–detector row scanners (CARE Dose; Siemens, Erlangen, Germany). In this implementation, the modulation is determined in real time by using projection data that lag 180° from the x-ray generation angle. A recent investigation of 100 helical CT imaging studies in children in whom angular modulation was used showed a 10%–60% decrease in dose, with a mean reduction of 22.3% (neck, 20%; thorax, 23%; abdomen, 23%; thorax and abdomen, 22%) without loss of image quality (63).

The ideal CT scanner will employ both z-axis and angular modulation techniques. When available in all commercial CT scanners, use of manual techniques, whereby a tube current value is selected on the basis of some simple measure of the patient (eg, weight or cross-sectional dimensions), will be replaced with this computerized objective approach. With these developments, tube current modulation in CT scanners will be comparable to photographic timing or automatic brightness controls currently used in conventional radiography. Indeed, automatic tube current modulation promises to be an important development in the optimization of scanning parameters that will help eliminate the guesswork involved in parameter selection.

Projection-adaptive Reconstruction Filters

A marked decrease in signal is common in regions such as the shoulders, owing to beam attenuation in a particular projection. This leads to increased image noise with substantial impairment of image quality and results from photon noise contamination with the electronic noise of the data-acquisition system. Projection space filters increase the filtration of signal-dependent noise in the reconstruction data and thus minimize the loss of resolution. Although there is some loss of image resolution (less than 5%) with the use of these filters, use of projection-adaptive reconstruction filters prevents an otherwise diagnostically compromised image. Kachelriess et al (64) investigated the use of multidimensional generalized adaptive filters for reducing image noise and patient radiation dose. They documented a 30%–60% reduction in image noise, typically along the direction of the highest attenuation in noncylindric body regions such as the shoulder and metallic implants, without an increase in radiation dose.

Computer-simulated Dose-Reduction Software

Evaluation of the effects of low-dose CT on image quality, lesion detection, and lesion conspicuity and comparison with standard-dose CT images is a fundamental part of dose-reduction research. This requires image acquisition with standard and reduced radiation doses, which frequently results in increased radiation dose to the volunteering subjects. Computer-simulated dose-reduction software adds noise to an image acquired at a particular tube current to simulate images acquired at a lower tube current (lower radiation). Mayo et al (65) reported that the technique provides realistic reduced-radiation-dose images of the chest without additional radiation exposure to patients. In a recent study, Frush et al (66) investigated the accuracy of computer-simulated dose reduction for evaluating systematic dose reduction for abdominal multi–detector row CT in pediatric patients. They reported that the technique could be applied to multi–detector row CT of abdominal organ systems for systematic evaluation of radiation dose reduction. Validation of this technique for simulating images acquired with reduced radiation dose in adult abdominal scans is needed to expand the applications and explore new areas of dose reduction. Leidecker et al (67) also investigated the feasibility of optimizing clinical CT protocols by providing tools for adding virtual noise to measured patient raw data in order to estimate the dose reduction potential for clinical CT protocols.

Filters

As discussed earlier, radiation dose reduction is limited by increased image noise that can obscure lesions otherwise visible on images obtained with standard higher dose parameters. Noise-reduction filters have been designed to decrease image noise on scans acquired with reduced radiation dose. Alvarez and Stonestrom (68) reported that two-dimensional linear filtering of the image may alter the spatial resolution and noise properties of CT images, depending on the knowledge of noise and imaging properties of the system. They developed filters that minimize the variation in noise subject to a constraint on spatial resolution, with a 17% reduction in noise variance in comparison with that of conventional filters. Use of nonlinear image-processing techniques, in particular smoothing, has also been reported (69) for creation of good-quality CT images obtained with lower radiation. Recently, Yu et al (70) reported use of a new algorithm for reconstruction of CT images with noise properties superior to those of images reconstructed with a conventional fan-beam filtered back-projection (FFBP) algorithm currently used in commercial CT systems, including multi–detector row scanners. This algorithm converts the fan-beam data to nonuniformly sampled parallel-beam data by invoking the Fourier shift theorem in the angular direction. The approach performs ramp filtration on nonuniform sampling grids along the radial direction before back projecting the filtered data to form the image. The decrease in noise with this algorithm may be translated into reduced x-ray dose delivered to the patient and enhanced detection of subtle lesions, compared with reconstructions based on the currently widely used FFBP algorithm.

Noise reduction filters have also been designed on the basis of the principle that a group of structural pixels representative of structures of interest and a group of nonstructural pixels representative of nonstructural regions are both present in any image (71,72). The structural pixels

can be identified by determining gradient values for each pixel and by identifying pixels with a desired relationship to the gradient threshold value (73). The noise-reduction filter technique involves isotropic filtering of nonstructural regions with a low-pass filter and directional filtering of structural regions with a smoothing filter operating parallel to the edges and an enhancing filter operating perpendicular to the edges. A blending parameter regulates the recombination of the structural and nonstructural segments. Noise-reduction filters decrease noise on low-dose CT images but adversely affect contrast and sharpness and may therefore decrease lesion contrast and conspicuity (71). This was validated in a subsequent evaluation of lesion detection and characterization with low-dose CT images processed with noise-reduction filters (74). Although these noise-reduction filters decreased image noise on low-dose images, they also decreased lesion conspicuity and lesion-to-background contrast. Further improvement in the technique is needed, therefore, to maintain image contrast while decreasing image noise so that this concept can be adopted to optimize the quality of CT images acquired at reduced radiation dose and make them more acceptable.

CONCLUSION

CT radiation dose optimization is a crucial issue that must be addressed by both radiologists and manufacturers of CT scanners. The benefit to the patient of an accurate diagnosis should always be balanced against radiation risk. CT screening procedures must show that the benefits for an asymptomatic population outweigh the inherent radiation risks. Radiologists, in conjunction with medical physicists, should adopt consistent strategies for limiting patient radiation dose, while manufacturers should focus their efforts toward improving CT technology to provide the necessary diagnostic image quality with reduced radiation dose (75,76). Finally, concerted efforts and research should be directed to define diagnostic image quality, and research efforts must focus on patient- and technology-based methods to achieve a diagnostic-quality CT image at an optimum radiation dose.

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Attachment E

Iterative Reconstruction in Image Space

Iterative Reconstruction in Image Space (IRIS)

White Paper

Katharine Grant, PhD, and Thomas Flohr, PhD

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SIEMENS

Iterative Reconstruction in Image Space (IRIS)

Katharine Grant, PhD, and Thomas Flohr, PhD

Siemens is continually looking for new, effective ways to reduce radiation dose and improve patient care. Over the past few years, Siemens has been developing a novel mathematical algorithm built on the theoretical concept of Iterative Reconstruction (IR). IR is a well developed concept, which in theory can provide optimal low noise, high contrast images by looping through "iterative" reconstruction cycles.

For instance, once an image is reconstructed from the measured projections, a "forward" projection, which follows the original reconstruction rays through the original image, is performed to calculate a new image. This new "forward projected" image simulates the CT measurement process, but now, the image serves as the measured object (in place of the patient). If the original image reconstruction was perfect, the measured and simulated (forward) projections would be identical. In reality, they are not identical and the differences between these two sets of projections are used to reconstruct a "corrected" image, which in turn, is used to update the original image.

In each update cycle, non-linear processing ("regularization") of the updated image is performed to ensure the stability of the reconstruction and to selectively reduce image noise in more homogenous areas. After the correction/regularization, the cycle is repeated; thereby improving the image with each iteration (contains less noise and, therefore, a better contrast-to-noise ratio). Carefully modeling the data acquisition system of the CT scanner, and its physical properties, during forward projection can also improve the spatial resolution of the images.

While IR is a very robust and beneficial technique, it is also impractical in computational power and time; requiring more hardware capacity than is currently available to avoid long image reconstruction times. In order to implement IR on CT scanners, some vendors have attempted to simplify theoretical IR with less complexity and faster reconstruction times. However, in order to achieve this, they have had to sacrifice the accuracy of the forward projection (CT system modeling) and the calculation of the correction image. This may result in strange, unfamiliar noise textures and a plastic-like look to the resulting images. Another common downfall of other IR algorithms is a change in CT numbers (Hounsfield Units) before and after applying the simplified IR algorithm. However, as shown in Figure 4, this issue can be avoided.

Siemens has taken a different approach. Our physicists have developed a unique IR algorithm, IRIS (Iterative Reconstruction in Image Space), that optimally utilizes all raw (measured data) in a master volume reconstruction. The master volume reconstruction provides all available image detail information, but at the expense of significantly increased noise. The benefit of this master reconstruction is that it moves the iterative reconstruction loop into the image domain, thus avoiding the time-consuming, traditional forward projections. In order to deal with the increased noise in the master image, an advanced image enhancement, similar to the regularization step in IR, is applied to the volume reconstruction for 3 to 5 iterations to significantly reduce noise and enhance object contrast step-by-step. IRIS reconstruction occurs fast enough for routine clinical use and concurrently provides images with noise texture similar to standard, well-established convolution kernels.

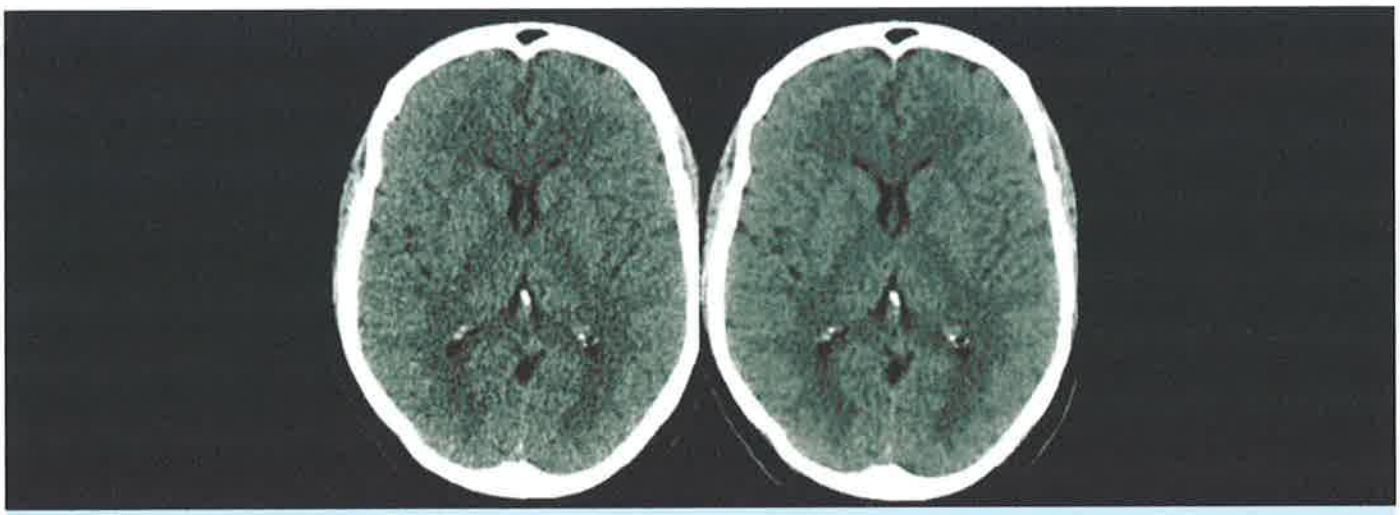


Figure 1. 70% dose H41kernel (left image), 70% dose with IRIS (J40kernel – right image)

The following examples will illustrate how IRIS is used to achieve low doses in neurological exams, improve diagnostic image quality in obese cardiac exams, and both lower doses and improve image quality in abdominal exams.

Figure 1 illustrates how helpful IRIS can be in neurological exams. In this case, IRIS is applied to an image where dose has been reduced by 30%. The image on the left is the original image, and the image on the right is displayed after applying IRIS and Neuro BestContrast. Notice the decreased noise levels, and improved image quality. IRIS, in combination with Neuro BestContrast, has allowed physicians to lower routine spiral head exams to 38 mGy. (E.P. Lindell, ISCT 2010)

Besides neurological exams, abdominal exams traditionally require higher dose to the patient than CT exams in other areas of the body. This is due to greater X-ray attenuation through the multiple organs within the abdomen, and to the complexity and level of detail involved in making a correct diagnosis in this region. However, by using IRIS in the reconstruction process, significant dose reduction is possible, while still preserving diagnostic image quality. Figure 2 is a fantastic example of how IRIS can improve patient care by significantly reducing dose in routine exams.

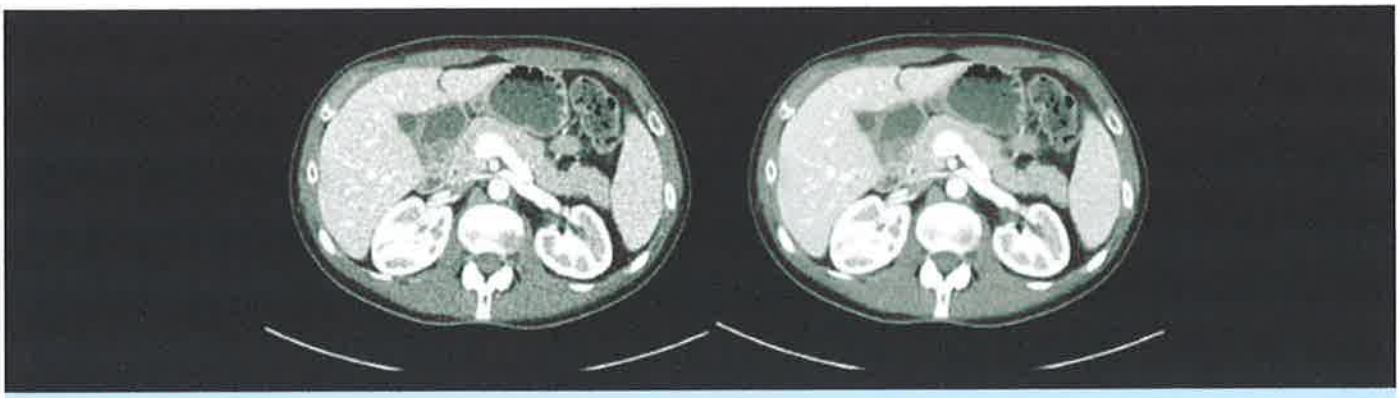
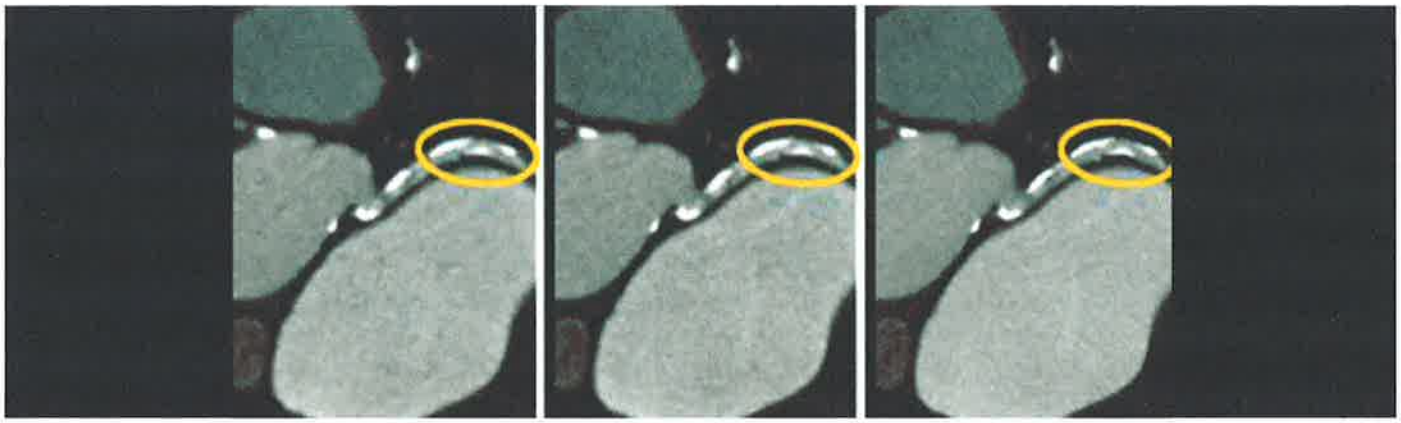


Figure 2. Example of IRIS used in an abdominal exam. The image on the left is at 50% dose (reconstructed from only 1 tube of a dual source exam). The image on the right is after applying IRIS.

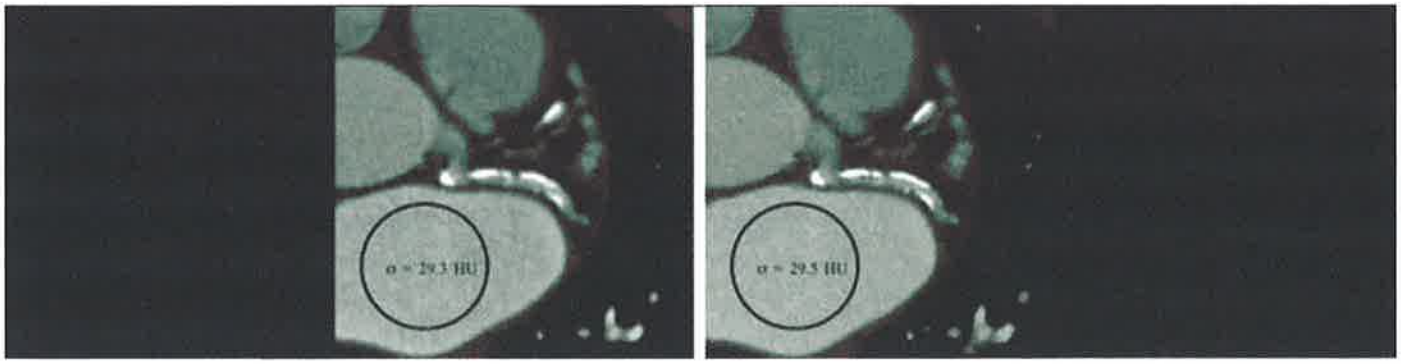


(a) 60% Dose with IRIS (b) Full Dose Standard Kernel (c) Full Dose with IRIS

Figure 3. Two different benefits of IRIS are illustrated above. By reducing dose by 60% and applying IRIS (a), noise and resolution levels similar to the standard full dose image (b) can be achieved. By applying IRIS to a full dose image (c), we can reduce blooming artifacts, thus improving image quality compared to the standard full dose image.

While low dose scans are a fantastic achievement, IRIS is NOT a dose reduction tool alone. IRIS can be extremely beneficial to patient care by providing a way to improve, or even "save" an exam, possibly preventing a re-scan. For example, in the United States, more than 60% of the population is obese. At routine doses, images of obese patients often contain higher levels of noise and artifact, making a confident diagnosis difficult. By applying IRIS to exams for obese patients, noise levels can be reduced significantly while preserving and even improving spatial resolution. This improved resolution can be seen in the cardiac exam shown in Figure 3, where the blooming artifact has been reduced, providing the physician with more diagnostic confidence. Another option is to reduce dose to the patient while maintaining resolution similar to the routine dose exam. A combination of these benefits can also be applied to images. In Figure 4, notice that IRIS does not affect CT numbers.

Several institutions around the world have already integrated IRIS into their routine practice. While these improvements to routine care through dose reduction are not yet published, we can provide some ideas for dose reduction in combination with IRIS, based on customer experience.



B25f IRIS

Figure 4. CT number (Hounsfield Units or HU) are unaltered when applying IRIS to images as demonstrated by the mean HU values between regions of interest in the original B25f kernel image on the left and the IRIS image on the right.

Table 1.

Exam Type	Reduce Dose (mAs) by:	New IRIS Protocol after Dose Reduction				Original Base Protocol			
		mAs	kV	CTDIvol (mGy)	Kernel	mAs	kV	CTDIvol (mGy)	Kernel
Abdomen	30%	150	120	10.1	I30	210	120	14.2	B30
Thorax/Chest	40%	65	120	4.4	I70	110	120	7.4	B31
HR Thorax	50-60%	50	120	3.4	I70	110	120	7.4	B80
Head (spiral)	30%	275	120	41.2	J30	390	120	59.6	H31
Sinus/Orbit	40%	75	120	10.6	J70	125	120	17.6	H60
Spine	30%	230	120	15.5	I30	330	120	22.3	B30
Peds-Body Angio	25%	70	80	1.1	I30	90	80	1.4	B30
Cardiac Flash	30%	260	100	~2.5	I26	370	100	~3.6	B26
DE Thorax	20%	71/60	100/140Sn	5.8	Q30	89/76	100/140Sn	7.3	D30
CTA Body	37%	75	120	5.1	I30	120	120	8.1	B30

The numbers in Table 1 are examples of dose reductions that have been successfully implemented into clinical practices across multiple institutions worldwide. Table 1 is based on Siemens default protocols; dose reductions (% decrease in mAs) should be applied to Siemens original base protocols in order to derive IRIS protocols. It is important to note, however, that image quality requirements at each institution may differ significantly, and thus, will affect the percent dose reduction that may be achieved for individual protocols. Each institution should thoroughly compare its current protocol parameters to those stated below when utilizing IRIS.

While it has been demonstrated that IR techniques are extremely effective in lowering patient dose, it is important to remember the percent of dose reduction is not as important as the actual dose delivered to the patient. For example, a 50% dose reduction from a starting point of 45 mGy is 22.5 mGy; whereas a 25% dose reduction from 25 mGy is 18.75 mGy. Also, even when low doses are achieved, diagnostic image quality must be the final result.

Table 2.

Examination	ACR Reference Levels (CTDIvol)
CT head	75 mGy
CT adult abdomen	25 mGy
CT pediatric abdomen (5 years old)	20 mGy

*From The American College Of Radiology: *Practice Guideline For Diagnostic Reference Levels In Medical X-Ray Imaging*, 2008.

In summary, IRIS can be used to significantly reduce dose while preserving and even improving image quality compared to standard full dose exams. Thus, IRIS is a fantastic new addition to the already powerful arsenal of dose reduction techniques available on Siemens scanners, which allow Siemens to deliver the lowest dose and our customers to provide the best possible patient care.

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Attachment F

Eliminating Over-Radiation with the Adaptive Dose Shield

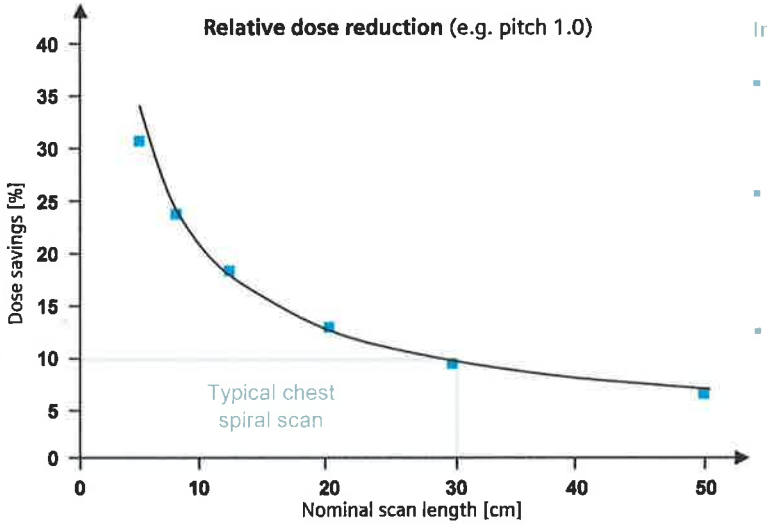
090

Eliminating over-radiation with the Adaptive Dose Shield

Publication – Effects of Adaptive Section Collimation on Patient Radiation Dose in Multisection Spiral CT

Paul D. Deak, PhD; Oliver Langner, Dipl Ing; Michael Lell,MD; Willi A. Kalender, PhD
in Radiology Volume 252 (July 2009), Pages 140-147

PURPOSE: To evaluate the potential effectiveness of adaptive collimation in reducing computed tomographic (CT) radiation dose owing to z-overscanning by using dose measurements and Monte Carlo (MC) dose simulations.
MATERIALS AND METHODS: Institutional review board approval was not necessary. Dose profiles were measured with thermoluminescent dosimeters in CT dose index phantoms and in an Alderson-Rando phantom without and with adaptive section collimation for spiral cardiac and chest CT protocols and were compared with the MC simulated dose profiles. Additional dose measurements were performed with an ionization chamber for scan ranges of 5-50 cm and pitch factors of 0.5-1.5.
RESULTS: The measured and simulated dose profiles agreed to within 3%. By using adaptive section collimation, a substantial dose reduction of up to 10% was achieved for cardiac and chest CT when measurements were performed free in air and of 7% on average when measurements were performed in phantoms. For scan ranges smaller than 12 cm, ionization chamber measurements and simulations indicated a dose reduction of up to 38%.
CONCLUSION: Adaptive section collimation allows substantial reduction of unnecessary exposure owing to z-overscanning in spiral CT. It can be combined in synergy with other means of dose reduction, such as spectral optimization and automatic exposure control. *(c)* RSNA, 2009.



Implications for patients

- Unnecessary radiation exposure of the patient can be avoided
- Especially in cardiac and pediatric examinations, the adaptive collimation can reduce dose
- Depending on scan range used, dose reductions up to 38% are expected

Source: *"Effects of adaptive section collimation on patient radiation dose in multisection spiral CT"*; Deak PD, Langner O, Lell M, Kalender WA; PMID: 19561253

SOMATOM Definition AS
Adapts for Complete Dose Protection

Answers for life.

SIEMENS

Superb image quality at lowest dose

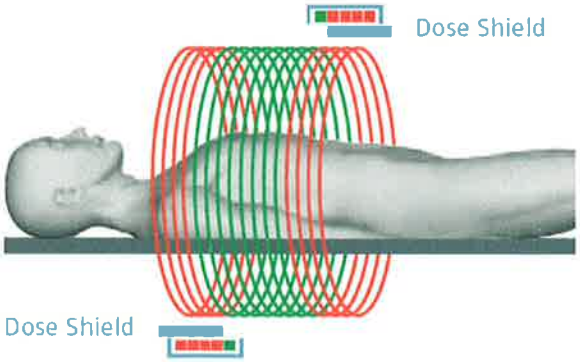
Most of today's clinical examinations benefit from spiral acquisition techniques. That's where the heart of our dose protection technologies lies. CARE Dose4D™, our real-time dose modulation, guarantees an unparalleled combination of maximum image quality at minimum dose for every patient in every spiral scan.

However, the continuous demand for more coverage and the corresponding increase of detector size has unveiled a new challenge for CT manufacturers – over-radiation, both pre- and post-spiral scan, has significantly grown.

Eliminating over-radiation in every spiral scan

The SOMATOM Definition AS eliminates over-radiation pre- and post-spiral to the patient (marked in red). The Adaptive Dose Shield, which is unique to the CT industry, is part of the innovative new STRATON X-ray tube design. It dynamically moves shields into place on the X-ray tube to block unnecessary dose. The Adaptive Dose Shield dynamically opens at the beginning of a spiral range and then dynamically closes at the end.

Now all clinically irrelevant dose is eliminated. Not only for dedicated applications, but for every single spiral acquisition. Giving you the ability to save dose in every routine exam.



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Attachment G

Health Care Advisory Board Technology Briefing on Hybrid PET/CT

TECHNOLOGY IN BRIEF

What Is It?
Positron emission tomography (PET) provides functional imaging of the body at the molecuar level by detecting metabolic activity in tissue. Combined with computed tomography (CT), PET/CT provides clinicians with both functional and structural imaging capabilities to accurately localize areas of increased metbolic activity, often indicative of cancer.

How Does It Work?
PET/CT scanning uses positron-emitting radioactive isotopes attached to glucose molecules. Fluorodeoxyglucose (FDG) is the most common isotope used for PET/CT imaging. Tissues with elevated metabolic activity (such as tumors) absorb a disproportionate amount of glucose. The scanner detects the "signal" emitted from the isotopes in this area, providing physicians with an image that localizes the metabolic activity.

What Problem Does It Solve?
PET/CT permits the non-invasive diagnosis and staging of cancer and offers support for radiation treatment planning and therapy monitoring. Cardiac PET/CT examines myocardial perfusion and viability; neuro PET/CT aids in the diagnosis of neurological disorders such as Alzheimer's disease; and bone PET/CT can assess bone metastases.

Service Line	Diagnostic Imaging
Applications	FDG-based tumor imaging for initial and subsequent treatment strategy; myocardial perfusion and viability studies; neurodegenerative disease evaluation
Current Standard of Care	PET/CT is the standard of care for the diagnosis, staging, and treatment planning for many cancers
Principal Vendors	GE, Philips, Siemens
Competing Technologies	Cardiology: SPECT, SPECT/CT Neurology: MRI Bone: SPECT/CT Niche oncology applications: SPECT/CT
Risk of Obsolescence	Low
Adoption Status	Fixed PET/CT: late majority Mobile PET/CT: majority
Projected Cost	Scanner: $1.2M-$2.6M Variable: $250-$350 per case
Reimbursement Status	Medicare reimburses for initial treatment planning for nearly all tumor sites and some for subsequent treatment plan performed as part of a clinical trial

TECHNOLOGY INSIGHTS TAKE

Oncology Dominates Near-Term and Long-Term PET/CT Applications; "Must-Have" for Oncology

- Hybrid PET/CT has become a must-have technology for cancer centers and is now the gold standard for oncology imaging. Currently, over 90 percent of all PET/CT scans are performed for oncology-related indications, with cardiac and neurology applications constituting most of the remaining 10 percent. While national PET/CT volumes are expected to grow significantly over the next decade, oncology will remain the primary application.

Continued Growth in National PET/CT Volumes Expected with Broader Adoption

- In the last decade, PET/CT has become more widely available, both in mobile and fixed-site settings. Continuing across the next decade, PET/CT volumes are anticipated to outpace those of other diagnostic imaging modalities as being driven by an aging population and continued innovation in molecular imaging with new radiotracers.

CMS Expands FDG-PET Coverage for Tumor Imaging; Bone Imaging Included as Well for 2011

- In response to considerable evidence supporting the use of FDG-PET for tumor imaging across most cancer sites and indications, the CMS recently expanded coverage for all cancers - save breast, prostate, and a form of melanoma – now covering one FDG-PET procedure as part of the initial treatment strategy, with more coverage determined on an individual basis by local contractors; coverage is also available for subsequent evaluation with registry submission.
- For cardiac and neurology applications, coverage of PET/CT is anticipated to remain stable as continued research substantiates the clinical efficacy of PET/CT for these applications.
- Bone PET/CT is increasingly used as a substitute for bone scintigraphy in the assessment of metastases, as growing clinical data suggests superior diagnostic performance; CMS has proposed coverage with clinical registry participation.

Sources: Fischer et al, N Engl J Med. 2011 Mar 10;364(10):982., Hillner *et al.* 2008. J Nucl Med 49 (12): 1928-35, CMS 2010-2011 HOPPS; Technology Insights interviews and analysis

For more information, please contact:
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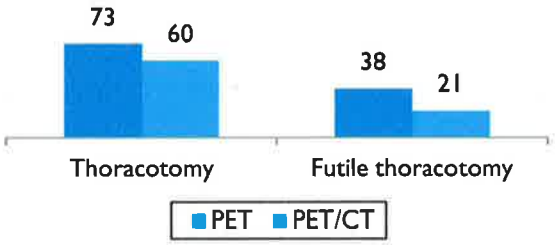
CLINICAL CONSIDERATIONS

- Hybrid PET/CT is considered the standard of care for oncology imaging for the initial and subsequent treatment strategies for appropriate cancer patients
- In addition to oncology imaging, other applications are slowly gaining traction, including myocardial perfusion and viability imaging, neuro-imaging for degenerative diseases such as Alzheimer's disease, and bone imaging; the hybrid PET/CT modality, however, is not immediately necessary for these applications
- Future PET/CT innovations likely due to novel radiotracers with only some modifications to hardware

Preoperative Lung Cancer Staging, PET vs. PET/CT

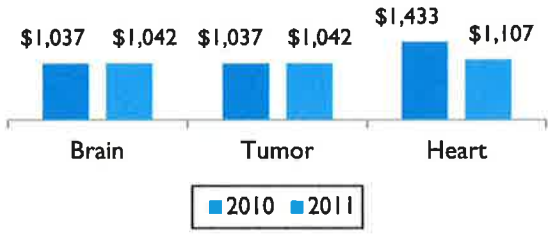


n = 91 PET; n = 98 PET/CT

FINANCIAL CONSIDERATIONS

- CMS has expanded coverage of tumor FDG-PET to nearly all solid tumors; covering one study as part of the initial treatment decision; other studies may be covered, though at the discretion of local CMS contractors
- Registry participation expands coverage to nearly all oncology applications for subsequent treatment monitoring
- Myocardial PET imaging reimbursement takes 23% hit in 2011 despite positive growth outlook
- Brain PET and tumor PET imaging reimbursement rates continue to be equivalent

2010-2011 OPPS Reimbursement for PET/CT



STRATEGIC/OPERATIONAL CONSIDERATIONS

- A wide referral network is required for the clinical and financial success of offering PET/CT imaging for all potential applications: cardiac, myocardial, and brain. While medical oncologists generate the majority of referrals, relationships with pulmonologists, surgeons, primary care physicians, cardiologists, neurologists, and radiation oncologists will prove invaluable to program development and sustainability.
- Prompt service is a cornerstone of successful PET/CT programs. Ease of scheduling and consistent, timely interpretation are the two primary factors that draw continued referral business.
- Several clinical and administrative staff members are required for a PET/CT program, with each requiring specific training to optimize performance and workflow; for organizations seeking to perform a diverse array of oncology, cardiac, and/or brain imaging studies, clinical staff must be cognizant of the unique patient management needs associated with the injection, uptake, and removal of different radiotracers.

NEXT STEPS

#1—Assess Local PET/CT Demand and Consider Possible Competition from Centers with Fixed, Mobile Systems

#2— Project Potential Volumes for Both Approved Applications and NOPR Indications

#3— Engage Referring Physicians Through Outreach and Education

#4—Develop Marketing Strategy to Ensure Breakeven Volume Capture

How Technology Insights Can Help

- **360° Assessment:** Provides in-depth clinical data, current reimbursement, experiences and strategies from early adopters, volumes forecast, and comprehensive financial analysis
- **Volumes Forecast:** Estimates local market for technology
- **Imaging Service Line Assessment:** Evaluates the need for fixed-site or mobile PET/CT technology across different sites; evaluates the potential referral sources for multiple and varied PET/CT indications across disciplines

Sources: Fischer et al, N Engl J Med. 2011 Mar 10;364(10):982., Hillner *et al.* 2008. J Nucl Med 49 (12): 1928-35, CMS 2010-2011 HOPPS; Technology Insights interviews and analysis

For more information, please contact:
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The Advisory Board Company

Attachment H

American Cancer Society "Cancer Facts and Figures 2011"

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Cancer Facts & Figures 2011

Estimated number of new cancer cases for 2011, excluding basal and squamous cell skin cancers and in situ carcinomas except urinary bladder.
Note: State estimates are offered as a rough guide and should be interpreted with caution. State estimates may not add to US total due to rounding.

Special Section:
Cancer Disparities and Premature Deaths
see page 24

American Cancer Society®

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Contents

**Indicates a figure or table*

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This publication attempts to summarize current scientific information about cancer.
Except when specified, it does not represent the official policy of the American Cancer Society.

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Basic Cancer Facts

What Is Cancer?

Cancer is a group of diseases characterized by uncontrolled growth and spread of abnormal cells. If the spread is not controlled, it can result in death. Cancer is caused by both external factors (tobacco, infectious organisms, chemicals, and radiation) and internal factors (inherited mutations, hormones, immune conditions, and mutations that occur from metabolism). These causal factors may act together or in sequence to initiate or promote carcinogenesis. Ten or more years often pass between exposure to external factors and detectable cancer. Cancer is treated with surgery, radiation, chemotherapy, hormone therapy, biological therapy, and targeted therapy.

Can Cancer Be Prevented?

All cancers caused by cigarette smoking and heavy use of alcohol could be prevented completely. The American Cancer Society estimates that in 2011 about 171,600 cancer deaths are expected to be caused by tobacco use. Scientific evidence suggests that about one-third of the 571,950 cancer deaths expected to occur in 2011 will be related to overweight or obesity, physical inactivity, and poor nutrition and thus could also be prevented. Certain cancers are related to infectious agents, such as hepatitis B virus (HBV), human papillomavirus (HPV), human immunodeficiency virus (HIV), *Helicobacter pylori (H. pylori)*, and others, and could be prevented through behavioral changes, vaccines, or antibiotics. In addition, many of the more than 2 million skin cancers that are diagnosed annually could be prevented by protection from the sun's rays and avoiding indoor tanning.

Regular screening examinations by a health care professional can result in the detection and removal of precancerous growths, as well as the diagnosis of cancers at an early stage, when they are most treatable. Cancers of the cervix, colon, and rectum can be prevented by removal of precancerous tissue. Cancers that can be diagnosed early through screening include cancers of the breast, colon, rectum, cervix, prostate, oral cavity, and skin. However, screening has been shown to reduce mortality only for cancers of the breast, colon, rectum, and cervix. A heightened awareness of breast changes or skin changes may also result in detection of these tumors at earlier stages. Cancers that can be prevented or detected earlier by screening account for at least half of all new cancer cases.

Who Is at Risk of Developing Cancer?

Anyone can develop cancer. Since the risk of being diagnosed with cancer increases with age, most cases occur in adults who are middle aged or older. About 78% of all cancers are diagnosed in persons 55 years of age and older. Cancer researchers use the word "risk" in different ways, most commonly expressing risk as lifetime risk or relative risk.

Lifetime risk refers to the probability that an individual, over the course of a lifetime, will develop or die from cancer. In the US, men have slightly less than a 1 in 2 lifetime risk of developing cancer; for women, the risk is a little more than 1 in 3.

Relative risk is a measure of the strength of the relationship between risk factors and a particular cancer. It compares the risk of developing cancer in persons with a certain exposure or trait to the risk in persons who do not have this characteristic. For example, male smokers are about 23 times more likely to develop lung cancer than nonsmokers, so their relative risk is 23. Most relative risks are not this large. For example, women who have a first-degree relative (mother, sister, or daughter) with a history of breast cancer have about twice the risk of developing breast cancer, compared to women who do not have this family history.

All cancers involve the malfunction of genes that control cell growth and division. About 5% of all cancers are strongly hereditary, in that an inherited genetic alteration confers a very high risk of developing one or more specific types of cancer. However, most cancers do not result from inherited genes but from damage to genes occurring during one's lifetime. Genetic damage may result from internal factors, such as hormones or the metabolism of nutrients within cells, or external factors, such as tobacco, chemicals, and excessive exposure to sunlight.

How Many People Alive Today Have Ever Had Cancer?

The National Cancer Institute estimates that approximately 11.7 million Americans with a history of cancer were alive in January 2007. Some of these individuals were cancer-free, while others still had evidence of cancer and may have been undergoing treatment.

How Many New Cases Are Expected to Occur This Year?

About 1,596,670 new cancer cases are expected to be diagnosed in 2011. This estimate does not include carcinoma in situ (noninvasive cancer) of any site except urinary bladder, and does not include basal and squamous cell skin cancers, which are not required to be reported to cancer registries.

How Many People Are Expected to Die of Cancer This Year?

In 2011, about 571,950 Americans are expected to die of cancer, more than 1,500 people a day. Cancer is the second most common cause of death in the US, exceeded only by heart disease. In the US, cancer accounts for nearly 1 of every 4 deaths.

What Percentage of People Survive Cancer?

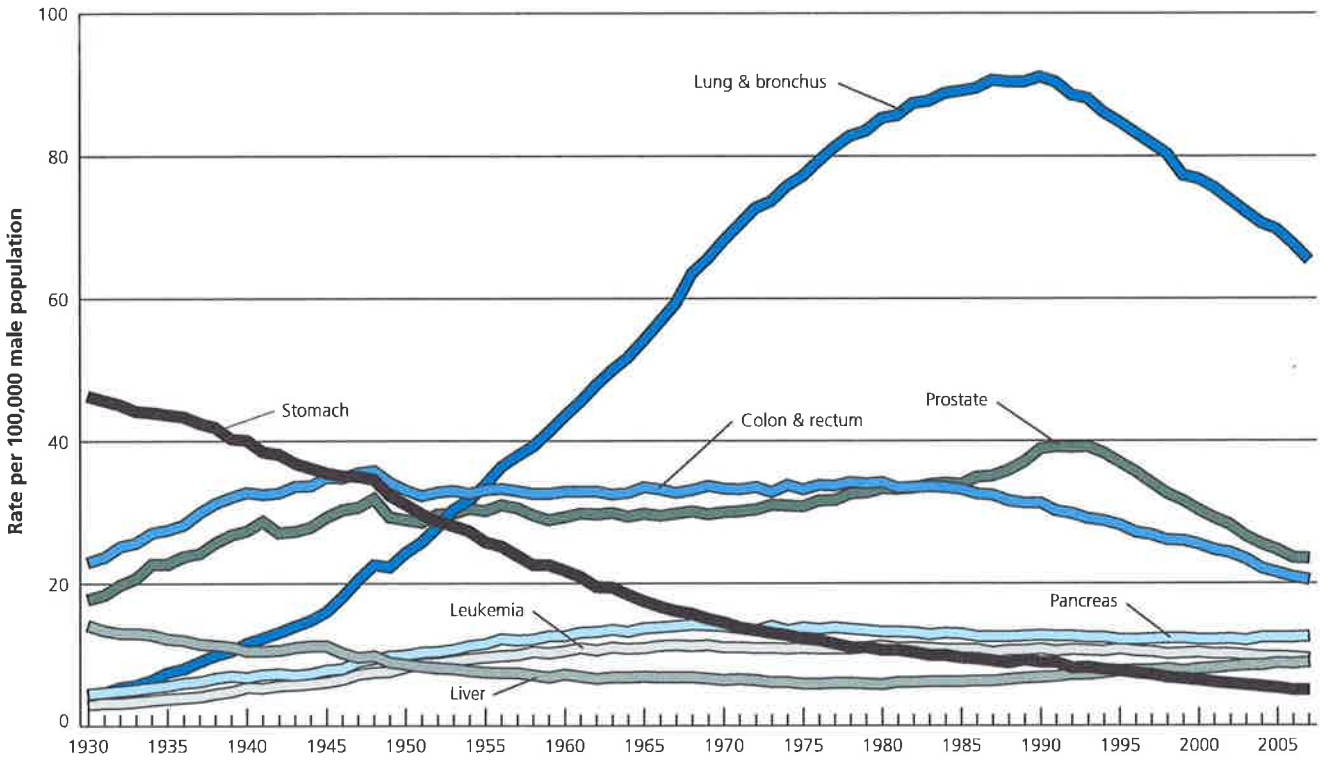
The 5-year relative survival rate for all cancers diagnosed between 1999 and 2006 is 68%, up from 50% in 1975-1977 (see page 18). The improvement in survival reflects progress in diagnosing certain cancers at an earlier stage and improvements in treatment. Survival statistics vary greatly by cancer type and stage at diagnosis. Relative survival compares survival among cancer patients to that of people not diagnosed with cancer who are of the same age, race, and sex. It represents the percentage of cancer patients who are alive after some designated time period (usually 5 years) relative to persons without cancer. It does not distinguish between patients who have been cured and those who have relapsed or are still in treatment. While 5-year relative survival is useful in monitoring progress in the early detection and treatment of cancer, it does not represent the proportion of people who are cured permanently, since cancer deaths can occur beyond 5 years after diagnosis.

Although relative survival for specific cancer types provides some indication about the average survival experience of cancer patients in a given population, it may or may not predict individual prognosis and should be interpreted with caution. First, 5-year relative survival rates for the most recent time period are based on patients who were diagnosed from 1999 to 2006 and do not reflect recent advances in detection and treatment. Second, factors that influence survival, such as treatment protocols, additional illnesses, and biological or behavioral differences of each individual, cannot be taken into account in the estimation of relative survival rates. For more information about survival rates, see Sources of Statistics on page 53.

How Is Cancer Staged?

Staging describes the extent or spread of the disease at the time of diagnosis. Proper staging is essential in determining the choice of therapy and in assessing prognosis. A cancer's stage is

Age-adjusted Cancer Death Rates,* Males by Site, US, 1930-2007



*Per 100,000, age adjusted to the 2000 US standard population.

Note: Due to changes in ICD coding, numerator information has changed over time. Rates for cancer of the liver, lung and bronchus, and colon and rectum are affected by these changes.

Source: US Mortality Data, 1960 to 2007, US Mortality Volumes, 1930 to 1959, National Center for Health Statistics, Centers for Disease Control and Prevention.

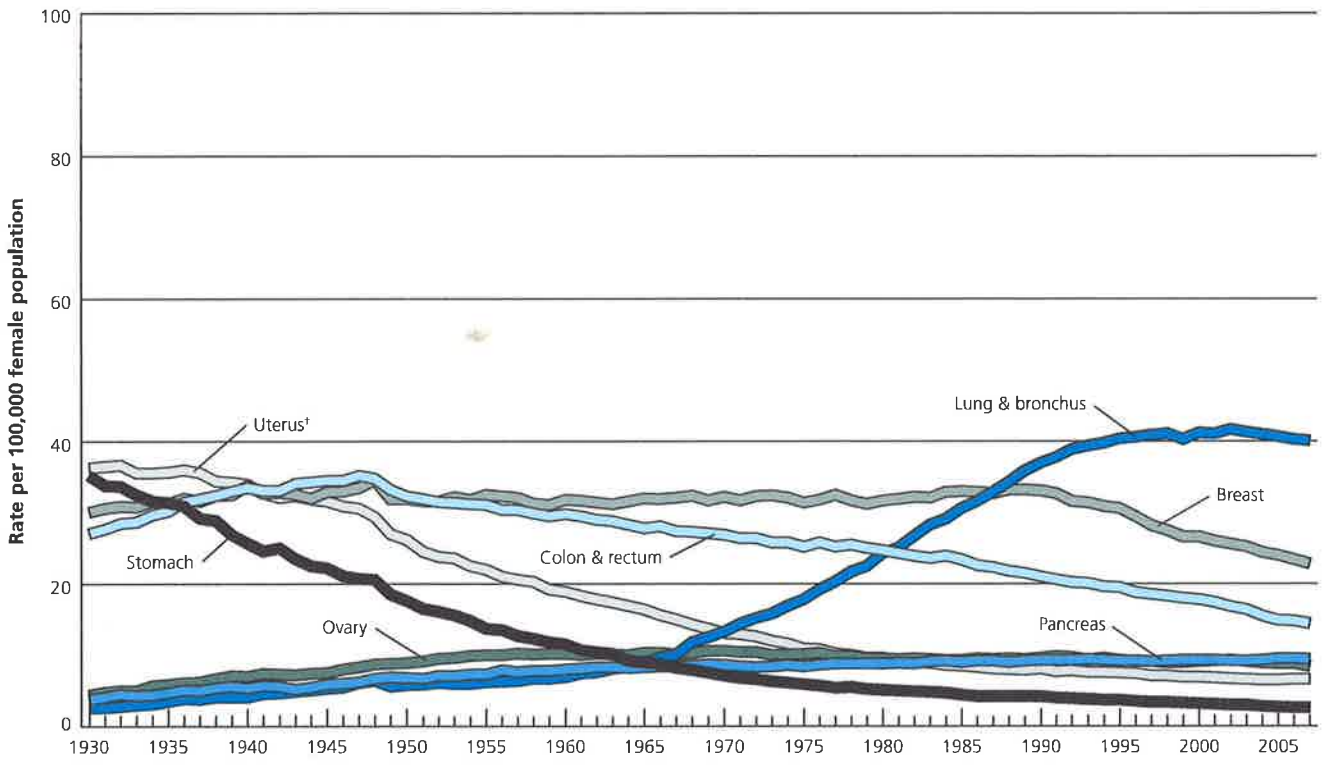
based on the primary tumor's size and whether it has spread to other areas of the body. A number of different staging systems are used to classify tumors. The TNM staging system assesses tumors in three ways: extent of the primary tumor (T), absence or presence of regional lymph node involvement (N), and absence or presence of distant metastases (M). Once the T, N, and M are determined, a stage of I, II, III, or IV is assigned, with stage I being early and stage IV being advanced disease. A different system of summary staging (in situ, local, regional, and distant) is used for descriptive and statistical analysis of tumor registry data. If cancer cells are present only in the layer of cells where they developed and have not spread, the stage is in situ. If cancer cells have penetrated the original layer of tissue, the cancer is invasive. (For a description of the other summary stage categories, see Five-year Relative Survival Rates by Stage at Diagnosis, 1999-2006, page 17.) As the molecular properties of cancer have become better understood, prognostic models have been developed for some cancer sites that incorporate biological markers and genetic features in addition to anatomical characteristics.

What Are the Costs of Cancer?

The National Institutes of Health estimates overall costs of cancer in 2010 at $263.8 billion: $102.8 billion for direct medical costs (total of all health expenditures); $20.9 billion for indirect morbidity costs (cost of lost productivity due to illness); and $140.1 billion for indirect mortality costs (cost of lost productivity due to premature death).

Lack of health insurance and other barriers prevents many Americans from receiving optimal health care. According to the US Census Bureau, almost 51 million Americans were uninsured in 2009; almost one-third of Hispanics (32%) and one in 10 children (17 years and younger) had no health insurance coverage. Uninsured patients and those from ethnic minorities are substantially more likely to be diagnosed with cancer at a later stage, when treatment can be more extensive and more costly. For more information on the relationship between health insurance and cancer, see *Cancer Facts & Figures 2008*, Special Section, available online at cancer.org/statistics.

Age-adjusted Cancer Death Rates,* Females by Site, US, 1930-2007



*Per 100,000, age adjusted to the 2000 US standard population.

Note: Due to changes in ICD coding, numerator information has changed over time. Rates for cancer of the liver, lung and bronchus, and colon and rectum are affected by these changes.

Source: US Mortality Data, 1960 to 2007, US Mortality Volumes, 1930 to 1959, National Center for Health Statistics, Centers for Disease Control and Prevention.

Estimated New Cancer Cases and Deaths by Sex for All Sites, US, 2011*

	Estimated New Cases			Estimated Deaths		
	Both Sexes	Male	Female	Both Sexes	Male	Female
All Sites	1,596,670	822,300	774,370	571,950	300,430	271,520
Oral cavity & pharynx	39,400	27,710	11,690	7,900	5,460	2,440
Tongue	12,060	8,560	3,500	2,030	1,320	710
Mouth	11,510	6,950	4,560	1,790	1,130	660
Pharynx	13,580	10,600	2,980	2,430	1,740	690
Other oral cavity	2,250	1,600	650	1,650	1,270	380
Digestive system	277,570	151,540	126,030	139,250	79,020	60,230
Esophagus	16,980	13,450	3,530	14,710	11,910	2,800
Stomach	21,520	13,120	8,400	10,340	6,260	4,080
Small intestine	7,570	3,990	3,580	1,100	610	490
Colon†	101,340	48,940	52,400	49,380	25,250	24,130
Rectum	39,870	22,910	16,960			
Anus, anal canal, & anorectum	5,820	2,140	3,680	770	300	470
Liver & intrahepatic bile duct	26,190	19,260	6,930	19,590	13,260	6,330
Gallbladder & other biliary	9,250	3,990	5,260	3,300	1,230	2,070
Pancreas	44,030	22,050	21,980	37,660	19,360	18,300
Other digestive organs	5,000	1,690	3,310	2,400	840	1,560
Respiratory system	239,320	128,890	110,430	161,250	88,890	72,360
Larynx	12,740	10,160	2,580	3,560	2,840	720
Lung & bronchus	221,130	115,060	106,070	156,940	85,600	71,340
Other respiratory organs	5,450	3,670	1,780	750	450	300
Bones & joints	2,810	1,620	1,190	1,490	850	640
Soft tissue (including heart)	10,980	6,050	4,930	3,920	2,060	1,860
Skin (excluding basal & squamous)	76,330	43,890	32,440	11,980	8,080	3,900
Melanoma-skin	70,230	40,010	30,220	8,790	5,750	3,040
Other nonepithelial skin	6,100	3,880	2,220	3,190	2,330	860
Breast	232,620	2,140	230,480	39,970	450	39,520
Genital system	338,620	250,540	88,080	63,980	34,390	29,590
Uterine cervix	12,710		12,710	4,290		4,290
Uterine corpus	46,470		46,470	8,120		8,120
Ovary	21,990		21,990	15,460		15,460
Vulva	4,340		4,340	940		940
Vagina & other genital, female	2,570		2,570	780		780
Prostate	240,890	240,890		33,720	33,720	
Testis	8,290	8,290		350	350	
Penis & other genital, male	1,360	1,360		320	320	
Urinary system	132,900	90,750	42,150	28,970	19,460	9,510
Urinary bladder	69,250	52,020	17,230	14,990	10,670	4,320
Kidney & renal pelvis	60,920	37,120	23,800	13,120	8,270	4,850
Ureter & other urinary organs	2,730	1,610	1,120	860	520	340
Eye & orbit	2,570	1,270	1,300	240	130	110
Brain & other nervous system	22,340	12,260	10,080	13,110	7,440	5,670
Endocrine system	50,400	12,820	37,580	2,620	1,160	1,460
Thyroid	48,020	11,470	36,550	1,740	760	980
Other endocrine	2,380	1,350	1,030	880	400	480
Lymphoma	75,190	40,880	34,310	20,620	10,510	10,110
Hodgkin lymphoma	8,830	4,820	4,010	1,300	760	540
Non-Hodgkin lymphoma	66,360	36,060	30,300	19,320	9,750	9,570
Myeloma	20,520	11,400	9,120	10,610	5,770	4,840
Leukemia	44,600	25,320	19,280	21,780	12,740	9,040
Acute lymphocytic leukemia	5,730	3,320	2,410	1,420	780	640
Chronic lymphocytic leukemia	14,570	8,520	6,050	4,380	2,660	1,720
Acute myeloid leukemia	12,950	6,830	6,120	9,050	5,440	3,610
Chronic myeloid leukemia	5,150	3,000	2,150	270	100	170
Other leukemia‡	6,200	3,650	2,550	6,660	3,760	2,900
Other & unspecified primary sites‡	30,500	15,220	15,280	44,260	24,020	20,240

*Rounded to the nearest 10; estimated new cases exclude basal and squamous cell skin cancers and in situ carcinomas except urinary bladder. About 57,650 carcinoma in situ of the female breast and 53,360 melanoma in situ will be newly diagnosed in 2011. †Estimated deaths for colon and rectum cancers are combined. ‡More deaths than cases may reflect lack of specificity in recording underlying cause of death on death certificates and/or an undercount in the case estimate.

Source: Estimated new cases are based on 1995-2007 incidence rates from 46 states and the District of Columbia as reported by the North American Association of Central Cancer Registries (NAACCR), represesnting about 95% of the US population. Estimated deaths are based on data from US Mortality Data, 1969 to 2007, National Center for Health Statistics, Centers for Disease Control and Prevention.

Estimated New Cancer Cases for Select Sites by State, US, 2011*

State	All Sites	Female Breast	Uterine Cervix	Colon & Rectum	Uterine Corpus	Leukemia	Lung & Bronchus	Melanoma of the Skin	Non-Hodgkin Lymphoma	Prostate	Urinary Bladder
Alabama	25,530	3,700	210	2,310	550	590	4,240	1,260	960	3,680	930
Alaska	3,090	460	†	260	80	80	380	90	130	490	130
Arizona	31,550	4,240	220	2,620	800	780	3,820	1,330	1,220	4,660	1,530
Arkansas	16,070	2,100	130	1,550	370	420	2,660	500	650	2,400	650
California	163,480	25,510	1,520	13,880	4,730	4,760	17,660	8,250	7,070	25,030	6,810
Colorado	22,390	3,390	160	1,780	600	710	2,250	1,130	970	3,920	960
Connecticut	21,440	3,280	110	1,680	700	520	2,680	1,060	880	3,300	1,050
Delaware	5,130	810	†	430	150	120	780	240	200	840	230
Dist. of Columbia	2,830	500	†	240	80	70	360	70	100	580	90
Florida	113,400	15,330	900	10,180	2,960	3,440	17,150	5,260	4,720	16,780	5,490
Georgia	44,580	7,030	410	3,940	1,120	1,130	6,410	2,120	1,670	7,360	1,460
Hawaii	6,710	1,040	50	670	230	170	780	340	230	850	230
Idaho	7,520	1,030	50	620	210	240	870	340	310	1,320	350
Illinois	65,610	9,510	570	6,240	2,050	1,870	9,210	2,340	2,640	9,340	2,910
Indiana	34,050	4,760	260	3,290	1,010	970	5,520	1,410	1,390	4,580	1,440
Iowa	17,500	2,120	100	1,670	560	580	2,480	890	770	2,590	810
Kansas	14,070	1,890	90	1,300	440	430	1,990	710	620	1,870	580
Kentucky	25,010	3,470	210	2,420	690	650	4,860	1,510	1,040	3,220	1,020
Louisiana	22,780	2,940	220	2,220	470	620	3,630	630	930	3,640	870
Maine	8,820	1,280	50	770	300	260	1,400	400	370	1,240	500
Maryland	28,890	4,850	230	2,470	900	700	3,960	1,330	1,130	5,060	1,150
Massachusetts	37,470	5,640	200	3,000	1,210	970	4,970	1,740	1,550	5,470	1,870
Michigan	57,010	7,890	360	4,800	1,810	1,630	8,140	2,470	2,330	8,940	2,680
Minnesota	27,600	3,380	130	2,110	820	820	3,340	880	1,140	4,370	1,100
Mississippi	14,990	2,170	150	1,520	320	370	2,430	500	550	2,150	520
Missouri	32,740	4,100	230	3,150	960	880	5,470	1,310	1,300	4,230	1,370
Montana	5,690	760	†	480	150	170	750	190	240	1,020	280
Nebraska	9,430	1,240	50	930	310	290	1,270	430	430	1,290	410
Nevada	12,800	1,420	110	1,080	290	290	1,510	410	440	1,850	540
New Hampshire	8,210	1,190	†	650	260	210	1,110	410	330	1,200	410
New Jersey	49,080	7,360	430	4,290	1,630	1,360	6,210	2,430	2,140	7,840	2,390
New Mexico	9,630	1,310	80	820	240	320	980	400	370	1,420	360
New York	107,260	15,710	960	9,480	3,670	3,070	14,200	3,750	4,650	15,950	5,150
North Carolina	48,870	7,390	380	4,200	1,280	1,230	7,300	2,300	1,930	7,580	1,900
North Dakota	3,560	430	†	340	100	100	420	130	150	600	170
Ohio	65,060	8,970	480	5,850	2,080	1,690	10,060	2,620	2,660	9,190	2,890
Oklahoma	18,980	2,680	170	1,800	480	590	3,270	690	850	2,730	760
Oregon	21,180	3,360	130	1,730	630	560	2,860	1,230	940	3,250	1,020
Pennsylvania	78,030	10,570	540	7,360	2,620	2,090	10,900	3,240	3,340	11,500	3,920
Rhode Island	6,090	930	†	510	200	160	880	270	250	880	320
South Carolina	25,510	3,710	200	2,100	650	640	3,900	1,200	960	4,230	950
South Dakota	4,430	590	†	460	130	140	580	180	190	670	220
Tennessee	34,750	5,020	280	3,170	850	930	5,870	1,810	1,410	4,850	1,350
Texas	105,000	15,070	1,230	9,560	2,670	3,280	13,880	3,970	4,520	15,630	3,670
Utah	10,530	1,380	70	760	300	320	630	600	440	1,890	400
Vermont	3,950	590	†	320	130	100	530	210	160	610	190
Virginia	38,720	6,480	300	3,420	1,150	940	5,670	1,920	1,520	6,420	1,500
Washington	35,360	5,630	230	2,720	1,060	1,060	4,540	2,000	1,610	5,470	1,640
West Virginia	11,080	1,510	80	1,140	360	300	2,080	480	480	1,510	510
Wisconsin	30,530	4,430	190	2,690	1,060	960	4,020	1,160	1,390	4,900	1,450
Wyoming	2,680	360	†	230	70	70	310	110	120	490	130
United States	1,596,670	230,480	12,710	141,210	46,470	44,600	221,130	70,230	66,360	240,890	69,250

*Rounded to nearest 10. Excludes basal and squamous cell skin cancers and in situ carcinomas except urinary bladder. †Estimate is fewer than 50 cases.

Note: These estimates are offered as a rough guide and should be interpreted with caution. State estimates may not sum to US total due to rounding and exclusion of state estimates fewer than 50 cases.

Estimated Cancer Deaths for Select Sites by State, US, 2011*

State	All Sites	Brain/ Nervous System	Female Breast	Colon & Rectum	Leukemia	Liver	Lung & Bronchus	Non-Hodgkin Lymphoma	Ovary	Pancreas	Prostate
Alabama	10,210	210	700	930	350	320	3,210	310	290	600	710
Alaska	910	†	70	80	†	†	250	†	†	60	†
Arizona	10,820	290	760	1,020	420	400	2,660	340	330	690	640
Arkansas	6,460	140	440	580	240	210	2,030	190	150	440	330
California	56,030	1,480	3,980	4,780	2,200	2,700	12,450	2,050	1,630	4,010	4,330
Colorado	6,980	210	500	650	300	240	1,690	290	240	480	430
Connecticut	6,800	150	480	500	260	220	1,750	220	190	550	460
Delaware	1,930	†	120	160	60	60	590	50	50	120	110
Dist. of Columbia	920	†	80	90	†	†	210	†	†	70	80
Florida	40,980	790	2,690	3,370	1,570	1,410	11,460	1,310	1,020	2,610	2,160
Georgia	15,860	330	1,120	1,420	560	450	4,670	500	440	980	1,080
Hawaii	2,370	†	140	220	80	120	580	90	60	180	140
Idaho	2,570	90	160	210	120	70	630	90	70	200	210
Illinois	23,140	470	1,830	2,190	900	710	6,420	680	640	1,610	1,310
Indiana	12,960	340	870	1,090	520	350	4,020	420	350	810	690
Iowa	6,390	160	380	600	300	170	1,770	290	190	390	410
Kansas	5,370	140	370	480	300	150	1,600	190	150	340	290
Kentucky	9,750	190	590	850	320	250	3,420	300	220	550	410
Louisiana	8,360	210	610	900	300	360	2,480	270	220	540	480
Maine	3,180	80	170	260	110	90	960	80	80	200	170
Maryland	10,240	210	800	920	390	380	2,720	300	270	710	770
Massachusetts	12,910	270	760	980	470	460	3,490	360	370	940	640
Michigan	20,770	510	1,320	1,670	820	610	5,830	660	560	1,360	1,150
Minnesota	9,240	230	610	750	390	290	2,470	310	250	610	460
Mississippi	6,060	150	400	620	220	200	2,010	190	150	360	360
Missouri	12,700	280	870	1,060	510	390	3,970	450	300	830	540
Montana	2,000	60	110	170	90	50	570	80	60	120	140
Nebraska	3,510	90	200	350	140	90	900	140	90	200	280
Nevada	4,740	120	330	540	100	190	1,290	150	120	320	310
New Hampshire	2,690	70	190	200	100	80	770	60	60	200	160
New Jersey	16,370	330	1,260	1,510	610	470	4,160	630	470	1,140	1,100
New Mexico	3,460	80	240	340	120	160	800	120	90	230	270
New York	34,350	810	2,450	2,890	1,350	1,310	8,580	1,470	1,000	2,470	1,770
North Carolina	19,760	340	1,390	1,480	660	520	5,770	550	460	1,200	990
North Dakota	1,280	†	80	110	50	†	310	†	†	100	80
Ohio	24,900	540	1,730	2,170	910	700	7,210	830	600	1,550	1,260
Oklahoma	7,780	170	530	690	290	230	2,390	280	180	400	350
Oregon	7,550	210	490	700	280	240	2,110	320	240	540	470
Pennsylvania	28,560	540	1,970	2,440	1,080	870	7,960	1,090	800	2,070	1,920
Rhode Island	2,150	50	120	140	90	80	590	50	60	140	80
South Carolina	9,310	200	660	740	330	280	2,910	300	260	570	550
South Dakota	1,680	†	100	150	70	50	450	80	50	110	120
Tennessee	13,790	340	890	1,170	490	390	4,570	470	330	770	750
Texas	36,770	830	2,620	3,230	1,410	1,730	9,560	1,060	950	2,260	2,060
Utah	2,880	100	260	250	140	80	490	100	90	200	230
Vermont	1,290	†	100	110	60	†	360	†	†	80	60
Virginia	14,340	300	1,140	1,270	500	430	4,100	440	410	950	780
Washington	11,740	380	800	960	490	460	3,090	430	370	790	760
West Virginia	4,680	100	270	420	140	120	1,480	190	120	220	120
Wisconsin	11,440	260	690	860	480	340	2,940	390	330	730	600
Wyoming	1,020	†	60	110	†	†	260	50	†	70	60
United States	571,950	13,110	39,520	49,380	21,780	19,590	156,940	19,320	15,460	37,660	33,720

*Rounded to nearest 10. †Estimate is fewer than 50 deaths.

Note: State estimates may not add to US total due to rounding and exclusion of state estimates fewer than 50 deaths.

Source: US Mortality Data, 1969 to 2007, National Center for Health Statistics, Centers for Disease Control and Prevention.

Cancer Incidence Rates* by Site and State, US, 2003-2007

	All Sites		Breast	Colon & Rectum		Lung & Bronchus		Non-Hodgkin Lymphoma		Prostate	Urinary Bladder	
State	Male	Female	Female	Male	Female	Male	Female	Male	Female	Male	Male	Female
Alabama†	567.5	381.2	114.5	61.4	41.6	106.3	53.2	20.0	13.9	158.4	32.0	7.7
Alaska	512.0	423.5	128.6	56.8	44.3	84.2	63.5	22.1	16.7	133.4	37.5	7.8
Arizona	452.0	355.0	103.6	44.7	33.1	65.4	48.5	18.0	13.1	123.4	33.0	8.4
Arkansas	565.2	386.5	111.3	57.5	41.9	110.9	60.2	22.1	15.2	161.3	33.3	8.6
California	508.9	392.4	121.0	51.4	38.8	63.9	46.3	22.5	15.5	147.1	34.0	8.1
Colorado	503.6	393.8	122.4	49.8	38.6	58.8	45.3	21.7	16.0	158.9	33.3	8.5
Connecticut	589.3	456.3	134.5	59.4	44.4	80.5	60.3	26.0	18.1	163.5	46.3	12.5
Delaware	612.6	443.6	125.7	61.4	44.0	98.0	70.7	23.9	16.6	182.2	43.6	11.8
Dist. of Columbia‡	569.5	421.9	139.4	58.1	47.9	79.4	46.3	22.9	13.4	185.4	24.8	8.6
Florida	532.0	401.0	112.5	53.1	40.4	86.7	59.4	21.5	15.2	137.2	36.4	9.4
Georgia	562.7	393.2	118.5	56.9	41.2	98.8	53.9	21.1	14.3	162.0	32.7	7.9
Hawaii	493.8	386.8	120.6	59.5	40.1	69.2	40.5	19.4	12.4	131.6	25.8	6.5
Idaho	536.2	404.9	116.3	48.2	38.4	68.3	49.1	21.8	17.1	165.8	36.0	9.0
Illinois	576.7	430.3	122.6	65.6	47.3	91.2	59.4	24.2	16.2	157.0	40.2	10.5
Indiana	552.7	416.1	113.8	61.3	45.2	102.4	63.9	22.9	17.0	137.2	37.2	9.4
Iowa	557.2	429.2	122.4	61.9	48.0	89.3	54.2	25.2	18.1	141.8	41.4	9.3
Kansas	559.3	419.3	124.6	60.7	42.4	87.6	53.7	24.3	18.1	158.5	36.2	8.9
Kentucky	610.0	452.8	120.1	67.6	48.9	131.3	78.2	23.5	17.1	141.7	39.2	10.1
Louisiana†	616.4	409.0	118.8	66.7	46.0	107.8	58.9	23.5	16.6	174.5	35.4	8.5
Maine	618.9	466.2	128.8	61.6	47.2	99.1	66.6	24.6	18.8	166.2	49.8	13.9
Maryland‡	537.8	414.7	123.8	54.4	41.4	81.5	57.9	20.9	14.5	159.4	32.8	9.8
Massachusetts	594.0	456.8	131.7	60.5	43.9	82.2	63.1	24.5	16.9	164.6	45.9	12.7
Michigan	591.8	437.2	122.2	57.1	43.4	91.9	62.5	25.7	18.7	173.0	41.9	10.7
Minnesota	567.2	418.4	125.9	54.8	41.6	69.0	49.7	26.3	17.8	183.4	40.0	10.1
Mississippi†‡	589.5	383.7	109.7	64.1	46.3	114.5	54.9	20.6	13.8	170.8	29.4	7.3
Missouri	549.3	417.8	119.8	61.1	44.0	104.1	63.9	21.8	15.8	132.5	35.7	8.6
Montana	527.8	405.3	120.2	50.3	39.6	74.5	58.3	22.5	14.5	168.5	38.3	9.3
Nebraska	562.4	419.2	122.8	66.6	47.4	84.2	51.2	24.4	17.7	159.0	37.1	9.5
Nevada§	—	—	—	—	—	—	—	—	—	—	—	—
New Hampshire	578.8	454.6	130.1	56.0	43.1	82.5	62.4	23.5	18.1	155.7	46.8	13.3
New Jersey	598.2	451.2	128.4	62.6	46.0	78.3	56.3	25.6	17.7	172.4	46.7	12.1
New Mexico	474.8	365.1	109.3	48.2	35.9	55.7	38.7	18.3	14.3	144.4	26.2	7.3
New York	576.8	435.6	124.3	58.4	44.3	78.2	54.3	25.0	17.5	165.8	42.2	11.1
North Carolina	561.6	406.3	121.4	56.0	40.9	101.0	57.6	21.9	15.4	153.9	35.7	9.0
North Dakota	552.3	410.0	123.4	68.5	43.5	73.6	48.0	23.1	16.8	165.8	40.3	10.4
Ohio	548.4	418.6	119.9	60.0	44.5	96.1	59.7	23.1	16.4	145.5	38.8	9.5
Oklahoma	572.3	428.9	126.8	58.6	43.7	105.3	64.9	23.2	17.8	154.0	35.9	8.8
Oregon	527.1	428.4	130.2	51.8	39.9	77.1	60.1	24.0	16.6	146.8	38.7	9.9
Pennsylvania	590.0	447.4	123.9	63.9	47.4	90.0	57.1	25.0	17.5	158.1	44.9	11.3
Rhode Island	607.1	460.0	130.0	61.8	45.7	92.6	61.9	24.9	17.4	153.5	52.9	13.0
South Carolina	576.5	398.6	119.8	58.5	42.8	100.2	53.7	20.8	14.4	166.5	31.6	8.0
South Dakota	526.0	387.4	116.8	56.6	42.7	77.4	46.3	21.0	16.5	165.0	35.7	7.9
Tennessee‡	543.8	399.1	116.5	57.8	43.0	109.8	60.1	21.5	15.5	135.6	33.4	8.1
Texas†	539.1	389.6	113.3	56.3	39.1	86.0	50.9	22.5	16.0	145.2	30.2	7.3
Utah	483.4	342.4	108.1	44.4	31.6	36.2	23.2	22.6	16.1	178.8	28.8	5.9
Vermont	562.1	456.4	130.4	49.4	42.9	84.5	61.1	23.8	18.3	155.5	45.1	12.6
Virginia	539.1	391.9	122.1	54.2	41.0	88.5	53.8	20.8	13.9	159.1	33.8	8.5
Washington	559.5	436.8	130.3	51.2	38.6	76.1	59.3	27.0	18.2	161.7	40.3	9.8
West Virginia	582.5	439.9	115.3	68.0	48.7	116.3	71.3	24.0	17.3	140.1	39.7	11.0
Wisconsin	543.8	426.3	122.0	54.6	42.2	76.8	53.8	25.5	18.7	148.3	39.7	11.1
Wyoming	512.0	389.9	114.8	51.0	41.6	59.9	48.3	21.3	15.7	167.9	40.8	9.3
United States	552.5	414.7	120.7	57.1	42.4	84.9	55.6	23.2	16.3	153.5	37.7	9.6

* Per 100,000, age adjusted to the 2000 US standard population. †Data for 2005 are limited to cases diagnosed from January-June due to the effect of large migrations of populations on this state as a result of Hurricane Katrina in September 2005. ‡This state's data are not included in the rates for the US overall because its cancer registry did not achieve high-quality data standards for one or more years during 2003-2007 according to the North American Association of Central Cancer Registry (NAACCR) data quality indicators. §This state's registry did not submit incidence data to NAACCR for 2003-2007.

Source: NAACCR, 2010. Data are collected by cancer registries participating in the National Cancer Institute's SEER program and the Centers for Disease Control and Prevention's National Program of Cancer Registries.

Cancer Death Rates* by Site and State, US, 2003-2007

	All Sites		Breast	Colon & Rectum		Lung & Bronchus		Non-Hodgkin Lymphoma		Pancreas		Prostate
State	Male	Female	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
Alabama	263.8	159.9	24.8	23.6	15.1	92.2	41.7	8.6	5.7	12.7	9.2	30.1
Alaska	213.0	156.0	22.7	21.0	13.8	64.8	44.4	7.4	4.8	11.7	9.3	20.6
Arizona	190.6	135.4	21.3	18.5	12.5	54.1	34.9	7.7	4.9	11.0	7.7	21.0
Arkansas	255.5	164.9	24.4	23.4	15.7	93.2	47.5	8.9	5.3	12.6	9.4	27.1
California	198.7	145.2	22.8	18.8	13.5	51.4	34.5	8.3	5.2	11.6	9.3	23.6
Colorado	190.6	139.4	21.3	18.7	13.9	47.8	32.9	8.4	5.0	10.9	8.8	24.5
Connecticut	218.2	154.7	23.7	18.8	14.2	59.6	40.1	8.8	5.5	14.2	10.0	25.5
Delaware	241.4	168.4	24.6	22.3	16.0	76.4	50.4	9.2	5.0	11.2	9.5	26.1
Dist. of Columbia	258.1	162.2	28.3	24.4	17.6	69.1	34.9	8.8	4.1	15.5	10.4	41.7
Florida	211.0	145.3	22.1	18.9	13.4	66.2	40.6	8.3	5.1	11.7	8.5	20.5
Georgia	241.1	153.0	23.9	21.3	14.7	81.6	39.7	8.2	5.0	12.5	9.1	28.9
Hawaii	187.3	122.6	17.9	19.9	11.4	51.2	27.7	7.5	4.3	12.2	9.3	17.1
Idaho	202.3	146.6	21.6	17.2	13.7	53.4	35.4	8.4	6.2	11.5	10.3	27.5
Illinois	235.4	163.4	25.2	23.9	16.5	71.1	42.2	9.2	5.7	13.0	9.9	26.2
Indiana	249.4	166.7	24.5	24.0	15.7	83.9	47.6	10.0	6.0	13.1	9.4	25.6
Iowa	225.4	153.3	22.0	22.1	15.8	70.8	39.1	9.5	5.9	11.7	8.9	25.9
Kansas	225.2	154.1	24.0	21.6	15.0	72.3	41.2	9.7	6.0	12.5	9.4	22.6
Kentucky	275.0	177.6	24.2	25.2	17.6	105.2	56.0	9.6	6.0	12.5	9.4	25.8
Louisiana	270.7	171.5	27.7	26.3	16.9	89.7	45.6	9.4	5.8	13.6	10.7	28.8
Maine	245.0	169.5	22.6	20.8	16.3	76.9	48.7	9.4	5.6	12.9	9.9	25.4
Maryland	230.8	161.7	25.8	22.8	15.6	69.1	42.9	8.1	5.1	12.8	10.5	27.5
Massachusetts	230.5	159.4	22.9	21.1	14.8	65.5	43.8	8.9	5.7	13.4	10.2	24.6
Michigan	232.8	163.1	24.5	21.1	15.4	72.5	44.1	9.6	6.3	13.4	9.7	23.9
Minnesota	211.9	149.1	21.8	18.8	13.7	58.3	37.0	9.5	5.5	11.7	9.1	25.3
Mississippi	276.3	162.0	25.8	24.9	16.9	99.4	43.0	8.3	4.9	13.5	9.8	32.1
Missouri	245.7	164.9	25.8	22.5	15.6	84.3	46.6	8.9	5.6	12.9	9.5	23.6
Montana	211.2	156.5	21.4	18.1	14.3	60.7	43.3	8.7	6.1	12.1	8.8	27.8
Nebraska	218.8	148.0	22.4	23.1	15.7	65.6	35.6	9.1	6.2	12.1	8.4	24.5
Nevada	217.9	165.2	23.9	22.0	16.5	65.0	50.9	7.0	5.3	11.9	9.5	24.5
New Hampshire	227.2	162.2	23.1	21.0	14.8	65.5	44.7	8.7	5.5	12.4	11.2	26.2
New Jersey	222.5	163.2	27.0	23.3	16.7	61.5	39.7	8.9	5.8	13.1	9.8	23.9
New Mexico	194.8	138.0	22.1	19.2	13.3	46.1	29.9	7.4	4.9	11.2	9.1	25.4
New York	206.0	150.5	23.9	20.8	15.0	57.7	36.7	8.0	5.2	12.4	9.6	23.5
North Carolina	244.8	157.7	24.8	21.2	14.5	82.5	42.0	8.3	5.4	12.8	9.6	27.7
North Dakota	210.8	147.9	22.4	21.3	14.8	58.6	35.1	8.4	5.2	11.6	9.5	26.4
Ohio	249.1	168.3	26.6	23.6	16.8	80.3	45.3	9.6	5.9	12.9	9.6	26.3
Oklahoma	246.0	162.6	24.7	23.1	15.0	85.0	47.1	9.3	5.9	11.8	8.5	23.6
Oregon	219.9	161.7	23.2	19.3	14.8	64.2	45.5	9.5	6.2	12.4	10.0	26.0
Pennsylvania	239.6	164.0	25.6	23.6	16.1	71.4	40.4	9.6	6.2	13.4	9.9	25.0
Rhode Island	234.9	158.6	22.8	21.0	14.6	69.8	42.0	8.8	5.2	11.5	9.3	24.2
South Carolina	249.0	156.7	24.4	21.4	15.2	83.9	40.6	8.0	5.2	12.4	9.3	28.9
South Dakota	220.3	145.7	22.3	21.4	15.1	65.5	36.5	8.8	5.4	11.2	9.5	26.0
Tennessee	264.0	167.1	25.4	23.1	15.9	95.7	47.5	9.5	5.9	12.7	9.2	27.6
Texas	221.3	147.3	23.0	21.0	13.9	68.3	37.5	8.3	5.3	11.6	8.6	23.1
Utah	161.7	116.3	22.8	15.1	10.9	31.4	17.6	8.1	5.2	9.8	8.1	25.7
Vermont	215.3	156.7	23.5	20.5	15.4	61.8	42.5	8.5	5.1	10.8	8.9	25.2
Virginia	235.7	158.0	25.6	21.7	14.7	74.5	42.1	8.2	5.3	13.0	9.8	27.3
Washington	214.0	158.5	23.0	18.3	13.4	61.5	44.3	9.0	5.8	12.2	9.6	25.4
West Virginia	259.4	175.8	24.3	25.3	17.9	91.0	50.5	10.0	6.4	11.4	7.5	22.3
Wisconsin	223.5	154.5	22.6	19.9	14.0	62.3	38.5	9.3	6.0	12.6	9.4	27.1
Wyoming	204.6	155.2	23.4	20.1	16.0	55.6	38.4	8.3	6.8	12.3	10.7	21.8
United States	225.4	155.4	24.0	21.2	14.9	68.8	40.6	8.7	5.5	12.3	9.4	24.7

*Per 100,000, age adjusted to the 2000 US standard population.

Source: US Mortality Data, National Center for Health Statistics, Centers for Disease Control and Prevention.

Selected Cancers

Breast

New Cases: An estimated 230,480 new cases of invasive breast cancer are expected to occur among women in the US during 2011; about 2,140 new cases are expected in men. Excluding cancers of the skin, breast cancer is the most frequently diagnosed cancer in women. The incidence rate for female breast cancer began to decline in 2000. The dramatic decrease of almost 7% from 2002 to 2003 has been attributed to reductions in the use of menopausal hormone therapy (MHT), previously known as hormone replacement therapy, following the publication of results from the Women's Health Initiative in 2002; this study found that the use of combined estrogen plus progestin MHT was associated with an increased risk of breast cancer, as well as coronary heart disease. Since 2003, breast cancer incidence rates have been generally stable.

In addition to invasive breast cancer, 57,650 new cases of in situ breast cancer are expected to occur among women in 2011. Of these, approximately 85% will be ductal carcinoma in situ (DCIS). Since 1998, in situ breast cancer incidence rates have been stable in white women and increasing in African American women by 1.6% per year.

Deaths: An estimated 39,970 breast cancer deaths (39,520 women, 450 men) are expected in 2011. Breast cancer ranks second as a cause of cancer death in women (after lung cancer). Death rates for breast cancer have steadily decreased in women since 1990, with larger decreases in women younger than 50 (a decrease of 3.2% per year) than in those 50 and older (2.0% per year). The decrease in breast cancer death rates represents progress in earlier detection, improved treatment, and more recently, decreased incidence.

Signs and symptoms: The earliest sign of breast cancer is often an abnormality detected on a mammogram, before it can be felt by the woman or a health care professional. Larger tumors may become evident as a painless mass. Less common symptoms include persistent changes to the breast, such as thickening, swelling, distortion, tenderness, skin irritation, redness, scaliness, or nipple abnormalities, such as ulceration, retraction, or spontaneous discharge. Typically, breast pain results from benign conditions and is not an early symptom of breast cancer.

Risk factors: Besides being female, increasing age is the most important risk factor for breast cancer. Potentially modifiable risk factors include weight gain after age 18, being overweight or obese (for postmenopausal breast cancer), use of combined estrogen and progestin hormone therapy, physical inactivity, and consumption of one or more alcoholic beverages per day. Medical findings that predict higher risk include high breast tissue density (a mammographic measure of the amount of glandular tissue relative to fatty tissue in the breast), high bone mineral density (routinely measured to identify women at increased risk for osteoporosis), and biopsy-confirmed hyperplasia (especially atypical hyperplasia). High-dose radiation to the chest, typically related to cancer treatment, also increases risk. Reproductive factors that increase risk include a long menstrual history (menstrual periods that start early and/or end late in life), recent use of oral contraceptives, never having children, and having one's first child after age 30.

Risk is also increased by a personal or family history of breast cancer and inherited genetic mutations in the breast cancer susceptibility genes BRCA1 and BRCA2. Although these mutations account for approximately 5%-10% of all breast cancer cases, they are very rare in the general population (less than 1%), so widespread genetic testing is not recommended. Some population groups, such as individuals of Ashkenazi Jewish descent, have an increased prevalence of BRCA1 and BRCA2 mutation carriers. Women with a strong family history of breast and/or ovarian cancer should be offered counseling to determine if genetic testing is appropriate. Studies suggest that prophylactic removal of the ovaries and/or breasts in BRCA1 and BRCA2 mutation carriers decreases the risk of breast cancer considerably, although not all women who choose this surgery would have developed breast cancer. Women who consider these options should undergo counseling before reaching a decision. Male BRCA gene mutation carriers are also at increased risk for breast cancer.

Modifiable factors that are associated with a lower risk of breast cancer include breastfeeding, moderate or vigorous physical activity, and maintaining a healthy body weight. Two medications, tamoxifen and raloxifene, have been approved to reduce breast cancer risk in women at high risk. Raloxifene appears to have a lower risk of certain side effects, such as uterine cancer and blood clots.

Research is ongoing to identify additional modifiable risk factors for breast cancer. The International Agency for Research on Cancer has concluded that there is limited evidence that tobacco smoking causes breast cancer. There is also some evidence that shift work, particularly at night, is associated with an increased risk of breast cancer.

Early detection: Mammography can often detect breast cancer at an early stage, when treatment is more effective and a cure is more likely. Numerous studies have shown that early detection saves lives and increases treatment options. Steady declines in breast cancer mortality among women since 1990 have been attributed to a combination of early detection and improvements in treatment. Mammography is a very accurate screening tool, both for women at average and increased risk; however, like most medical tests, it is not perfect. On average, mammography will detect about 80%-90% of breast cancers in women without symptoms. All suspicious abnormalities should be biopsied for a

Leading Sites of New Cancer Cases and Deaths – 2011 Estimates

Estimated New Cases*		Estimated Deaths	
Male	**Female**	**Male**	**Female**
Prostate 240,890 (29%)	Breast 230,480 (30%)	Lung & bronchus 85,600 (28%)	Lung & bronchus 71,340 (26%)
Lung & bronchus 115,060 (14%)	Lung & bronchus 106,070 (14%)	Prostate 33,720 (11%)	Breast 39,520 (15%)
Colon & rectum 71,850 (9%)	Colon & rectum 69,360 (9%)	Colon & rectum 25,250 (8%)	Colon & rectum 24,130 (9%)
Urinary bladder 52,020 (6%)	Uterine corpus 46,470 (6%)	Pancreas 19,360 (6%)	Pancreas 18,300 (7%)
Melanoma of the skin 40,010 (5%)	Thyroid 36,550 (5%)	Liver & intrahepatic bile duct 13,260 (4%)	Ovary 15,460 (6%)
Kidney & renal pelvis 37,120 (5%)	Non-Hodgkin lymphoma 30,300 (4%)	Leukemia 12,740 (4%)	Non-Hodgkin lymphoma 9,570 (4%)
Non-Hodgkin lymphoma 36,060 (4%)	Melanoma of the skin 30,220 (4%)	Esophagus 11,910 (4%)	Leukemia 9,040 (3%)
Oral cavity & pharynx 27,710 (3%)	Kidney & renal pelvis 23,800 (3%)	Urinary bladder 10,670 (4%)	Uterine corpus 8,120 (3%)
Leukemia 25,320 (3%)	Ovary 21,990 (3%)	Non-Hodgkin lymphoma 9,750 (3%)	Liver & intrahepatic bile duct 6,330 (2%)
Pancreas 22,050 (3%)	Pancreas 21,980 (3%)	Kidney & renal pelvis 8,270 (3%)	Brain & other nervous system 5,670 (2%)
All sites 822,300 (100%)	All sites 774,370 (100%)	All sites 300,430 (100%)	All sites 271,520 (100%)

*Excludes basal and squamous cell skin cancers and in situ carcinoma except urinary bladder.

definitive diagnosis. Annual screening using magnetic resonance imaging (MRI) in addition to mammography is recommended for women at high lifetime risk of breast cancer starting at age 30. (For more information, see Saslow et al. *CA Cancer J Clin* 2007; 57:75-89.) Concerted efforts should be made to improve access to health care and to encourage all women 40 and older to receive regular mammograms.

Treatment: Taking into account tumor size, extent of spread, and other characteristics, as well as patient preference, treatment usually involves lumpectomy (surgical removal of the tumor with clear margins) or mastectomy (surgical removal of the breast). For women whose cancer has not spread to the skin, chest wall, or distant organs, numerous studies have shown that long-term survival rates after lumpectomy plus radiation therapy are similar to survival rates after mastectomy. For women undergoing mastectomy, significant advances in reconstruction techniques provide several options for breast reconstruction, including the timing of the procedure (i.e., during mastectomy or in the time period following the procedure).

Removal of some of the underarm lymph nodes during surgery is usually recommended to determine whether the tumor has spread beyond the breast. In women with early stage disease, sentinel lymph node biopsy (SLNB), a procedure in which only the first lymph nodes to which cancer is likely to spread are removed, is as effective as and less damaging than full axillary node dissection, in which many underarm nodes are removed. For women with smaller tumors whose cancer has spread to only one or two nearby lymph nodes, the use of SLNB, in addition to treatment with whole-breast radiation and chemotherapy or hormone therapy, results in the same outcomes and fewer complications as axillary node dissection.

Treatment may also involve radiation therapy, chemotherapy (before or after surgery), hormone therapy (tamoxifen, aromatase inhibitors), or targeted therapy. Postmenopausal women with breast cancer that tests positive for hormone receptors benefit from treatment with an aromatase inhibitor (i.e., letrozole, anastrozole, or exemestane), either after, or instead of, tamoxifen. For women whose cancer tests positive for HER2/neu, approved targeted therapies include trastuzumab (Herceptin) and, for advanced disease, lapatinib (Tykerb). After granting accelerated approval of bevacizumab (Avastin) for the treatment of metastatic breast cancer in 2008, the US Food and Drug Administration (FDA) began the process of removing approval of the drug in early 2011 because subsequent studies have shown minimal benefit combined with some potentially dangerous side effects.

It is recommended that all patients with ductal carcinoma in situ (DCIS) be treated to avoid the potential development of invasive cancer. Treatment options for DCIS include lumpectomy with radiation therapy or mastectomy; either of these options may be followed by treatment with tamoxifen if the tumor is hormone

receptor-positive. Removal of axillary lymph nodes is not generally needed. A report by a panel of experts convened by the National Institutes of Health concluded that in light of the noninvasive nature and favorable prognosis of DCIS, the primary goal for future research is the ability to accurately group patients into risk categories that will allow the most successful outcomes with the minimum necessary treatment.

Survival: The 5-year relative survival rate for female breast cancer patients has improved from 63% in the early 1960s to 90% today. The survival rate for women diagnosed with localized breast cancer (cancer that has not spread to lymph nodes or other locations outside the breast) is 98%. If the cancer has spread to nearby lymph nodes (regional stage) or distant lymph nodes or organs (distant stage), the 5-year survival is 84% or 23%, respectively. Relative survival continues to decline after 5 years; for all stages combined, rates at 10 and 15 years after diagnosis are 82% and 75%, respectively. Caution should be used when interpreting long-term survival rates since they represent patients who were diagnosed and treated up to 22 years ago. Improvements in diagnosis and treatment may result in a better outlook for more recently diagnosed patients.

Many studies have shown that being overweight adversely affects survival for postmenopausal women with breast cancer. Women who are more physically active are less likely to die from the disease than women who are inactive.

For more information about breast cancer, see the American Cancer Society's *Breast Cancer Facts & Figures*, available online at cancer.org/statistics.

Childhood Cancer

New cases: An estimated 11,210 new cases are expected to occur among children 0 to 14 years of age in 2011. Childhood cancers are rare, representing less than 1% of all new cancer diagnoses. Overall, childhood cancer incidence rates have been increasing slightly by 0.6% per year since 1975.

Deaths: An estimated 1,320 cancer deaths are expected to occur among children 0 to 14 years of age in 2011, about one-third of these from leukemia. Although uncommon, cancer is the second leading cause of death in children, exceeded only by accidents. Mortality rates for childhood cancer have declined by 53% since 1975. The substantial progress in childhood cancer is largely attributable to improvements in treatment and the high proportion of pediatric patients participating in clinical trials.

Early detection: Early symptoms are usually nonspecific. Parents should ensure that children have regular medical checkups and should be alert to any unusual symptoms that persist. Symptoms of childhood cancer include an unusual mass or swelling; unexplained paleness or loss of energy; sudden tendency to bruise; a persistent, localized pain; prolonged, unexplained fever or illness; frequent headaches, often with vomiting; sudden eye or vision changes; and excessive, rapid weight loss. Major categories of pediatric cancer and specific symptoms include:

- Leukemia (34% of all childhood cancers), which may be recognized by bone and joint pain, weakness, bleeding, and fever
- Brain and other nervous system (27%), which in early stages may cause headaches, nausea, vomiting, blurred or double vision, dizziness, and difficulty in walking or handling objects
- Neuroblastoma (7%), a cancer of the nervous system most common in children younger than 5 years that usually appears as a swelling in the abdomen
- Wilms tumor (5%), a kidney cancer that may be recognized by a swelling or lump in the abdomen
- Non-Hodgkin lymphoma (4%) and Hodgkin lymphoma (4%), which affect lymph nodes but may spread to bone marrow and other organs, and may cause swelling of lymph nodes in the neck, armpit, or groin; weakness; and fever
- Rhabdomyosarcoma (3%), a soft tissue sarcoma that can occur in the head and neck, genitourinary area, trunk, and extremities, and may cause pain and/or a mass or swelling
- Retinoblastoma (3%), an eye cancer that is typically recognized because of discoloration of the eye pupil and usually occurs in children younger than 5 years
- Osteosarcoma (3%), a bone cancer that most commonly appears as sporadic pain in the affected bone that may worsen at night or with activity, with eventual progression to local swelling; most often occurs in adolescents
- Ewing sarcoma (1%), another type of cancer that usually arises in bone, appears as pain at the tumor site, and most often occurs in adolescents

(Proportions are provided for all races combined and may vary according to race/ethnicity.)

Treatment: Childhood cancers can be treated by a combination of therapies (surgery, radiation, and chemotherapy) chosen based on the type and stage of cancer. Treatment is coordinated by a team of experts, including pediatric oncologists, pediatric nurses, social workers, psychologists, and others who assist children and their families. Because these cancers are uncommon, outcomes are more successful when treatment is managed by a children's cancer center. If the child is eligible, placement in a clinical trial, which compares a new treatment to the best current treatment, should also be considered.

Survival: For all childhood cancers combined, the 5-year relative survival rate has improved markedly over the past 30 years, from less than 50% before the 1970s to 80% today, due to new and improved treatments. However, rates vary considerably depending on cancer type and patient characteristics. For the most recent time period (1999-2006), the 5-year survival for Hodgkin lymphoma is 95%; Wilms tumor, 89%; non-Hodgkin lymphoma, 85%; leukemia, 82%; neuroblastoma, 73%; brain and other nervous

system, 71%; osteosarcoma, 70%; and rhabdomyosarcoma, 66%. Pediatric cancer patients may experience treatment-related side effects not only at the time of treatment, but several years after diagnosis as well. Late treatment effects include impairment in the function of specific organs, secondary cancers, and cognitive impairments. The Children's Oncology Group (COG) has developed long-term follow-up guidelines for screening and management of late effects in survivors of childhood cancer. For more information on childhood cancer management, see the COG Web site at survivorshipguidelines.org. The Childhood Cancer Survivor Study, which has followed more than 14,000 long-term childhood cancer survivors, has also provided important and valuable new information about the late effects of cancer treatment; for more information, visit ccss.stjude.org/.

Colon and Rectum

New cases: An estimated 101,340 cases of colon and 39,870 cases of rectal cancer are expected to occur in 2011. Colorectal cancer is the third most common cancer in both men and women. Colorectal cancer incidence rates have been decreasing for most of the past two decades (from 66.3 cases per 100,000 persons in 1985 to 45.3 in 2007). The decline accelerated from 1998 to 2007 (2.9% per year in men and 2.2% per year in women), which has largely been attributed to increases in the use of colorectal cancer screening tests that allow the detection and removal of colorectal polyps before they progress to cancer. In contrast to the overall declines, among adults younger than 50 years, for whom screening is not recommended for those at average risk, colorectal cancer incidence rates have been increasing by 1.6% per year since 1998.

Deaths: An estimated 49,380 deaths from colorectal cancer are expected to occur in 2011, accounting for about 9% of all cancer deaths. Mortality rates for colorectal cancer have declined in both men and women over the past two decades; since 1998, the rate has declined by 2.8% per year in men and by 2.7% per year in women. This decrease reflects declining incidence rates and improvements in early detection and treatment.

Signs and symptoms: Early stage colorectal cancer does not usually have symptoms; therefore, screening is usually necessary to detect colorectal cancer in its early stages. Advanced disease may cause rectal bleeding, blood in the stool, a change in bowel habits, and cramping pain in the lower abdomen. In some cases, blood loss from the cancer leads to anemia (low red blood cells), causing symptoms such as weakness and excessive fatigue. Due to an increase in colorectal cancer incidence in younger adults in recent years, timely evaluation of symptoms consistent with colorectal cancer in adults under age 50 is especially important.

Risk factors: The risk of colorectal cancer increases with age; 90% of cases are diagnosed in individuals 50 years of age and older. Several modifiable factors are associated with increased risk of colorectal cancer. Among these are obesity, physical inactivity, a diet high in red or processed meat, alcohol consumption, long-term smoking, and possibly inadequate intake of fruits and vegetables. Consumption of milk and calcium and higher blood levels of vitamin D appear to decrease risk. Studies suggest that regular use of nonsteroidal anti-inflammatory drugs, such as aspirin, and menopausal hormone therapy also reduce colorectal cancer risk. However, these drugs are not recommended for the prevention of colorectal cancer because they can have serious adverse health effects.

Colorectal cancer risk is also increased by certain inherited genetic conditions (e.g., Lynch syndrome, also known as hereditary nonpolyposis colorectal cancer, and familial adenomatous polyposis [FAP]), a personal or family history of colorectal cancer and/or polyps, or a personal history of chronic inflammatory bowel disease. Studies have also found that individuals with type 2 diabetes are at higher risk of colorectal cancer.

Early detection: Beginning at age 50, men and women who are at average risk for developing colorectal cancer should begin screening. Screening can result in the detection and removal of colorectal polyps before they become cancerous, as well as the detection of cancer that is at an early stage. In 2008, the American Cancer Society collaborated with several other organizations to release updated colorectal cancer screening guidelines. These joint guidelines emphasize cancer prevention and draw a distinction between colorectal screening tests that primarily detect cancer and those that can detect both cancer and precancerous polyps. There are a number of recommended screening options that vary by the extent of bowel preparation, as well as test performance, limitations, time interval, and cost. For detailed information on colorectal cancer screening options, see page 55 for the American Cancer Society's screening guidelines for colorectal cancer or the Society's *Colorectal Cancer Facts & Figures 2011-2013* on cancer.org/statistics.

Treatment: Surgery is the most common treatment for colorectal cancer. For cancers that have not spread, surgical removal may be curative. A permanent colostomy (creation of an abdominal opening for elimination of body wastes) is rarely needed for colon cancer and is infrequently required for rectal cancer. Chemotherapy alone, or in combination with radiation, is given before or after surgery to most patients whose cancer has penetrated the bowel wall deeply or spread to lymph nodes. Adjuvant chemotherapy (anticancer drugs in addition to surgery or radiation) for colon cancer in otherwise healthy patients 70 years of age and older is equally effective as in younger patients; toxicity in older patients can be limited if certain drugs (e.g., oxaliplatin) are avoided. Three targeted monoclonal antibody therapies are approved by the FDA to treat metastatic colorectal cancer: bevacizumab (Avastin) blocks the growth of blood vessels to the tumor, and cetuximab (Erbitux) and panitumumab (Vectibix) both block the effects of hormone-like factors that promote cancer cell growth.

Survival: The 1- and 5-year relative survival rates for persons with colorectal cancer are 83% and 65%, respectively. Survival continues to decline beyond 5 years to 58% at 10 years after diagnosis. When colorectal cancers are detected at an early, localized stage, the 5-year survival is 90%; however, only 39% of colorectal cancers are diagnosed at this stage, in part due to the underuse of screening. After the cancer has spread regionally to involve adjacent organs or lymph nodes, the 5-year survival drops to 70%. When the disease has spread to distant organs, 5-year survival is 12%.

Kidney

New cases: An estimated 60,920 new cases of kidney (renal) cancer are expected to be diagnosed in 2011. Kidney cancer includes renal cell carcinoma (92%), renal pelvis carcinoma (7%), and Wilms tumor (1%), a childhood cancer that usually develops before age 5. (See Childhood Cancer, page 11, for information about Wilms tumor.) The incidence rate of kidney cancer has been increasing by 2.0% per year in men since 1992 and 3.0% per year in women since 1998, primarily due to a rapid increase in local stage disease. The increase has been attributed in part to incidental diagnosis during abdominal imaging, which has increased in the past two decades, as opposed to a true increase in cancer occurrence.

Deaths: An estimated 13,120 deaths from kidney cancer are expected to occur in 2011. Death rates for kidney cancer have been decreasing in women by 0.6% per year since 1992 and in men by 1.3% per year since 2002.

Signs and symptoms: Early stage kidney cancer usually has no symptoms. Symptoms that may develop as the tumor progresses include blood in the urine, a pain or lump in the lower back or abdomen, fatigue, weight loss, fever, or swelling in the legs and ankles.

Risk factors: Tobacco use is a strong risk factor for kidney cancer, with the largest increased risk for cancer of the renal pelvis, particularly for heavy smokers. Additional risk factors for renal cell carcinoma include obesity, to which an estimated 30% of cases can be attributed; hypertension (high blood pressure); chronic renal failure; and occupational exposure to trichloroethylene, an industrial agent used as a metal degreaser and chemical additive. A small proportion of renal cell cancers are the result of rare hereditary conditions, such as von Hippel-Lindau disease.

Early detection: There are no reliable screening tests for people at average risk.

Treatment: Surgery (traditional or laparoscopic) is the primary treatment for most kidney cancers. Patients who are not surgical candidates may be offered ablation therapy, a procedure that uses heat or cold to destroy the tumor. Kidney cancer tends to be resistant to both traditional chemotherapy and radiation therapy. Until recently, immunotherapy (interferon-alpha and interleukin-2), which has intense side effects and generally modest survival benefits, was the main treatment option for late-stage disease. However, improved understanding of the biology of kidney cancer has led to the development of new targeted therapies that block the tumor's blood supply or target other parts of kidney cancer cells. Since 2005, six of these agents have been approved by the FDA for the treatment of metastatic disease: sorafenib (Nexavar), sunitinib (Sutent), temsirolimus (Torisel), everolimus (Afinitor), bevacizumab (Avastin), and pazopanib (Votrient).

Survival: The 1- and 5-year relative survival rates for cancers of the kidney and renal pelvis are 83% and 69%, respectively. More than half of cases are diagnosed at the local stage, for which the 5-year relative survival rate is 90%. Five-year survival is lower for renal pelvis (52%) than for renal cell (70%) carcinoma.

Leukemia

New cases: An estimated 44,600 new cases of leukemia are expected in 2011. Leukemia, a cancer of the bone marrow and blood, is classified into four groups according to cell type: acute lymphocytic (ALL), chronic lymphocytic (CLL), acute myeloid (AML), and chronic myeloid (CML). The most common type in children is ALL, accounting for three-fourths of leukemia cases among children and adolescents 0 to 19 years of age. Almost 90% of leukemia cases are diagnosed in adults 20 years of age and older, in whom the most common types are AML and CLL. Since 1992, leukemia incidence rates overall have been stable in males and increasing slightly (0.5% per year) in females.

Deaths: An estimated 21,780 deaths are expected to occur in 2011. Death rates for leukemia have been declining for the past several decades; since 2003, rates have declined by 0.9% per year among males and by 1.6% per year among females.

Signs and symptoms: Symptoms may include fatigue, paleness, weight loss, repeated infections, fever, bruising easily, and nosebleeds or other hemorrhages. In acute leukemia, these signs can appear suddenly. Chronic leukemia typically progresses slowly with few symptoms and is often diagnosed during routine blood tests.

Risk factors: Exposure to ionizing radiation increases risk of several types of leukemia. Medical radiation, such as that used in cancer treatment, is a substantial source of radiation exposure. Leukemia may also occur as a side effect of chemotherapy. Children with Down syndrome and certain other genetic abnormalities have higher incidence rates of leukemia. Some recent studies suggest that obesity may also be associated with an increased risk of leukemia. Family history is one of the strongest risk factors for CLL. Cigarette smoking and exposure to certain chemicals such as benzene, a component in gasoline and cigarette smoke, are risk factors for AML. Infection with human T-cell leukemia virus type I (HTLV-I) can cause a rare type of CLL called adult T-cell leukemia/lymphoma. The prevalence of

Probability (%) of Developing Invasive Cancers over Selected Age Intervals by Sex, US, 2005-2007*

		Birth to 39	40 to 59	60 to 69	70 and Older	Birth to Death
All sites†	Male	1.44 (1 in 69)	8.50 (1 in 12)	15.71 (1 in 6)	37.95 (1 in 3)	44.29 (1 in 2)
	Female	2.12 (1 in 47)	9.01 (1 in 11)	10.22 (1 in 10)	26.49 (1 in 4)	37.76 (1 in 3)
Urinary bladder‡	Male	0.02 (1 in 4,693)	0.38 (1 in 262)	0.93 (1 in 107)	3.67 (1 in 27)	3.80 (1 in 26)
	Female	0.01 (1 in 12,116)	0.12 (1 in 836)	0.26 (1 in 390)	0.98 (1 in 102)	1.16 (1 in 87)
Breast	Female	0.48 (1 in 207)	3.75 (1 in 27)	3.45 (1 in 29)	6.53 (1 in 15)	12.15 (1 in 8)
Colon & rectum	Male	0.08 (1 in 1,270)	0.91 (1 in 110)	1.46 (1 in 69)	4.38 (1 in 23)	5.30 (1 in 19)
	Female	0.08 (1 in 1,272)	0.72 (1 in 138)	1.05 (1 in 95)	4.00 (1 in 25)	4.97 (1 in 20)
Leukemia	Male	0.17 (1 in 598)	0.22 (1 in 462)	0.33 (1 in 302)	1.20 (1 in 83)	1.52 (1 in 66)
	Female	0.13 (1 in 759)	0.15 (1 in 688)	0.20 (1 in 494)	0.78 (1 in 128)	1.10 (1 in 91)
Lung & bronchus	Male	0.03 (1 in 3,646)	0.93 (1 in 108)	2.29 (1 in 44)	6.70 (1 in 15)	7.67 (1 in 13)
	Female	0.03 (1 in 3,185)	0.77 (1 in 130)	1.74 (1 in 57)	4.90 (1 in 20)	6.35 (1 in 16)
Melanoma of the skin§	Male	0.15 (1 in 656)	0.64 (1 in 157)	0.74 (1 in 136)	1.85 (1 in 54)	2.73 (1 in 37)
	Female	0.28 (1 in 353)	0.55 (1 in 181)	0.37 (1 in 267)	0.81 (1 in 123)	1.82 (1 in 55)
Non-Hodgkin lymphoma	Male	0.13 (1 in 782)	0.44 (1 in 226)	0.60 (1 in 168)	1.73 (1 in 58)	2.30 (1 in 43)
	Female	0.08 (1 in 1,179)	0.31 (1 in 318)	0.44 (1 in 229)	1.39 (1 in 72)	1.92 (1 in 52)
Prostate	Male	0.01 (1 in 8,517)	2.52 (1 in 40)	6.62 (1 in 15)	12.60 (1 in 8)	16.22 (1 in 6)
Uterine cervix	Female	0.15 (1 in 656)	0.27 (1 in 377)	0.13 (1 in 762)	0.18 (1 in 544)	0.68 (1 in 147)
Uterine corpus	Female	0.07 (1 in 1,423)	0.75 (1 in 134)	0.85 (1 in 117)	1.24 (1 in 81)	2.58 (1 in 39)

*For people free of cancer at beginning of age interval. Percentages and "1 in" numbers may not be equivalent due to rounding. †All sites excludes basal and squamous cell skin cancers and in situ cancers except urinary bladder. ‡Includes invasive and in situ cancer cases. §Statistic is for whites only.

Source: DevCan: Probability of Developing or Dying of Cancer Software, Version 6.5.0. Statistical Research and Applications Branch, National Cancer Institute, 2010. srab.cancer.gov/devcan.

HTLV-I infection is geographically localized and is most common in southern Japan and the Caribbean; infected individuals in the US tend to be descendants or immigrants from endemic regions.

Early detection: Leukemia can be difficult to diagnose early because symptoms often resemble those of other, less serious conditions. When a physician does suspect leukemia, diagnosis can be made using blood tests and a bone marrow biopsy.

Treatment: Chemotherapy is the most effective method of treating leukemia. Various anticancer drugs are used, either in combination or as single agents. Imatinib (Gleevec), nilotinib (Tasigna), and dasatinib (Sprycel) are very effective targeted drugs for the treatment of CML. These drugs are also sometimes used to treat a certain type of ALL. Recent clinical trials have shown that adults with AML who are treated with twice the conventional dose of daunorubicin experience higher and more rapid rates of remission. Antibiotics and transfusions of blood components are used as supportive treatments. Under appropriate conditions, stem cell transplantation may be useful in treating certain types of leukemia.

Survival: Survival rates vary substantially by leukemia type, ranging from a 5-year relative survival of 24% for patients diagnosed with AML to 80% for those with CLL. Advances in treatment have resulted in a dramatic improvement in survival over the past three decades for most types of leukemia. From 1975-1977 to 1999-2006, the 5-year relative survival rate for ALL increased from 42% to 66% overall and from 58% to 89% among children. In large part due to the discovery of the targeted cancer drug Gleevec, 5-year survival rates for CML have increased from 33% for cases diagnosed during 1990-1992 to 55% for those diagnosed during 1999-2006.

Liver

New Cases: An estimated 26,190 new cases of liver cancer (including intrahepatic bile duct cancers) are expected to occur in the US during 2011. More than 80% of these cases are hepatocellular carcinoma (HCC), originating from hepatocytes, the predominant type of cell in the liver. The incidence of liver cancer has been increasing by 3.4% per year in men and by 3.0% per year in women since 1992. In contrast to most common cancer sites, incidence rates are highest among Asian Americans/Pacific Islanders and Hispanics.

Deaths: An estimated 19,590 liver cancer deaths (6,330 women, 13,260 men) are expected in 2011. Since 1998, death rates for liver cancer have increased by 2.1% per year in men and by 1.3% per year in women. Incidence and mortality rates are more than twice as high in men as in women.

Signs and symptoms: Common symptoms include abdominal pain and/or swelling, weight loss, weakness, loss of appetite, jaundice (a yellowish discoloration of the skin and eyes), and fever. Enlargement of the liver is the most common physical sign, occurring in 50%-90% of patients.

Risk factors: In the US and other western countries, alcohol-related cirrhosis and possibly non-alcoholic fatty liver disease associated with obesity account for the majority of liver cancer cases. Chronic infections with hepatitis B virus (HBV) and hepatitis C virus (HCV) are associated with less than half of liver cancer cases in the US, although they are the major risk factors for the disease worldwide. In the US, rates of HCC are higher in immigrants from areas where HBV is endemic, such as China, Southeast Asia, and sub-Saharan Africa. A vaccine that protects against HBV has been available since 1982. The HBV vaccination is recommended for all infants at birth; for all children under 18 years who were not vaccinated at birth; and for adults in high-risk groups, including health care workers. It is also recommended that all pregnant women be tested for HBV. In contrast to HBV, no vaccine is available against HCV. The Centers for Disease Control and Prevention (CDC) recommends routine HCV testing for individuals at high risk so that infected individuals can receive counseling in order to reduce the risk of HCV transmission to others. Other preventive measures for HCV infection include screening of donated blood, organs, and tissues; instituting infection control practices during all medical, surgical, and dental procedures; and needle-exchange programs for injecting drug users. Treatment of chronic HCV infection with interferon may reduce the risk of progression to cancer and is the subject of ongoing research. For more information on hepatitis infections, including who is at risk, visit the CDC Web site at cdc.gov/hepatitis/.

Other risk factors for liver cancer, particularly in economically developing countries, include parasitic infections (schistosomiasis and liver flukes) and consumption of food contaminated with aflatoxin, a toxin produced by mold during the storage of agricultural products in a warm, humid environment.

Early detection: Screening for liver cancer has not been proven to improve survival. Nonetheless, many doctors in the US screen high-risk persons (for example, those chronically infected with HBV or HCV) with ultrasound or blood tests.

Treatment: Early stage liver cancer can sometimes be successfully treated with surgery in patients with sufficient healthy liver tissue; liver transplantation may also be an option. Fewer surgical options exist for patients diagnosed at an advanced stage of the disease, often because the portion of the liver not affected by cancer is damaged as well. Patients whose tumors cannot be surgically removed may choose ablation (tumor destruction) or embolization, a procedure that cuts off blood flow to the tumor. Sorafenib (Nexavar) is a targeted drug approved for the treatment of HCC in patients who are not candidates for surgery.

Survival: The overall 5-year relative survival rate for patients with liver cancer is 14%. Thirty-seven percent of patients are diagnosed at an early stage, for which five-year survival is 26%. Survival decreases to 9% and 3% for patients who are diagnosed at regional and distant stages of disease, respectively.

Lung and Bronchus 112

New cases: An estimated 221,130 new cases of lung cancer are expected in 2011, accounting for about 14% of cancer diagnoses. The incidence rate is declining significantly in men, from a high of 102.1 cases per 100,000 in 1984 to 71.8 cases in 2007. In women, the rate has begun to decrease after a long period of increase. Lung cancer is classified as small cell (14%) or non-small cell (85%) for the purposes of treatment.

Deaths: Lung cancer accounts for more deaths than any other cancer in both men and women. An estimated 156,940 deaths, accounting for about 27% of all cancer deaths, are expected to occur in 2011. Since 1987, more women have died each year from lung cancer than from breast cancer. The decrease in death rates that began in men in 1991 accelerated to 3.0% per year in 2005. Female lung cancer death rates have been decreasing by 0.9% per year since 2003 after continuously increasing since at least 1930. Gender differences in lung cancer mortality patterns reflect historical differences in uptake and reduction of cigarette smoking between men and women over the past 50 years.

Signs and symptoms: Symptoms may include persistent cough, sputum streaked with blood, chest pain, voice change, and recurrent pneumonia or bronchitis.

Risk factors: Cigarette smoking is by far the most important risk factor for lung cancer. Risk increases with quantity and duration of smoking. Cigar and pipe smoking also increase risk. Other risk factors include occupational or environmental exposure to secondhand smoke, radon, asbestos (particularly among smokers), certain metals (chromium, cadmium, arsenic), some organic chemicals, radiation, air pollution, and probably a medical history of tuberculosis. Genetic susceptibility plays a contributing role in the development of lung cancer, especially in those who develop the disease at a younger age.

Early detection: Early detection by chest x-ray, analysis of cells in sputum, and fiber-optic examination of the bronchial passages has shown limited effectiveness in reducing lung cancer deaths. Newer tests, such as low-dose spiral computed tomography (CT) scans and molecular markers in sputum, have produced promising results in detecting lung cancers at earlier, more operable stages in high-risk patients. Early results from the National Lung Screening Trial, a clinical trial designed to determine the effectiveness of lung cancer screening in high-risk individuals, showed 20% fewer lung cancer deaths among current and former heavy smokers who were screened with spiral CT compared to standard chest x-ray. However, these results may not be applicable to the general population because this study cohort was comprised strictly of individuals with a history of heavy smoking – the equivalent of at least a pack of cigarettes per day for 30 years. In addition, the potential risks associated with screening, including cumulative radiation exposure from multiple CT scans, and unnecessary lung biopsy and surgery, have not yet been evaluated.

Treatment: Treatment options are determined by the type (small cell or non-small cell) and stage of cancer and include surgery, radiation therapy, chemotherapy, and targeted therapies such as bevacizumab (Avastin) and erlotinib (Tarceva). For localized cancers, surgery is usually the treatment of choice. Survival for most patients with early stage, non-small cell lung cancer is improved by giving chemotherapy after surgery. Because the disease has usually spread by the time it is discovered, radiation therapy and chemotherapy are often used, sometimes in combination with surgery. Advanced-stage non-small cell lung cancer patients may benefit from the addition of targeted drugs such as bevacizumab (Avastin) or cetuximab (Erbitux) combined with chemotherapy. Chemotherapy alone or combined with radiation is the usual treatment of choice for small cell lung cancer; on this regimen, a large percentage of patients experience remission, though the cancer often returns.

Survival: The 1-year relative survival for lung cancer increased from 35% in 1975-1979 to 43% in 2003-2006, largely due to improvements in surgical techniques and combined therapies. However, the 5-year survival rate for all stages combined is only 16%. The 5-year survival rate is 53% for cases detected when the disease is still localized, but only 15% of lung cancers are diagnosed at this early stage. The 5-year survival for small cell lung cancer (6%) is lower than that for non-small cell (17%).

Lymphoma

New cases: An estimated 75,190 new cases of lymphoma will occur in 2011. Lymphoma is cancer of the lymphocytes, or white blood cells, and is classified as Hodgkin (8,830 cases in 2011) or non-Hodgkin (66,360 cases in 2011). Non-Hodgkin lymphoma (NHL) encompasses a wide variety of disease subtypes for which incidence patterns vary; overall incidence has been stable since 1998 in both men and women. Rates for Hodgkin lymphoma have also remained stable since 1998.

Deaths: An estimated 20,620 deaths from lymphoma will occur in 2011 (Hodgkin lymphoma, 1,300; non-Hodgkin lymphoma, 19,320). Death rates for NHL have been decreasing in men since 1997 (by 3.0% per year) and in women since 1998 (by 3.6% per year) after increasing for most of the previous two decades. Death rates for Hodgkin lymphoma have been decreasing in both men and women for more than three decades.

Signs and symptoms: Symptoms may include swollen lymph nodes, itching, night sweats, fatigue, unexplained weight loss, and intermittent fever.

Risk factors: Like most cancers, the risk of developing NHL increases with age. In contrast, the risk of Hodgkin lymphoma is highest during adolescence and early adulthood. In most cases of lymphoma the cause is unknown, although various risk factors associated with altered immune function have been identified. Non-Hodgkin lymphoma risk is elevated in persons with organ transplants who receive immune suppressants to prevent transplant rejection, in people with severe autoimmune conditions, and in people infected with human immunodeficiency virus (HIV) and human T-cell leukemia virus type I. Epstein-Barr virus causes Burkitt lymphoma (an aggressive type of NHL that occurs most often in children and young adults), is found in a number of autoimmune-related NHLs, and is also associated with some types of Hodgkin lymphoma. *H. pylori* infection increases the risk of gastric lymphoma. A family history of lymphoma and certain common genetic variations in immune response genes are associated with a modestly increased risk. Occupational and environmental exposures to certain chemicals are also associated with moderately increased risk.

Treatment: Non-Hodgkin lymphoma patients are usually treated with chemotherapy; radiation, alone or in combination with chemotherapy, is used less often. Highly specific monoclonal antibodies directed at lymphoma cells, such as rituximab (Rituxan) and alemtuzumab (Campath), are used for initial treatment and recurrence of some types of non-Hodgkin lymphoma, as are antibodies linked to a radioactive atom, such as ibritumomab tiuxetan (Zevalin) and tositumomab (Bexxar). High-dose chemotherapy with stem cell transplantation and low-dose chemotherapy with stem cell transplantation (called non-myeloablative) may be options if non-Hodgkin lymphoma persists or recurs after standard treatment.

Hodgkin lymphoma is usually treated with chemotherapy, radiation therapy, bone marrow or stem cell transplantation, or any combination thereof, depending on stage and cell type of the disease. Recent intermediate results from a clinical trial showed promise for an investigational targeted therapy (brentuximab vedotin) in high-risk Hodgkin patients whose disease had failed to respond to other treatment.

Survival: Survival varies widely by cell type and stage of disease. For NHL, the overall 1- and 5-year relative survival is 80% and 67%, respectively; survival declines to 57% at 10 years after diagnosis. For Hodgkin lymphoma, the 1-, 5-, and 10-year relative survival rates are 92%, 85%, and 81%, respectively.

Oral Cavity and Pharynx

New cases: An estimated 39,400 new cases of cancer of the oral cavity and pharynx are expected in 2011. Incidence rates are more than twice as high in men as in women. Since 1992, incidence rates have been declining annually by 1.4% in men and by 1.1% in women. However, recent studies have shown that incidence is increasing for oral cavity cancers associated with human papillomavirus (HPV) infection among white men younger than 50.

Five-year Relative Survival Rates* (%) by Stage at Diagnosis, 1999-2006

	All Stages	Local	Regional	Distant		All Stages	Local	Regional	Distant
Breast (female)	89	98	84	23	Ovary	46	94	73	28
Colon & rectum	65	90	70	12	Pancreas	6	23	9	2
Esophagus	17	37	19	3	Prostate	99	100	100	30
Kidney†	69	90	63	11	Stomach	26	63	27	3
Larynx	61	78	42	33	Testis	95	99	96	72
Liver‡	14	26	9	3	Thyroid	97	100	97	58
Lung & bronchus	16	53	24	4	Urinary bladder	79	73	36	6
Melanoma of the skin	91	98	62	16	Uterine cervix	70	91	58	17
Oral cavity & pharynx	61	83	55	32	Uterine corpus	83	96	68	17

*Rates are adjusted for normal life expectancy and are based on cases diagnosed in the SEER 17 areas from 1999-2006, followed through 2007.
†Includes renal pelvis. ‡Includes intrahepatic bile duct.

Local: an invasive malignant cancer confined entirely to the organ of origin. **Regional:** a malignant cancer that 1) has extended beyond the limits of the organ of origin directly into surrounding organs or tissues; 2) involves regional lymph nodes by way of lymphatic system; or 3) has both regional extension and involvement of regional lymph nodes. **Distant:** a malignant cancer that has spread to parts of the body remote from the primary tumor either by direct extension or by discontinuous metastasis to distant organs, tissues, or via the lymphatic system to distant lymph nodes.

Source: Altekruse SF, Kosary CL, Krapcho M, et al. (eds). *SEER Cancer Statistics Review, 1975-2007*, National Cancer Institute, Bethesda, MD, www.seer.cancer.gov/csr/1975_2007/, 2010.

Deaths: An estimated 7,900 deaths from oral cavity and pharynx cancer are expected in 2011. Death rates have been decreasing continuously in both men and women over the past three decades.

Signs and symptoms: Symptoms may include a sore in the throat or mouth that bleeds easily and does not heal, a red or white patch that persists, a lump or thickening, ear pain, a neck mass, or coughing up blood. Difficulties in chewing, swallowing, or moving the tongue or jaws are often late symptoms.

Risk factors: Known risk factors include all forms of smoked and smokeless tobacco products and excessive consumption of alcohol. Many studies have reported a synergism between smoking and alcohol use, resulting in a more than 30-fold increased risk for individuals who both smoke and drink heavily. HPV infection is associated with cancers of the tonsil, base of tongue, and some other sites within the oropharynx.

Early detection: Cancer can affect any part of the oral cavity, including the lip, tongue, mouth, and throat. Through visual inspection, dentists and primary care physicians can often detect premalignant abnormalities and cancer at an early stage, when they are most curable.

Treatment: Radiation therapy and surgery, separately or in combination, are standard treatments. In advanced disease, chemotherapy is added to surgery and/or radiation. Targeted therapy with cetuximab (Erbitux) may be combined with radiation in initial treatment or used alone to treat recurrent cancer.

Survival: For all stages combined, about 84% of persons with oral cavity and pharynx cancer survive 1 year after diagnosis. The 5-year and 10-year relative survival rates are 61% and 51%, respectively.

Ovary

New cases: An estimated 21,990 new cases of ovarian cancer are expected in the US in 2011. Ovarian cancer accounts for about 3% of all cancers among women. Incidence has been declining by 1.0% per year since 1992.

Deaths: An estimated 15,460 deaths are expected in 2011. Ovarian cancer causes more deaths than any other cancer of the female reproductive system. Death rates for ovarian cancer have been decreasing by 1.7% per year since 2002.

Signs and symptoms: Early ovarian cancer usually has no obvious symptoms, although women with early stage disease occasionally experience pelvic pain. Studies have indicated, however, that some women may experience persistent, nonspecific symptoms, such as bloating, pelvic or abdominal pain, difficulty eating or feeling full quickly, or urinary urgency or frequency. Women who experience such symptoms daily for more than a few weeks should seek prompt medical evaluation. The most common sign is enlargement of the abdomen, which is caused by the accumulation of fluid. Abnormal vaginal bleeding is rarely a symptom of ovarian cancer.

Risk factors: The most important risk factor is a strong family history of breast or ovarian cancer. Women who have had breast cancer or who have tested positive for inherited mutations in BRCA1 or BRCA2 genes are at increased risk. Studies suggest that preventive surgery to remove the ovaries and fallopian tubes in these women can decrease the risk of ovarian cancers. A genetic condition called Lynch syndrome (also known as hereditary nonpolyposis colon cancer) is also associated with increased risk. The use of estrogen alone as postmenopausal hormone therapy has been shown to increase risk in several large studies.

Trends in 5-year Relative Survival Rates* (%) by Race and Year of Diagnosis, US, 1975-2006

	All races			White			African American		
	1975-77	1984-86	1999-2006	1975-77	1984-86	1999-2006	1975-77	1984-86	1999-2006
All sites	50	54	68†	51	55	69†	40	41	59†
Brain	24	29	36†	23	28	35†	27	32	41†
Breast (female)	75	79	90†	76	81	91†	62	65	78†
Colon	52	59	66†	52	60	67†	47	50	55†
Esophagus	5	10	19†	6	11	20†	3	9	13†
Hodgkin lymphoma	74	80	87†	74	80	88†	71	75	82†
Kidney	51	56	70†	51	56	70†	50	54	67†
Larynx	67	66	63†	68	68	65	59	53	49†
Leukemia	36	42	55†	36	43	56†	34	34	47†
Liver & bile duct	4	6	14†	4	6	14†	2	5	10†
Lung & bronchus	13	13	16†	13	14	17†	12	11	13†
Melanoma of the skin	83	87	93†	83	87	93†	60‡	70§	74‡
Myeloma	26	29	39†	26	27	39†	31	32	38†
Non-Hodgkin lymphoma	48	53	69†	49	54	71†	49	48	60†
Oral cavity & pharynx	53	55	63†	55	57	65†	36	36	45†
Ovary	37	40	45†	37	39	45†	43	41	37
Pancreas	3	3	6†	3	3	6†	2	5	5†
Prostate	69	76	100†	70	78	100†	61	66	97†
Rectum	49	57	69†	50	58	70†	45	46	60†
Stomach	16	18	27†	15	18	26†	16	20	26†
Testis	83	93	96†	83	93	97†	73‡#	87‡	87
Thyroid	93	94	97†	93	94	98†	91	90	95
Urinary bladder	74	78	81†	75	79	82†	51	61	66†
Uterine cervix	70	68	71	71	70	73	65	59	64
Uterine corpus	88	84	84†	89	85	86†	61	58	61

*Survival rates are adjusted for normal life expectancy and are based on cases diagnosed in the SEER 9 areas from 1975-77, 1984-86, 1999 to 2006, and followed through 2007. †The difference in rates between 1975-1977 and 1999-2006 is statistically significant ($p < 0.05$). ‡The standard error of the survival rate is between 5 and 10 percentage points. §The standard error of the survival rate is greater than 10 percentage points. #Survival rate is for 1978-1980.

Source: Altekruse SF, Kosary CL, Krapcho M, et al (eds.). *SEER Cancer Statistics Review, 1975-2007*, National Cancer Institute, Bethesda, MD, seer.cancer.gov/csr/1975_2007/, 2010.

Tobacco smoking increases risk of mucinous ovarian cancer. Heavier body weight may be associated with increased risk of ovarian cancer. Pregnancy, long-term use of oral contraceptives, and tubal ligation reduce the risk of developing ovarian cancer; hysterectomy also appears to decrease risk.

Early detection: There is currently no sufficiently accurate screening test proven to be effective in the early detection of ovarian cancer. Pelvic examination only occasionally detects ovarian cancer, generally when the disease is advanced. However, for women who are at high risk of ovarian cancer and women who have persistent, unexplained symptoms, the combination of a thorough pelvic exam, transvaginal ultrasound, and a blood test for the tumor marker CA125 may be offered. For women at average risk, transvaginal ultrasound and testing for the tumor marker CA125 may help in diagnosis but are not used for routine screening. However, a large clinical trial using these methods to assess the effect of ovarian cancer screening on mortality is currently under way in the United Kingdom.

Treatment: Treatment includes surgery and usually chemotherapy. Surgery usually involves removal of one or both ovaries and fallopian tubes (salpingo-oophorectomy) and the uterus (hysterectomy). In younger women with very early stage tumors who wish to have children, only the involved ovary and fallopian tube may be removed. Among patients with early ovarian cancer, more complete surgical staging has been associated with better outcomes. For women with advanced disease, surgically removing all abdominal metastases enhances the effect of chemotherapy and helps improve survival. For women with stage III ovarian cancer that has been optimally debulked (removal of as much of the cancerous tissue as possible), studies have shown that chemotherapy administered both intravenously and directly into the abdomen improves survival. Studies have found that ovarian cancer patients whose surgery is performed by a gynecologic oncologist have more successful outcomes. Clinical trials are currently under way to test targeted drugs such as bevacizumab and cediranib in the treatment of ovarian cancer.

Survival: Relative survival varies by age; women younger than 65 are almost twice as likely to survive 5 years (57%) following

diagnosis as women 65 and older (29%). Overall, the 1-, 5-, and 10-year relative survival of ovarian cancer patients is 75%, 46%, and 38%, respectively. If diagnosed at the localized stage, the 5-year survival rate is 94%; however, only 15% of all cases are detected at this stage, usually incidentally during another medical procedure. The majority of cases (62%) are diagnosed at distant stage. For women with regional and distant disease, 5-year survival rates are 73% and 28%, respectively.

Pancreas

New cases: An estimated 44,030 new cases of pancreatic cancer are expected to occur in the US in 2011. Since 1998, incidence rates of pancreatic cancer have been increasing by 0.8% per year in men and by 1.0% per year in women.

Deaths: An estimated 37,660 deaths are expected to occur in 2011. The death rate for pancreatic cancer increased from 2003 to 2007 by 0.7% per year in men and by 0.1% per year in women.

Signs and symptoms: Cancer of the pancreas often develops without early symptoms. Symptoms may include weight loss, pain in the upper abdomen that may radiate to the back, and occasionally glucose intolerance (high blood glucose levels). Tumors that develop near the common bile duct may cause a blockage that leads to jaundice (yellowing of the skin and eyes), which can sometimes allow the tumor to be diagnosed at an early stage.

Risk factors: Tobacco smoking and smokeless tobacco use increase the risk of pancreatic cancer; incidence rates are about twice as high for cigarette smokers as for nonsmokers. Risk also increases with a family history of pancreatic cancer and a personal history of pancreatitis, diabetes, obesity, and possibly alcohol consumption. Individuals with Lynch syndrome are also at increased risk. Though evidence is still accumulating, consumption of red meat may increase risk.

Early detection: At present, there is no method for the early detection of pancreatic cancer. The disease is usually asymptomatic at first; only 8% of cases are diagnosed at an early stage. Research is under way to identify better methods of early detection.

Treatment: Surgery, radiation therapy, and chemotherapy are treatment options that may extend survival and/or relieve symptoms in many patients, but seldom produce a cure. Less than 20% of patients are candidates for surgery because pancreatic cancer is usually detected after it has spread beyond the pancreas. For patients who do undergo surgery, adjuvant treatment with the chemotherapy drug gemcitabine lengthens survival. The targeted anticancer drug erlotinib (Tarceva) has demonstrated a small improvement in advanced pancreatic cancer survival when used along with gemcitabine. Clinical trials with several new agents, combined with radiation and surgery, may offer improved survival and should be considered as a treatment option.

Survival: For all stages combined, the 1- and 5-year relative survival rates are 26% and 6%, respectively. Even for those people diagnosed with local disease, the 5-year survival is only 23%.

Prostate

New cases: An estimated 240,890 new cases of prostate cancer will occur in the US during 2011. Prostate cancer is the most frequently diagnosed cancer in men. For reasons that remain unclear, incidence rates are significantly higher in African Americans than in whites. Incidence rates for prostate cancer changed substantially between the mid-1980s and mid-1990s, in large part reflecting changes in prostate cancer screening with the prostate-specific antigen (PSA) blood test. Since 1998, incidence rates have remained relatively stable.

Deaths: With an estimated 33,720 deaths in 2011, prostate cancer is the second-leading cause of cancer death in men. Prostate cancer death rates have been decreasing since the mid-1990s in both African Americans and whites. Although death rates have decreased more rapidly among African American than white men, rates in African Americans remain more than twice as high as those in whites.

Signs and symptoms: Early prostate cancer usually has no symptoms. With more advanced disease, men may experience weak or interrupted urine flow; inability to urinate or difficulty starting or stopping the urine flow; the need to urinate frequently, especially at night; blood in the urine; or pain or burning with urination. Advanced prostate cancer commonly spreads to the bones, which can cause pain in the hips, spine, ribs, or other areas.

Risk factors: The only well-established risk factors for prostate cancer are age, race/ethnicity, and family history of the disease. About 62% of all prostate cancer cases are diagnosed in men 65 years of age and older, and 97% occur in men 50 and older. African American men and Jamaican men of African descent have the highest prostate cancer incidence rates in the world. The disease is common in North America and northwestern Europe, but less common in Asia and South America. Genetic studies suggest that strong familial predisposition may be responsible for 5%-10% of prostate cancers. Recent studies suggest that a diet high in processed meat or dairy foods may be a risk factor, and obesity appears to increase risk of aggressive prostate cancer.

Prevention: The chemoprevention of prostate cancer is an active area of research. Two drugs of interest, finasteride and dutasteride, reduce the amount of certain male hormones in the body and are already used to treat the symptoms of benign prostate enlargement. Both drugs have been found to lower the risk of prostate cancer by about 25% in large clinical trials with similar potential side effects, including reduced libido and risk of erectile dysfunction. However, in December 2010, an advisory committee to the FDA recommended against approval for both

finasteride and dutasteride for the prevention of prostate cancer based on risk-benefit analyses. In contrast to previous findings, results from the Selenium and Vitamin E Cancer Prevention Trial showed that vitamin E and selenium do not appear to protect against prostate cancer. Some studies suggest that diets high in lycopene (e.g. tomatoes, especially those cooked in oil), may reduce the risk of prostate cancer.

Early detection: At this time, there are insufficient data to recommend for or against routine testing for early prostate cancer detection with the PSA test. The American Cancer Society recommends that beginning at age 50, men who are at average risk of prostate cancer and have a life expectancy of at least 10 years receive information about the potential benefits and known limitations of testing for early prostate cancer detection and have an opportunity to make an informed decision about testing. Men at high risk of developing prostate cancer (African Americans or men with a close relative diagnosed with prostate cancer before age 65) should have this discussion with their health care provider beginning at age 45. Men at even higher risk (because they have several close relatives diagnosed with prostate cancer at an early age) should have this discussion with their provider at age 40. All men should be given sufficient information about the benefits and limitations of testing to allow them to make a decision based on their personal values and preferences.

Results of two large clinical trials, one conducted in Europe and the other in the US, that were designed to determine the efficacy of PSA testing were published in 2009. The European study found a lower risk of death from prostate cancer among men receiving PSA screening while the US study did not. Further analyses of these studies are under way. See page 55 for the American Cancer Society's screening guidelines for the early detection of prostate cancer.

Treatment: Treatment options vary depending on age, stage, and grade of the cancer, as well as other medical conditions, and should be discussed with the individual's physician. The grade assigned to the tumor, typically called the Gleason score, indicates the likely aggressiveness of the cancer and ranges from 2 (nonaggressive) to 10 (very aggressive). Surgery (open, laparoscopic, or robotic-assisted), external beam radiation, or radioactive seed implants (brachytherapy) may be used to treat early stage disease; hormonal therapy may be added in some cases. All of these treatments may impact a man's quality of life through side effects or complications that include urinary and erectile difficulties.

Accumulating evidence suggests that careful observation ("active surveillance" or "watchful waiting"), rather than immediate treatment, can be an appropriate option for men with less aggressive tumors and for older men. Hormonal therapy, chemotherapy, radiation, or a combination of these treatments is used to treat more advanced disease. Hormone treatment may control advanced prostate cancer for long periods by shrinking the size or limiting the growth of the cancer, thus helping to relieve pain and other symptoms. A newer option for some men with advanced prostate cancer that is no longer responding to hormones is a cancer vaccine known as sipuleucel-T (Provenge). For this treatment, special immune cells are removed from a man's body, exposed to prostate proteins in a lab, and then reinfused back into the body, where they attack the prostate cancer cells. The chemotherapy drug cabazitaxel (Jevtana) was approved in 2010 to treat metastatic prostate cancer that does not respond to other treatments.

Survival: More than 90% of all prostate cancers are discovered in the local or regional stages, for which the 5-year relative survival rate approaches 100%. Over the past 25 years, the 5-year relative survival rate for all stages combined has increased from 69% to 99.6%. According to the most recent data, 10-year survival is 95% and 15-year survival is 82%. Obesity and smoking are associated with an increased risk of dying from prostate cancer.

Skin

New cases: The number of basal cell and squamous cell skin cancers (i.e., nonmelanoma skin cancers, or NMSC) is difficult to estimate because these cases are not required to be reported to cancer registries. According to one report, in 2006 an estimated 3.5 million cases of NMSC occurred and approximately 2.2 million people were treated for NMSC. Individuals with a history of NMSC are much more likely to develop subsequent NMSC than the general population. Most, but not all, of these forms of skin cancer are highly curable. Melanoma is responsible for most skin cancer deaths, though it accounts for less than 5% of all skin cancer cases, and is expected to be diagnosed in about 70,230 persons in 2011. Melanoma is 10 times more common in whites than in African Americans. Incidence rates are similar in men and women under 65 years, but are more than twice as high in men as in women 65 and older. Melanoma incidence rates have been increasing for at least 30 years. Since 1992, incidence rates among whites have increased by 2.8% per year in both men and women.

Deaths: An estimated 11,980 deaths (8,790 from melanoma and 3,190 from other nonepithelial skin cancers) will occur in 2011. The death rate for melanoma has been decreasing rapidly in whites younger than 50, by 3.0% per year since 1991 in men and by 2.2% per year since 1984 in women. In contrast, in those 50 and older, death rates have been increasing by 1.1% per year since 1989 in men and have been stable since 1990 in women.

Signs and symptoms: Important warning signs of melanoma include changes in size, shape, or color of a mole or other skin lesion or the appearance of a new growth on the skin. Changes that occur over a few days are usually not cancer, but changes that progress over a month or more should be evaluated by a doctor. Basal cell carcinomas may appear as growths that are flat, or as small, raised, pink or red, translucent, shiny areas that may bleed following minor injury. Squamous cell cancer may appear as growing lumps, often with a rough surface, or as flat,

reddish patches that grow slowly. Another sign of basal and squamous cell skin cancers is a sore that doesn't heal.

Risk factors: Risk factors vary for different types of skin cancer. For melanoma, major risk factors include a personal or family history of melanoma and the presence of atypical or numerous moles (more than 50). Other risk factors for all types of skin cancer include sun sensitivity (sunburning easily, difficulty tanning, natural blond or red hair color); a history of excessive sun exposure, including sunburns; use of tanning booths; diseases that suppress the immune system; and a past history of basal cell or squamous cell skin cancers.

Prevention: Skin should be protected from intense sun exposure by covering with tightly woven clothing and a wide-brimmed hat, applying sunscreen that has a sun protection factor (SPF) of 15 or higher to unprotected skin, seeking shade (especially at midday, when the sun's rays are strongest) and avoiding sunbathing and indoor tanning. Sunglasses should be worn to protect the skin around the eyes. Children in particular should be protected from the sun because severe sunburns in childhood may greatly increase risk of melanoma in later life. Tanning beds and sun lamps, which provide an additional source of UV radiation, are associated with cancer risk and should be avoided. In 2009, the International Agency for Research on Cancer upgraded their classification of indoor tanning devices from "probably carcinogenic to humans" to definitively "carcinogenic to humans" after a reassessment of the scientific evidence.

Early detection: The best way to detect skin cancer early is to recognize changes in skin growths or the appearance of new growths. Adults should thoroughly examine their skin regularly, preferably once a month. New or unusual lesions or a progressive change in a lesion's appearance (size, shape, or color, etc.) should be evaluated promptly by a physician. Melanomas often start as small, mole-like growths that increase in size and may change color. A simple ABCD rule outlines the warning signals of the most common type of melanoma: A is for asymmetry (one half of the mole does not match the other half); B is for border irregularity (the edges are ragged, notched, or blurred); C is for color (the pigmentation is not uniform, with variable degrees of tan, brown, or black); D is for diameter greater than 6 millimeters (about the size of a pencil eraser). Other types of melanoma may not have these signs, so be alert for any new or changing skin growths.

Treatment: Removal and microscopic examination of all suspicious skin lesions are essential. Early stage basal and squamous cell cancers can be removed in most cases by one of several methods: surgical excision, electrodesiccation and curettage (tissue destruction by electric current and removal by scraping with a curette), or cryosurgery (tissue destruction by freezing). Radiation therapy and certain topical medications may be used in some cases. For malignant melanoma, the primary growth and surrounding normal tissue are removed and sometimes a sentinel lymph node is biopsied to determine stage. More extensive lymph node surgery may be needed if lymph node metastases are present. Melanomas with deep invasion or that have spread to lymph nodes may be treated with surgery, immunotherapy, chemotherapy, and/or radiation therapy. Advanced cases of melanoma are treated with palliative surgery, immunotherapy, and/or chemotherapy, and sometimes radiation therapy. Clinical trials have recently shown that two newer targeted drugs, ipilimumab and RG7204 (PLX4032), may extend survival in people with advanced melanoma.

Survival: Most basal and squamous cell cancers can be cured, especially if the cancer is detected and treated early. Melanoma is also highly curable if detected in its earliest stages and treated properly. However, melanoma is more likely than other skin tumors to spread to other parts of the body. The 5- and 10-year relative survival rates for persons with melanoma are 91% and 90%, respectively. For localized melanoma, the 5-year survival rate is 98%; 5-year survival rates for regional and distant stage diseases are 62% and 16%, respectively. About 84% of melanomas are diagnosed at a localized stage.

Thyroid

New cases: An estimated 48,020 new cases of thyroid cancer are expected to be diagnosed in 2011 in the US, with 3 in 4 cases occurring in women. The incidence rate of thyroid cancer has been increasing sharply since the mid-1990s, and it is the fastest-increasing cancer in both men and women.

Deaths: An estimated 1,740 deaths from thyroid cancer are expected in 2011 in the US. Since 1998, the death rate for thyroid cancer has been increasing in men (by 1.1% per year) and stable in women.

Signs and symptoms: The most common symptom of thyroid cancer is a lump in the neck that is noticed by a patient or felt by a health care provider in a clinical exam. Other symptoms include a tight or full feeling in the neck, difficulty breathing or swallowing, hoarseness or swollen lymph nodes, and pain in the throat or neck that does not go away. Although most lumps in the thyroid gland are not cancerous, individuals who detect an abnormality should seek timely medical attention.

Risk factors: Risk factors for thyroid cancer include being female, having a history of goiter (enlarged thyroid) or other nonmalignant thyroid condition, a family history of thyroid cancer, and radiation exposure related to medical treatment during childhood. Radiation exposure as a result of radioactive fallout from atomic weapons testing and nuclear power plant accidents (Chernobyl) has also been linked to increased risk of thyroid cancer, especially in children. Certain rare genetic syndromes also increase risk. Individuals who test positive for an abnormal gene that causes a hereditary form of aggressive thyroid cancer can decrease the chance of developing the disease by surgical removal of the thyroid gland. Unlike other adult cancers, for

which older age increases risk, 80% of newly diagnosed thyroid cancer patients are under 65 years of age.

Early detection: At present, there is no screening method for the early detection of thyroid cancer. Tests used in the evaluation of thyroid nodules include: blood tests to determine levels of hormones related to normal functions of the thyroid gland; medical imaging techniques to determine the size and characteristics of the nodule and nearby lymph nodes; and biopsy to determine if the cells in the nodule are benign or malignant.

Treatment: Most thyroid cancers are highly curable, though about 5% of cases are more aggressive and tend to spread to other organs. Treatment depends on the cell type, tumor size, and extent of the disease. The first choice of treatment is surgery. Total removal of the thyroid gland (thyroidectomy) is recommended for most patients, and lymph node removal is recommended for some. Treatment with radioactive iodine (I131) after surgery may be recommended to destroy any remaining thyroid tissue. Hormone therapy is given to replace hormones normally produced by the thyroid gland after thyroidectomy and to prevent the body from making thyroid-stimulating hormone, decreasing the likelihood of recurrence.

Survival: The 5-year relative survival rate for all thyroid cancer patients is 97%. However, survival varies markedly by stage, age at diagnosis, and disease subtype. The 5-year survival rate approaches 100% for localized disease, is 97% for regional stage disease, and 58% for distant stage disease. By age, the survival rate for all stages combined progressively decreases from 99% for patients under 45 years of age to 82% for those 75 or older.

Urinary Bladder

New cases: An estimated 69,250 new cases of bladder cancer are expected to occur in 2011. Since 1992, bladder cancer incidence rates have been stable in both men and women. Bladder cancer incidence is about four times higher in men than in women and almost twice as high in white men as in African American men.

Deaths: An estimated 14,990 deaths will occur in 2011. Since 1998, mortality rates have been stable in men and decreasing slowly in women (by 0.4% per year).

Signs and symptoms: The most common symptom is blood in the urine. Other symptoms may include increased frequency or urgency of urination and irritation during urination.

Risk factors: Smoking is the most important risk factor for bladder cancer. Smokers' risk of bladder cancer is approximately three-fold that of nonsmokers'. Smoking is estimated to cause about 46% of bladder cancer deaths among men and 27% among women. Workers in the dye, rubber, or leather industries and people who live in communities with high levels of arsenic in the drinking water also have increased risk.

Early detection: There is currently no screening method recommended for individuals at average risk. Bladder cancer is diagnosed by microscopic examination of cells from urine or bladder tissue and examination of the bladder wall with a cystoscope, a slender tube fitted with a lens and light that can be inserted through the urethra. These tests may be used to screen people at increased risk due to occupational exposure, or for follow up after bladder cancer treatment to detect recurrent or new tumors.

Treatment: Surgery, alone or in combination with other treatments, is used in more than 90% of cases. Superficial, localized cancers may also be treated by administering immunotherapy or chemotherapy directly into the bladder. Chemotherapy, alone or with radiation before cystectomy (bladder removal), has improved treatment results. Timely follow-up care is extremely important because of the high rate of bladder cancer recurrence.

Survival: For all stages combined, the 5-year relative survival rate is 79%. Survival declines to 75% at 10 years and 71% at 15 years after diagnosis. Half of all bladder cancer patients are diagnosed while the tumor is in situ (noninvasive, present only in the layer of cells in which the cancer developed), for which the 5-year survival is 97%. Patients with invasive tumors diagnosed at a localized stage have a 5-year survival rate of 73%; 35% of cancers are detected at this early stage. For regional and distant stage disease, 5-year survival is 36% and 6%, respectively.

Uterine Cervix

New cases: An estimated 12,710 cases of invasive cervical cancer are expected to be diagnosed in 2011. Incidence rates have decreased over most of the past several decades in both white and African American women.

Deaths: An estimated 4,290 deaths from cervical cancer are expected in 2011. Mortality rates declined steadily from 1975 to 2003 due to prevention and early detection as a result of screening with the Pap test; however, since 2003 rates have remained stable.

Signs and symptoms: Symptoms usually do not appear until abnormal cervical cells become cancerous and invade nearby tissue. When this happens, the most common symptom is abnormal vaginal bleeding. Bleeding may start and stop between regular menstrual periods, or it may occur after sexual intercourse, douching, or a pelvic exam. Menstrual bleeding may last longer and be heavier than usual. Bleeding after menopause or increased vaginal discharge may also be symptoms.

Risk factors: The primary cause of cervical cancer is infection with certain types of human papillomavirus (HPV). Women who begin having sex at an early age or who have many sexual partners are at increased risk for HPV infection and cervical cancer. However, a woman may be infected with HPV even if she has had only one sexual partner. Importantly, HPV infections

are common in healthy women and only rarely result in cervical cancer. Persistence of HPV infection and progression to cancer may be influenced by many factors, including immunosuppression, high parity (number of childbirths), and cigarette smoking. Long-term use of oral contraceptives is also associated with increased risk of cervical cancer.

Prevention: There are two vaccines approved for the prevention of the most common types of HPV infection that cause cervical cancer; Gardasil is recommended for use in females 9 to 26 years of age, and Cervarix in females 10 to 25 years of age. In December 2010, Gardasil was also approved for use in males 9 to 26 years of age to prevent anal cancer and associated precancerous lesions; approximately 90% of anal cancers have been linked to HPV infection. These vaccines cannot protect against established infections, nor do they protect against all HPV types.

Screening can prevent cervical cancer by detecting precancerous lesions. As screening has become more common, preinvasive lesions of the cervix are detected far more frequently than invasive cancer. The Pap test is the most widely used cervical cancer screening method. It is a simple procedure in which a small sample of cells is collected from the cervix and examined under a microscope. Pap tests are effective, but not perfect. Sometimes results are reported as normal when abnormal cells are present (false negative), and likewise, sometimes test results are abnormal when no abnormal cells are present (false positive). DNA tests to detect HPV strains associated with cervical cancer may be used in conjunction with the Pap test, either as an additional screening test or when Pap test results are equivocal. Fortunately, most cervical precancers develop slowly, so nearly all cancers can be prevented if a woman is screened regularly. It is important for all women, even those who have received the HPV vaccine, to follow cervical cancer screening guidelines.

Early detection: In addition to preventing cancer, cervical cancer screening can detect cancer early, when treatment is most successful. Liquid-based Pap tests may be used as an alternative to conventional Pap tests. See page 55 for the American Cancer Society's screening guidelines for the early detection of cervical cancer.

Treatment: Preinvasive lesions may be treated by electrocoagulation (the destruction of tissue through intense heat by electric current), cryotherapy (the destruction of cells by extreme cold), laser ablation, or local surgery. Invasive cervical cancers are generally treated with surgery, radiation, or both, and with chemotherapy in selected cases.

Survival: One- and 5-year relative survival rates for cervical cancer patients are 87% and 70%, respectively. The 5-year survival rate for patients diagnosed with localized disease is 91%. Cervical cancer is diagnosed at an early stage more often in whites (50%) than in African Americans (43%) and in women younger than 50 (60%) than in women 50 and older (35%).

Uterine Corpus (Endometrium)

New cases: An estimated 46,470 cases of cancer of the uterine corpus (body of the uterus) are expected to be diagnosed in 2011. These usually occur in the endometrium (lining of the uterus). Since 1992, incidence rates of endometrial cancer have been stable in white women, but increasing in African American women by 1.7% per year.

Deaths: An estimated 8,120 deaths are expected in 2011. Similar to incidence, death rates for cancer of the uterine corpus have been stable in white women, but increasing in African American women by 0.8% per year since 1998.

Signs and symptoms: Abnormal uterine bleeding or spotting (especially in postmenopausal women) is a frequent early sign. Pain during urination, intercourse, or in the pelvic area is also a symptom.

Risk factors: Obesity and greater abdominal fatness increase the risk of endometrial cancer, most likely by increasing the amount of estrogen in the body. Increased estrogen exposure is a strong risk factor for endometrial cancer. Other factors that increase estrogen exposure include menopausal estrogen therapy (without use of progestin), late menopause, never having children, and a history of polycystic ovary syndrome. (Estrogen plus progestin menopausal hormone therapy does not appear to increase risk.) Tamoxifen use increases risk slightly because it has estrogen-like effects on the uterus. Medical conditions that increase risk include Lynch syndrome, also known as hereditary nonpolyposis colon cancer (HNPCC), and diabetes. Pregnancy, use of oral contraceptives, and physical activity provide protection against endometrial cancer.

Early detection: There is no standard or routine screening test for endometrial cancer. Most endometrial cancer (69%) is diagnosed at an early stage because of postmenopausal bleeding. Women are encouraged to report any unexpected bleeding or spotting to their physicians. The American Cancer Society recommends that women with Lynch syndrome, or who are otherwise at high risk for endometrial cancer, should be offered annual screening with endometrial biopsy and/or transvaginal ultrasound beginning at 35 years of age.

Treatment: Uterine corpus cancers are usually treated with surgery, radiation, hormones, and/or chemotherapy, depending on the stage of disease.

Survival: The 1- and 5-year relative survival rates for uterine corpus cancer are 92% and 83%, respectively. The 5-year survival rate is 96%, 68%, or 17%, if the cancer is diagnosed at a local, regional, or distant stage, respectively. Relative survival in whites exceeds that for African Americans by more than 8 percentage points at every stage of diagnosis.

Special Section: Cancer Disparities and Premature Deaths

Introduction

There has been remarkable progress in reducing cancer death rates in the United States. Between 1990 and 2007, the most recent year for which mortality data are available, overall cancer death rates decreased by about 22% in men and 14% in women, translating to the avoidance of 898,000 deaths from cancer. However, not all segments of the US population have benefitted equally from this progress.[1] Death rates in persons with lower socioeconomic status, as defined by education, occupation, or residence, showed little or no decrease, and even increased in some instances.[2-5] Similarly, the decreases in cancer death rates in minorities occurred later and were slower compared to those of whites. As a result, the gap in mortality rates between advantaged and disadvantaged segments of the US population has continued to widen.[2,6] For instance, in both black and white men aged 25-64, the cancer death rate was two times higher in the least educated compared to the most educated in 1993;[7] by 2007, this disparity had increased to a nearly three-fold difference.

Eliminating cancer disparities among different segments of the US population defined in terms of socioeconomic status (income, education, insurance status, etc.), race/ethnicity, residence, sex, and sexual orientation is an overarching objective of the American Cancer Society's 2015 challenge goals.[8] Specifically, the aim is to reduce cancer incidence and mortality and increase cancer survival in disadvantaged groups to levels comparable to the general population.[8] The decennial US Department of Health and Human Services Healthy People Initiative, which began in 1979, also commits the nation to the goal of eliminating health disparities.[9] This goal remains ambitious to achieve, even for the collective resources of federal, state, and private health organizations.

This special section attempts to quantify the number of premature cancer deaths that could be avoided or delayed if we were to eliminate disparities by educational attainment and race. It also briefly addresses the causes of disparities, as well as strategies and current efforts by the Society and other government and private health agencies to eliminate health inequities. The purpose of this document is to stimulate concerted action on the part of communities, policy makers, and private and governmental health agencies toward reducing and ultimately eliminating disparities in the cancer burden.

What Causes Cancer Disparities?

The causes of cancer disparities within different socioeconomic or racial/ethnicity groups are complex, and include interrelated social, economic, cultural, and health system factors. However, disparities predominantly arise from inequities in work, wealth, income, education, housing, and overall standard of living, as well as social barriers to high-quality cancer prevention, early detection, and treatment services. In 1989, Dr. Samuel Broder, who was then director of the National Cancer Institute, suggested that "poverty is a carcinogen," a cancer-causing agent.

When educational attainment is used as an indicator of socioeconomic status (SES), persons with lower SES have a higher cancer burden compared to those with higher SES, regardless of demographic factors such as race/ethnicity, for all cancers combined and for the four major cancers (Table 1). The disparity is largest for lung cancer, for which death rates are 4 to 5 times higher in the least educated than in the most educated individuals.

Cancer death rates are affected by both incidence (risk of developing cancer) and survival after diagnosis. Persons with lower SES are more likely to engage in behaviors that increase cancer risk, such as tobacco use, physical inactivity, and poor diet (Table 2), partly because marketing strategies, such as those by tobacco companies, and also because of environmental or community barriers to opportunities for physical activity and access to fresh fruits and vegetables. Lower socioeconomic status is also associated with financial, structural, and personal obstacles to health care, including inadequate health insurance, reduced access to recommended preventive care and treatment services, and lower literacy rates. Individuals with no health insurance are more likely to be diagnosed with advanced cancer and less likely to receive standard treatment and survive their disease.[10] For more information about the relationship between health insurance and cancer, see *Cancer Facts & Figures 2008*, Special Section, available online at cancer.org/statistics.

Similarly, much of the disparity in the cancer burden among racial and ethnic minorities largely reflects obstacles to receiving health care services related to cancer prevention, early detection, and high-quality treatment, with poverty (low SES) as the overriding factor. According to the US Census Bureau, in 2009, 1 in 4 African Americans and Hispanics/Latinos lived below the poverty line, compared to 1 in 11 non-Hispanic whites. Moreover, 1 in 5 African Americans and 1 in 3 Hispanics/Latinos or American Indian/Alaska Natives were uninsured, while only 1 in 8 non-Hispanic whites lacked health insurance (Figure 1).

Discrimination is another factor that contributes to racial/ethnic disparities in the cancer burden. Racial and ethnic minorities tend to receive lower-quality health care than whites, even when insurance status, age, severity of disease, and health status are comparable.[11] Social inequalities, including discrimination,

Table 1. Cancer Death Rates* by Educational Attainment, Race/Ethnicity, and Sex, Ages 25-64, US, 2007

	Men				Women			
	All Races	Non-Hispanic African American	Non-Hispanic White	Hispanic	All Races	Non-Hispanic African American	Non-Hispanic White	Hispanic
All sites								
All education levels	104.36	170.43	101.68	51.00	90.75	126.43	89.42	54.03
< = 12 years of education	147.85	216.48	148.79	52.80	119.38	145.38	123.96	55.99
13-15 years of education	72.67	101.67	71.33	45.71	69.07	105.88	66.24	35.84
> = 16 years of education	55.92	76.90	56.48	37.05	59.13	86.18	57.79	58.68
RR (95% CI)	2.64 (2.53 - 2.76)	2.82 (2.40 - 3.30)	2.63 (2.52 - 2.76)	1.43 (1.06 - 1.92)	2.02 (1.94 - 2.10)	1.69 (1.49 - 1.90)	2.15 (2.05 - 2.25)	0.95 (0.69 - 1.32)
Absolute difference	91.94	139.58	92.32	15.75	60.25	59.20	66.17	-2.68
Lung								
All education levels	32.19	53.98	31.74	9.23	22.38	26.04	23.36	5.39
< = 12 years of education	51.63	73.01	53.49	9.40	33.86	33.20	37.71	5.43
13-15 years of education	20.54	28.26	20.48	6.85	15.28	20.22	15.29	4.42
> = 16 years of education	10.35	17.64	10.18	8.61	8.77	11.96	8.62	6.48
RR (95% CI)	4.99 (4.65 - 5.34)	4.14 (3.27 - 5.24)	5.26 (4.88 - 5.67)	1.09 (0.66 - 1.82)	3.86 (3.58 - 4.17)	2.78 (2.22 - 3.48)	4.38 (4.02 - 4.76)	0.84 (0.38 - 1.83)
Absolute difference	41.28	55.37	43.31	0.79	25.09	21.24	29.09	-1.05
Colorectal								
All education levels	10.10	19.00	9.43	5.52	7.38	12.58	6.95	5.03
< = 12 years of education	13.59	22.45	13.18	5.34	9.75	13.97	9.74	5.11
13-15 years of education	7.41	13.46	6.74	6.30	5.65	9.87	5.23	3.26
> = 16 years of education	6.22	10.37	6.05	3.80	4.73	9.81	4.43	4.60
RR (95% CI)	2.18 (2.00 - 2.39)	2.17 (1.663 - 2.87)	2.18 (1.97 - 2.41)	1.41 (0.67 - 2.96)	2.06 (1.86 - 2.29)	1.42 (1.11 - 1.83)	2.20 (1.95 - 2.48)	1.11 (0.47 - 2.60)
Absolute difference	7.37	12.08	7.13	1.54	5.02	4.16	5.31	0.51
Prostate								
All education levels	2.88	7.93	2.46	1.40				
< = 12 years of education	3.61	9.03	3.04	1.33				
13-15 years of education	2.16	5.51	1.81	1.85		N/A		
>= 16 years of education	2.17	5.99	2.05	0.82				
RR (95% CI)	1.66 (1.44 - 1.93)	1.51 (1.03 - 2.22)	1.48 (1.25 - 1.75)	1.61 (0.36 - 7.20)				
Absolute difference	1.44	3.04	0.99	0.51				
Breast								
All education levels					19.34	32.44	18.14	11.94
< = 12 years of education					22.12	33.53	21.41	11.93
13-15 years of education		N/A			16.23	31.17	14.60	7.97
> = 16 years of education					16.51	27.44	15.76	18.46
RR (95% CI)					1.34 (1.26 - 1.43)	1.22 (1.03 - 1.44)	1.36 (1.26 - 1.46)	0.65 (0.41 - 1.03)
Absolute difference					5.60	6.09	5.64	-6.52

RR=relative risk of cancer death among those with the lowest level of education, compared to those with the highest level; CI=confidence interval; NA=not applicable.
Education categories are defined based on 1989 death certificates. *Rates are for individuals 25-64 years at death, per 100,000, and age adjusted to the 2000 US standard population.
Data Source: National Center for Health Statistics.

Table 2. Prevalence (%) of Risk Factor Behaviors (Adults 18 and Older in 2009) and Cancer Screening* (2008) in the US

	Current Smoking†		Obesity‡		FOBT/ Endoscopy§	Mammogram (within the past 2 years)
	Men	Women	Men	Women	Men and Women ≥50 Yrs	Women ≥40 Yrs
Education¶						
<= 12 years	30.5	23.1	32.6	32.8	47.5	60.8
General Educational Development (GED)	53.2	44.7	37.0	38.6	54.9	65.9
Some college	24.1	20.3	32.5	30.5	56.3	69.1
Undergraduate degree	12.4	9.9	25.5	20.2	60.8	76.5
Graduate degree	4.9	6.3	19.0	17.2	69.5	80.1
Race/Ethnicity						
White (non-Hispanic)	24.5	19.8	27.5	24.7	56.0	68.0
African American (non-Hispanic)	23.9	19.2	33.1	42.8	48.9	67.7
Hispanic/Latino	19.0	9.8	32.0	30.4	37.2	61.5
American Indian/Alaska Native#	29.7	N/A	34.5	30.2	29.9	59.7
Asian (non-Hispanic)**	16.9	7.5	9.4	8.5	47.8	65.1
Immigration						
Born in US	25.0	19.9	29.5	28.0	55.0	67.6
Born in US territory	19.2	15.8	33.4	36.4	45.9	63.6
In US fewer than 10 years	16.7	5.2	14.9	13.5	28.0	49.7
In US 10 years or more	16.0	7.5	23.4	24.5	41.9	65.8
Health Insurance Coverage						
Uninsured	37.8	27.2	26.8	30.5	19.5	35.6
Insured	19.7	16.2	28.5	26.5	55.7	70.5

*Percentages are age adjusted to the 2000 US standard population. †Adults who reported having smoked at least 100 cigarettes and now smoke every day or some days. ‡Body mass index ≥30.0 kg/m2. §Either a fecal occult blood test (FOBT) within the past year, sigmoidoscopy within the past five years, or colonoscopy within the past 10 years. ¶Persons aged 25 years or older. #Estimates should be interpreted with caution because of the small sample sizes. **Does not include Native Hawaiians and other Pacific Islanders. N/A=Not available due to insufficient sample size.

Source: National Health Interview Survey, 2008, 2009, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, 2009, 2010.

American Cancer Society, Inc., Surveillance Research

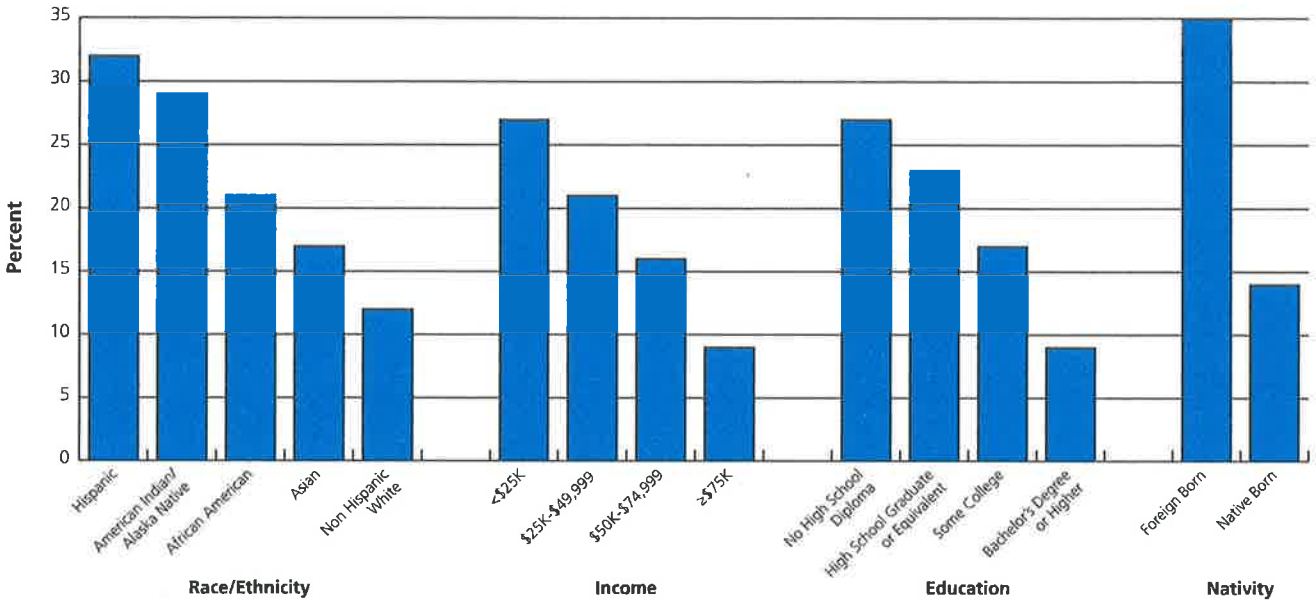
communication barriers, and provider assumptions, can affect interactions between patient and physician and contribute to miscommunication or delivery of substandard care.[12,13]

In addition to poverty and social discrimination, cancer occurrence in a population may also be influenced by cultural and/or inherited factors that decrease or increase risk. For example, Hispanic women have a lower risk of breast cancer probably partly because they tend to begin having children at a younger age, which decreases breast cancer risk. Individuals who maintain a primarily plant-based diet or do not use tobacco because of cultural or religious beliefs have a lower risk of many cancers. Higher rates of cancers related to infectious agents (stomach, liver, uterine cervix) in populations that include a large number of recent immigrants, such as Hispanics and Asians, may reflect a higher prevalence of infection in the country of origin. Genetic factors may also explain some differences in cancer incidence. For example, women from population groups with an increased frequency of mutations or alterations in the breast cancer susceptibility genes (BRCA1 and BRCA2), such as women of Ashkenazi Jewish descent, have an increased risk of breast and ovarian cancers. Genetic factors may also play a role in the elevated risk of prostate cancer among African American men and the incidence of more aggressive forms of breast cancer in African American women. However, genetic differences associated with race are thought to make a minor contribution to the disparate cancer burden between different racial/ethnic populations.[14] A more in-depth overview of cancer disparities within racial or socioeconomic groups can be found in *Cancer Facts & Figures 2004*.

How many cancer deaths could be avoided by eliminating racial or socioeconomic disparities?

In 2007, about 164,000 men and women aged 25-64 years died of cancer in the US. More than 60,000 (37%) of these deaths could have been avoided if all segments of the population had the same cancer death rates as the most educated whites (Figure 2; see sidebar on page 27 for calculation method). During the same

Figure 1. People without Health Insurance by Select Characteristics, US, 2009



American Cancer Society, Inc., Surveillance Research

year, about 24,560 African Americans aged 25-64 years died of cancer. If all African American men and women of this age were to have the same cancer death rates as the most educated African Americans, more than 10,000 (40%) deaths could have been avoided. In contrast, if all African American men and women were to have the same death rates as their white counterparts with the same level of education, about 5,000 (20%) cancer deaths among African Americans could have been avoided. Thus, among African Americans, eliminating socioeconomic disparities has the potential to avert twice as many cancer deaths as eliminating racial disparities. This underscores the importance of poverty in cancer disparities across all segments of the population. In addition, much of the disparity between African Americans and whites within the same level of education results from differences in risk factors and access to health care that cannot be captured in terms of educational attainment.

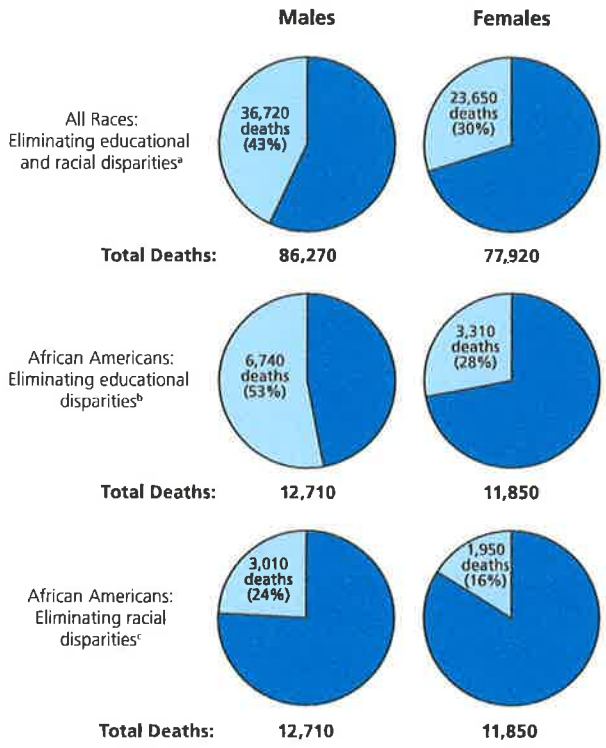
The estimated number of premature cancer deaths (deaths occurring between age 25-64) that could be avoided by eliminating socioeconomic and racial disparities was calculated by applying the age- and sex-specific cancer death rates of the most educated non-Hispanic whites in 2007 to all populations. Similarly, the age-, sex-, and educational attainment-specific cancer death rates of non-Hispanic whites in 2007 were applied to the corresponding population of African Americans in order to estimate the total number of premature cancer deaths that could be avoided in African Americans by eliminating racial disparities in cancer death rates.

What Are the Strategies to Reduce and/or Eliminate Cancer Disparities?

In principle, equal application of existing knowledge about cancer prevention, early detection, and treatment to all segments of the population can substantially reduce and ultimately eliminate cancer disparities. This will require a health care delivery system that emphasizes health promotion and wellness; provides access to prevention, early detection, and treatment for all; is culturally and linguistically competent; is geographically accessible; is capable of appropriate care in a timely manner; and includes diversity within the health care provider workforce. In addition, more research is needed to improve the methodology for public health interventions, including community-based, participatory research, and to better understand how the environment influences health behaviors, and how cancer treatment can be monitored to ensure that all patients receive optimal care. Information is still lacking about how to prevent, detect, and cure many cancers, such as prostate cancer, which disproportionately affects African Americans.

Health Promotion: Health promotion and disease prevention are cornerstones of a long, healthy, and productive life. Smoking and obesity are the two major risk factors for cancer in the US, accounting for about 30% and 15%-20%, respectively, of all cancer deaths.[15,16] Since the first Surgeon General's report on the health hazards of smoking was published in 1964, smoking prevalence among US adults has decreased by about 50%. This was possible because of the implementation of proven policies and interventions at the community and state level, including

Figure 2. Potential US* Cancer Deaths That Could Have Been Avoided by Eliminating Educational and/or Racial Disparities, Ages 25-64, 2007



*Excludes Rhode Island and Georgia. [a]Age-specific cancer death rates of the most educated non-Hispanic whites in 2007 were applied to all races. [b]Age-specific cancer death rates of the most educated African Americans in 2007 were applied to all African Americans. [c]Age- and educational attainment-specific cancer death rates of non-Hispanic whites in 2007 were applied to the corresponding population of African Americans.

increased cigarette prices, clean air laws banning smoking in public places that changed the social norms of smoking, restrictions of advertising and counteradvertising of tobacco products, and policies restricting youth access to cigarettes. Yet 20% of US adults 18 and older (45 million) are current smokers, with the prevalence ranging from 5% in men with graduate degrees to 53% in men with a GED certificate (Table 2). There is an opportunity for substantial reductions in smoking prevalence and the associated morbidity and mortality among high-risk populations through targeted intervention programs. Clinicians can also play a major role in promoting cessation and discouraging initiation of smoking in persons of lower SES, who are more likely to smoke.[17]

In contrast to smoking, the prevalence of obesity has more than doubled among adults (from 15% to 33%), and tripled among adolescents aged 12-19 years (from 5% to 15.5%) since the 1970s. Half of all African American and Hispanic women are obese, compared to 1 in 3 white women. Overweight and obesity are associated with an increased risk of developing many cancers, including cancers of the endometrium, colon, breast (occurring after menopause), esophagus, and kidney.[15,16]

Balanced caloric intake and a plant-based diet and regular physical activity are the best approaches to achieve and maintain a healthy body weight.[18,19] However, the physical environment often presents obstacles in the adoption of these healthy behaviors, especially in socioeconomically disadvantaged neighborhoods. Examples of community barriers to a healthy lifestyle include a high density of fast food restaurants, the absence of supermarkets with fresh fruits and vegetables, and a lack of parks, biking paths, and safe environments for physical activity. Affecting changes in social and physical environments requires public and community organizations working together to facilitate and promote policies that enable people to adopt and maintain healthy nutrition and engage in regular physical activity. Primary care physicians can and should counsel and assist patients who are overweight or obese in managing and controlling their body weight according to established guidelines.[20-22]

The US health care system emphasizes the diagnosis and treatment of diseases more than health promotion and prevention, in part because the compensation structure heavily favors the former. However, this may be changing with new health promotion and wellness initiatives at federal, state, and local governments and large private companies. As part of the Patient Protection and Affordable Care Act – health care reform legislation that was signed into law by President Obama in 2010 – annual wellness visits are now in place for Medicare beneficiaries. The federal government is also instituting model health promotion programs for its employees such as The Wellness Works program in the Office of Personnel Management. States with similar health promotion programs include Alabama, Washington, and Delaware.

Improving Access to Care: According to the US Census Bureau, more than 50.7 million Americans were uninsured in 2009.[23] Uninsured persons have limited access to health care across the cancer continuum, from prevention to early diagnosis, treatment, and palliative care. They are more likely to be diagnosed with an advanced stage of disease and less likely to receive early detection services and recommended treatment. A study by the American Cancer Society showed that uninsured or Medicaid-insured patients diagnosed with early stage colorectal cancer were less likely to survive five years than privately insured patients diagnosed with a more advanced stage of the disease.[24] This disparity likely reflects unequal treatment, generally poorer underlying health, and physical barriers to care, such as transportation to health facilities, among non-privately insured patients. It is important to note that many Medicaid patients are initially enrolled in the program at the time of cancer diagnosis, and were previously uninsured and without access to care. In addition, Medicaid beneficiaries are vulnerable to intermittent coverage loss because the Medicaid certification process requires frequent review and can disqualify individuals based on salary fluctuations. Therefore, even patients who were enrolled prior to

diagnosis may experience diminished access to care and consistent treatment.

Cultural Competence and Diversity of Workforce: Cultural competence is an important element in providing high-quality health care and preventive services. It reflects the ability to acquire and use knowledge about health-related beliefs, attitudes and practices, and communication patterns of clients and their families; increase community participation; and close the gaps in health status among diverse populations. For example, traditional values within the Hispanic culture emphasize the importance of family, respect, and personal familiarity. Increasing the number of minority health providers may substantially improve cultural competence and reduce language-access barriers (below). In addition, patients who are seen by health care providers of the same race or ethnic background report a higher level of satisfaction with their care and greater participation in decisions involving their health.[25,26] However, while African Americans, Hispanics, and Native Americans account for about 26% of the US population, only 6% of physicians are from these minority groups.[27] Therefore, more concerted effort is needed by public and private institutions to substantially increase the number of minority health care providers.

Language: In 2000, 47 million people (18% of the US population) spoke a language other than English at home, with Hispanics accounting for the majority of this population.[28] Proficiency in the English language is a major barrier to receiving adequate care for new immigrant patients or those who are not completely acculturated. For example, the colorectal cancer screening rate in persons who have resided in the US fewer than 10 years is half as high as the rate among those born in the US (28% compared to 55%). Several studies have shown that effective language services improve outcomes for patients with limited English proficiency by increasing satisfaction levels, use of health services, and compliance with recommended medical advice.[29]

Literacy: Illiteracy and health literacy are additional factors that affect access to and utilization of health care services.[30] Persons with low literacy are less likely to seek timely medical attention, to understand and follow the recommendations of their providers, and to successfully navigate the health care system.[31,32] According to the 2003 National Assessment of Adult Literacy (NAAL) survey, 14% of US adults 16 and older (30 million) had a below basic level of prose literacy, defined as the ability to use printed and written information to acquire knowledge and function in society. Individuals who did not graduate from high school, minorities (African Americans and Hispanics), the elderly, and those with disabilities were disproportionately represented in the below basic literacy level.

The health effects of illiteracy in the US have been considered by some as a silent epidemic largely because of lack of awareness among health care providers, despite its high prevalence.[32] Interventions that have been used or considered to alleviate this problem in doctors' offices include educational videotapes, color-coded medication schedules, simply written educational materials and reminders, and literacy screening, although the latter approach is thought to cause patient embarrassment and is time consuming for doctors.

Health literacy is the ability to read, understand, and act on health information. Tens of millions of adults are unable to understand health information brochures, medical test results, and dosage instructions for over-the-counter or prescription drugs. According to the latest NAAL survey, approximately 36% (77 million) of the US adult English-speaking population has basic or below basic health literacy skills, the majority of whom are native-born.[33] Similar to illiteracy, health literacy levels are low among the elderly, those who have lower education levels, and the poor.[34,35] People with low health literacy are more likely to report poorer health, are less likely to use preventive services, are at greater risk of hospitalization, and are associated with higher health care costs.[30,36]

Collection of Data on Socioeconomic Status

Collecting information on SES is extremely important in order to identify and monitor cancer disparities and evaluate the effectiveness of interventions. However, unlike in several European countries, information on SES is not routinely collected on medical records in the US, with the exception of recording educational attainment on death certificates. As a result, researchers in the US customarily use residential-based poverty rates, income, or educational attainment as a substitute for individual-level SES. Area-based SES is a very crude measure of individual SES because there is often a lack of uniformity among populations residing within the same geographic area, although neighborhood characteristics in and of themselves are contributing factors for disparities. Collection of individual indicators of SES (e.g., income, education) should be a core element of medical records in order to monitor progress in eliminating racial and socioeconomic health disparities.

What Is the American Cancer Society Doing to Reduce Cancer Disparities?

Over the past 30 years, the American Cancer Society has issued a number of special reports on cancer disparities, including *The Culture of Poverty, Cancer and the Poor: A Report to the Nation*, and *Cancer in the Socioeconomically Disadvantaged*. These reports concluded that poverty is the primary contributing factor to cancer disparities between racial and ethnic groups, that racial differences in biological or inherited characteristics are less important, and that people living in poverty lack access to health care and endure greater pain and suffering from cancer.

In June 2004, the Society adopted a strategic framework of information, prevention and detection, quality of life, and research that included strategies for reducing health care disparities.[37]

The Society has implemented many programs that focus on prevention and services designed to meet the needs of cancer survivors and their families. In terms of their potential impact on disparity reduction, nationally developed programs can be divided into three major categories:

1. Technology-based programs such as the Society's Web site (cancer.org), which provides downloadable versions of *Cancer Facts & Figures* publications, including those for African Americans and for Hispanics, and our cancer information hotline (1-800-227-2345), where trained Cancer Information Specialists are available by telephone, 24 hours a day, 7 days a week to provide the latest information, day-to-day help, and emotional support to people during their cancer experience.
2. Broad-based community initiatives offered through the American Cancer Society, such as the Patient Navigator Program, which helps patients and their families understand and make their way through the complex medical system to ensure treatment completion; the Reach To Recovery® program, a one-on-one breast cancer support program; Hope Lodge®, which provides temporary housing to patients and caregivers during treatment far from home; and Road To Recovery®, which provides cancer patients rides to and from treatment because lack of transportation is a key deterrent for underserved or low SES populations receiving adequate health care.[38] The Patient Navigator Program and Road To Recovery, in particular, have the potential to greatly reduce health care disparities and even achieve equity in treatment completion.
3. Select population programs available through the Society that address specific health disparities. Circle of Life℠ (COL), which trains American Indian and Alaskan Native (AIAN) women to contact family and friends about the importance of having regular mammograms, is currently offered in the Great Lakes (Indiana and Michigan) and Midwest (Iowa, Minnesota, South Dakota, and Wisconsin) Divisions. Let's Talk About It®, which was developed by the American Cancer Society in partnership with 100 Black Men of America, provides communities easy step-by-step ways to organize prostate cancer awareness events to empower African American men and their loved ones to reduce their risk of prostate cancer and make informed decisions about detecting and treating the disease. The program, which is currently available in the Midwest and East Central (Ohio and Pennsylvania) Divisions, utilizes the Society's revised prostate cancer screening guidelines and emphasizes informed decision making.

The availability of Society programs varies widely across the country because each Division makes its own strategic decisions in determining which programs and services best meet its population needs. Examples of select programs and services are shown in Table 3. They represent initiatives designed specifically to meet the prevention, access to care, and patient-support needs of communities, some of which are in partnership with other organizations and systems (such as worksites, health care centers, hospitals, and health plans). Select programs to reduce disparities by government and private public health agencies are listed in Table 4.

Research

The American Cancer Society has made the reduction of cancer health disparities a priority for research funding because of its overarching objective of eliminating disparities in cancer burden by 2015. Since 1999, the Society has funded 117 studies totaling $99 million devoted to the poor and medically underserved. In addition, the Society's intramural research department focuses substantial resources on community-based interventions and disparities research. To learn more, visit cancer.org/research.

Specific examples of ongoing intramural and extramural research addressing disparities include:

- Assessing the specific needs of African American breast cancer survivors through focus groups and surveys and using this information to develop programs and resources to educate and support African American breast cancer survivors
- A statewide representative sample of adults to examine African American-white disparities in cancer-risk factors in Georgia
- Investigating whether African Americans and whites who are diagnosed with colorectal cancer make changes in health behaviors (e.g., diet, physical activity, and dietary supplement use) and what effect these changes may have on cancer recurrence
- Researching treatment delays and the types of treatment received among African American breast cancer patients and exploring reasons for the less frequent treatment among African American women in an effort to improve breast cancer outcomes
- Monitoring racial, socioeconomic, and geographic disparities in the cancer burden, including differences in screening, stage at diagnosis, treatment, survival, and mortality
- Evaluating the usage and effectiveness of smoking cessation help lines in low socioeconomic and segregated African American communities, as well as examining smokers' preferences for various cessation treatments in order for the Society to target and increase use of cessation treatments within these communities
- Developing a mapping tool to identify and target underserved populations and assist the Society in more effectively allocating its programs and services

Table 3. Select Examples of American Cancer Society Programs[37]

Program	Program Description
Body and Soul	Faith-based initiative designed to reach priority populations such as African Americans and Latinos with linguistically appropriate and culturally competent health information and education
Circle Of Life	Program that trains Native American and Alaska Native women to contact family and friends about the importance of having regular mammograms. The program guidelines were developed to respect the values of native communities and in particular, to gain the support of tribal leaders at every phase.
Con Amor Aprendemos (With Love We Learn)	Program designed to raise awareness among Latino couples and clarify myths associated with HPV and cervical cancer. The program encourages culturally competent contact between participants and educators.
Deep South Network	Program implemented among African American communities to address the disparities in breast and cervical cancer mortality by encouraging coalition development, community empowerment, and utilizing community health advisors.
NYC Colon Cancer Screening Initiative (C5)	Partnership program between the NYC Department of Health and Mental Hygiene, NYC Council, the American Cancer Society, and 18 participating hospitals in New York City that assist in increasing colorectal cancer screening rates in the city, especially for the underserved, by funding screening colonoscopies to uninsured and underinsured New Yorkers; and to provide the Society's patient navigation services to cancer patients
Ozioma	National cancer information news service targeted toward African American and Latino populations. News releases are based on new cancer science and timely cancer topics.
Patient Navigator Program	Hospital-based service program employing individuals as patient navigators, serving as a barrier-reducing, focused intervention, in which services are provided to individual patients from all population groups for a defined episode of cancer-related care
Road To Recovery	Program that strives to improve the quality of life for all patients undergoing cancer care by providing transportation to their treatments and home again

Public Policy

The American Cancer Society and the American Cancer Society Cancer Action Network℠ (ACS CAN), the Society's nonprofit, nonpartisan advocacy affiliate, are dedicated to reducing cancer incidence and mortality rates among minority and medically underserved populations. This goal can be achieved by instituting effective policies and public health programs that promote overall wellness and help save lives. Listed below are some of the efforts at both the state and federal levels that the Society and ACS CAN have been involved with in the past few years:

- **Patient Protection and Affordable Care Act.** The Society and ACS CAN are working to ensure that key provisions of the Affordable Care Act (ACA) that benefit cancer patients and survivors are implemented as strongly as possible and are adequately funded. Some of the law's provisions that will directly help address disparities include:
  - Improving the affordability of coverage by increasing insurance subsidies and eliminating arbitrary annual and lifetime caps on coverage for all insurance plans so that families affected by cancer will face fewer financial barriers to care
  - Focusing on prevention and early detection by requiring all insurance plans to provide coverage for essential, evidence-based preventive measures with no additional co-pays. As of January 2011, preventive services like colonoscopies are exempt from co-payments and deductibles under the Medicare program.
  - Eliminating discrimination based on health status and preexisting conditions, which has been so detrimental to cancer patients over the years
  - Increasing funding for community health centers, which provide comprehensive health care for everyone, regardless of the ability to pay
  - Requiring qualified health plans to provide materials in appropriate languages, as well as the development of a strategy for increasing access to language translation services

ACS CAN will continue to look for ways to strengthen the legislation throughout the implementation process both at the federal and state level.

Table 4. Select External Initiatives in Eliminating Cancer Disparities

Program Name	Description	Population Served
National Cancer Institute Programs		
Community Networks Program (CPN)	Reduces cancer health disparities through community-based participatory education, training, and research among racial/ethnic minorities and underserved populations	25 institutions received $95 million in 5-year grants
Patient Navigation Research Program (PNRP)	Focus on developing and testing patient interventions with respect to disparities in screening and follow up for patients who are racial/ethnic minorities, of lower SES, and rural-area residents	Breast, cervical, prostate, and colorectal cancer patients
Community Cancer Centers Program (NCCCP)	A pilot program to build a community-based research platform to support basic, clinical, and population-based research on cancer prevention, screening, diagnosis, treatment, survivorship, and palliative care at hospitals	Patients of community-based hospitals
Community Clinical Oncology Program (CCOP)	A network for testing and validating medical interventions against cancer. It improves the quality of cancer care in local communities by disseminating research findings and boosts participation of minority and underserved populations in cancer clinical trials.	Cancer patients needing new treatments
Center to Reduce Cancer Health Disparities	• Initiates, integrates, and engages in collaborative research studies to promote cancer health disparities research and to identify innovative scientific opportunities to improve outcomes in communities • Leads NCI's efforts to train students and investigators from diverse populations to become competitive researchers in cancer and cancer health disparities research • Creates state-of-the-art regional networks and centers dedicated to cancer health disparities research and care through geographic program management	Populations experiencing a higher burden of cancer
Centers for Disease Control and Prevention (CDC) Programs		
National Breast and Cervical Cancer Early Detection Program (NBCCEDP)	Provides breast and cervical screening, diagnosis, and access to treatment to low-income, medically underserved, and uninsured women (especially minority women) through states, tribes, and territories	Women at risk for or diagnosed with breast, cervical cancers
National Comprehensive Cancer Control Program (NCCCP)	Provides seed funding and structure to develop and implement Comprehensive Cancer Control (CCC) plans. CCC communities pool resources to reduce the cancer burden by efforts to reduce risk, detect early, treat better, and improve survival.	Underserved communities
Colorectal Cancer Control Program (CRCCP)	Supports population-based screening efforts and provides colorectal screening services to low-income men and women aged 50-64 years who are underinsured or uninsured for screening	Low-income men and women
Racial and Ethnic Approaches to Community Health Across the US (REACH US)	CDC partners establish community-based programs and culturally appropriate interventions to eliminate health disparities.	Ethnic and racial minorities
Cancer Prevention and Control Research Network (CPCRN)	Accelerates the use of evidence-based cancer prevention and control in communities by advancing cancer prevention and control science and influencing public health and primary care practice.	Underserved populations
Independent Programs		
Project Brotherhood Colorectal Cancer Prevention	Culturally specific 12-hour curriculum to train barbers about colorectal cancer to increase screening rates among African American men. The program is funded by the American Cancer Society.	African American men
Intercultural Cancer Council (ICC)	Promotes policies, programs, partnerships, and research to eliminate the unequal burden of cancer in the US and its associated territories	Racial/ethnic minorities and the medically underserved
National Medical Association (NMA)	NMA partnered with the Society to develop and distribute culturally relevant patient and provider materials that focus on prevention, early detection, and treatment of breast, prostate, and colorectal cancers, and nutrition and physical activity.	African Americans and other underserved populations
National African American Tobacco Education Network (NAATEN)	A collaboration of national, state, and local organizations to eliminate tobacco use in the African American community	African Americans
African American Collaborative Obesity Research Network (AACORN)	Researchers and community-based partners dedicated to improving the quality and quantity of research addressing weight-related health issues in African American communities	African Americans
Susan G. Komen for the Cure Grants		
Career Catalyst in Disparities Research	Grants up to $450,000 over three years to foster independent careers in disparities research and support programs of research into disparities in breast cancer	All populations facing breast cancer disparities
Investigator Initiated Research	Grants of up to $200,000 per year for two to three years to explore new ideas and approaches leading to reductions in breast cancer mortality and/or incidence within the decade	All women
Post Baccalaureate in Disparities Research	Grants up to $135,000 per student over three years to support training very early in their career to allow them to begin to define meaningful career paths focused on disparities in breast cancer.	All populations facing breast cancer disparities
American Association for Cancer Research	AACR collaboration with focus on cancer prevention, cancer disparities, and ensuring ethical, standardized tissue sample storage and access for patients and researchers	All populations facing breast cancer disparities

- **National Breast and Cervical Cancer Early Detection Program.** A high priority for the Society and ACS CAN at both the state and federal level is fighting to increase funding for the National Breast and Cervical Cancer Early Detection Program (NBCCEDP). This successful program, which recently celebrated its 20th anniversary, provides community-based breast and cervical cancer screening to low-income, uninsured, and underinsured women, about 50% of whom are from racial/ethnic minority groups.[39-41] Due to a large cut in funding, screening rates within the program declined to an all-time low in 2007; rates have been increasing slowly since, but still have not fully recovered. ACS CAN is asking Congress to increase funding to $275 million for fiscal year 2012 to support continued growth and give women access to lifesaving screening services. While the Affordable Care Act will greatly improve access to screening, the NBCCEDP will remain an essential program for improving breast and cervical cancer screening and treatment in our nation's most vulnerable populations. It will be critical to use the program's infrastructure and community-outreach specialists to help women and their families receive the lifesaving services they need.
- **Colorectal Cancer Prevention, Early Detection, and Treatment Act.** The Society and ACS CAN are advocating for the Colorectal Cancer Prevention, Early Detection, and Treatment Act, a national screening, treatment, and outreach program focused on increasing colorectal cancer screening rates in low-income, medically underserved populations.
- **Patient Navigator Program.** The Society and ACS CAN continue to work with Congress to secure additional funding for the Patient Navigator Program, which helps patients in medically underserved communities work their way through the health care system, provides outreach and education for patients to encourage preventive screenings, and addresses needs that may impact compliance with screening and treatment. ACS CAN supports the Affordable Care Act's reauthorization of the Patient Navigator Program until 2015.

The Society and ACS CAN also are leading efforts to increase federal investment in cutting-edge biomedical and cancer research and treatments, and ways to expand access to them.

To learn more, to get involved, and to make a difference in the fight against cancer, visit cancer.org/involved/advocate.

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Tobacco Use

Smoking-related diseases remain the world's most preventable cause of death. Since the first US Surgeon General's report on smoking and health in 1964, there have been more than 15 million premature deaths attributable to smoking in the US.[1,2] The World Health Organization estimates that there are 5.4 million smoking-related premature deaths worldwide each year. The number of smoking-attributable deaths is almost evenly divided between industrialized and developing nations, and is greater in men (80%) than in women. More men die from smoking in developing nations than in industrialized nations.[3]

Health Consequences of Smoking

Half of all those who continue to smoke will die from smoking-related diseases.[4] In the US, tobacco use is responsible for nearly 1 in 5 deaths; this equaled an estimated 443,000 premature deaths each year between 2000 and 2004.[5,6] In addition, an estimated 8.6 million people suffer from chronic conditions related to smoking, such as chronic bronchitis, emphysema, and cardiovascular diseases.[7]

- •Smoking accounts for at least 30% of all cancer deaths and 87% of lung cancer deaths.[8,9]
- The risk of developing lung cancer is about 23 times higher in male smokers and 13 times higher in female smokers, compared to lifelong nonsmokers.[1]
- Smoking increases the risk of the following types of cancer: nasopharynx, nasal cavity and paranasal sinuses, lip, oral cavity, pharynx, larynx, lung, esophagus, pancreas, uterine cervix, ovary (mucinous), kidney, bladder, stomach, colorectum, and acute myeloid leukemia.[1,10]
- The International Agency for Research on Cancer (IARC) recently concluded that there is limited evidence that tobacco smoking causes female breast cancer.[10]
- Smoking is a major cause of heart disease, cerebrovascular disease, chronic bronchitis, and emphysema, and is associated with gastric ulcers.[1,9]
- The risk of lung cancer is just as high in smokers of "light" or "low-tar" yield cigarettes as in those who smoke "regular" or "full-flavored" products.[11]

Reducing Tobacco Use and Exposure

The US Surgeon General in 2000 outlined the goals and components of comprehensive statewide tobacco control programs.[12] These programs seek to prevent the initiation of tobacco use among youth; promote quitting at all ages; eliminate nonsmokers' exposure to secondhand smoke; and identify and eliminate the disparities related to tobacco use and its effects among different population groups.[13] The Centers for Disease Control and Prevention (CDC) recommends funding levels for comprehensive tobacco use prevention and cessation programs for all 50 states and the District of Columbia. In fiscal year 2011, 7 states allocated 50% or more of CDC-recommended funding levels for tobacco control programs.[14] States that have invested in comprehensive tobacco control programs, such as California, Massachusetts, and Florida, have reduced smoking rates and saved millions of dollars in tobacco-related health care costs.[12,15] Recent federal initiatives in tobacco control, including national legislation ensuring coverage of clinical cessation service coverage, regulation of tobacco products, tax increases, and increased tobacco control funding, hold promise for reducing tobacco use. Provisions in the Affordable Care Act signed into law on March 23, 2010, ensure coverage of evidence-based cessation treatments, including pharmacotherapy and cessation counseling to previously uninsured individuals and Medicare recipients, while state Medicaid programs can no longer exempt cessation pharmacotherapy from prescription drug coverage starting in the year 2014. Several provisions of the Family Smoking Prevention and Tobacco Control Act, which for the first time grants the US Food and Drug Administration the authority to regulate the manufacturing, selling, and marketing of tobacco products, have already gone into effect. As part of the federal Communities Putting Prevention to Work initiative, 21 communities received a total of $143 million exclusively focused on tobacco control, and additional funding was dedicated to this program in 2010 through the Prevention and Public Health Fund, created as part of the Affordable Care Act.

For more information about tobacco control, see the American Cancer Society's *Cancer Prevention & Early Detection Facts & Figures 2011*, available online at http://cancer.org/statistics.

Trends in Smoking

- Between 1965 and 2004, cigarette smoking among adults 18 years of age and older declined by half from 42% to 21%. Since 2004, smoking rates have changed little; in 2009 an estimated 21% of adults, or 46.6 million Americans, smoked cigarettes.[16,17]
- Although cigarette smoking became prevalent among men before women, the gender gap narrowed in the mid-1980s and has remained constant since then.[18] As of 2009, there was a 5% absolute difference in smoking prevalence between white men (25%) and women (20%), a 5% difference between African American men (24%) and women (19%), a 9% difference between Hispanic men (19%) and women (10%) and a 9% difference between Asian men (17%) and women (8%).[17]
- Smoking is most common among the least educated. While the percentage of smokers has decreased at every level of educational attainment since 1983, college graduates had the greatest decline, from 21% to 9% in 2009. By contrast, among those with a high school diploma, prevalence decreased modestly from 34% to 29% during the same time period.[19] Adults

with a GED certificate (high school equivalency diploma) had the highest smoking rate (49%) in 2009.[17] Groups with a high school degree or less quit smoking at lower rates than higher educated groups between 1998 and 2008.[20]

- The decrease in smoking prevalence among high school students between the late 1970s and early 1990s was more rapid among African Americans than whites; consequently, lung cancer rates among adults younger than 40 years of age, which historically has been substantially higher in African Americans, have converged in these two groups.[21]
- Although cigarette smoking among US high school students increased significantly from 28% in 1991 to 36% in 1997, the rate declined to 21% (male: 22%, female: 22%) by 2003.[22,23] Since 2003, there has been no significant change in the smoking rate among high school males (20%) and females (19%).[24]

Smokeless Tobacco Products

Smokeless tobacco products include moist snuff, chewing tobacco, snus (a "spitless," moist powder tobacco pouch), dissolvable nicotine products (Orbs, Strips and Sticks), and a variety of other tobacco-containing products that are not smoked. Tobacco companies are actively promoting these products both for use in settings where smoking is prohibited and as a way to quit smoking; however, there is no evidence that these products are as effective as proven cessation therapies. Use of any smokeless tobacco product is not considered a safe substitute for quitting. These products cause oral and pancreatic cancers, precancerous lesions of the mouth, gum recession, bone loss around the teeth, and tooth staining; they can also lead to nicotine addiction.[25]

- Smokers who use smokeless products as a supplemental source of nicotine to postpone or avoid quitting will increase rather than decrease their risk of lung cancer.[26]
- Long-term use of snuff substantially increases the risk of cancers of the oral cavity, particularly cancers of the cheek and gum.[25]
- According to the US Department of Agriculture, manufactured output of moist snuff has increased more than 83% in the past two decades, from 48 million pounds in 1991 to an estimated 88 million pounds in 2007.[27,28]
- In 2009, 3.5% of adults 18 years of age and older, 7% of men and 0.3% of women used smokeless products in the past month. Whites (5%) were more likely to use smokeless tobacco than African Americans (2 %), Hispanic/Latinos (1%), or Asians (1%).[29]
- Smokeless tobacco use (including snus use) varied from 1.3% to 9.1% across states, with higher rates observed in the South and North-Central states.[30]
- When smokeless tobacco was aggressively marketed in the US in the 1970s, use of these products increased among adolescent males, not among older smokers trying to quit.[31,32]
- Nationwide, 9% of high school students, 15% of males and 2% of females, were currently using chewing tobacco, snuff, or dip in 2009.[24]

Cigars

Cigar smoking has health consequences similar to those of cigarette smoking and smokeless tobacco.[33] Regular cigar smoking is associated with an increased risk of cancers of the lung, oral cavity, larynx, esophagus, and probably pancreas. Cigar smokers have 4 to 10 times the risk of dying from laryngeal, oral, or esophageal cancer compared to nonsmokers.[33]

- In 2008, 5% of adults 18 years of age and older (9% of men and 2% of women) had smoked cigars in the past month. African Americans (8%) and American Indian/Alaska Natives (6%) had the highest prevalence of past month cigar use, followed by, whites (5%), Hispanics (5%), and Asians (1%).[29]
- Among states, cigar smoking prevalence among adults ranges from between 2.2% to 5.4%.[30]
- In 2009, 14% of US high school students had smoked cigars, cigarillos, or little cigars at least once in the past 30 days.[24]
- Between 1997 and 2007, while sales of little cigars had increased by 240%, large cigar sales decreased by 6%.[34] Small cigars are similar in shape and size to cigarettes, but are not regulated or taxed like cigarettes, making them more affordable to youth.

Smoking Cessation

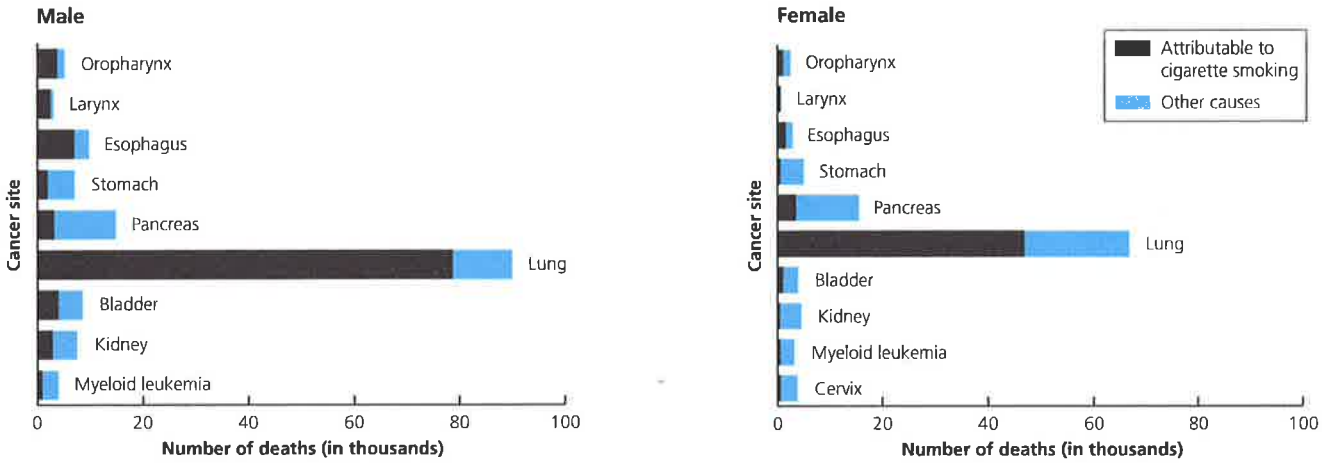
A US Surgeon General's Report outlined the benefits of smoking cessation:[35]

- People who quit, regardless of age, live longer than people who continue to smoke.
- Smokers who quit before 50 years of age cut their risk of dying in the next 15 years in half, compared to those who continue to smoke.
- Quitting smoking substantially decreases the risk of lung, laryngeal, esophageal, oral, pancreatic, bladder, and cervical cancers.
- Quitting lowers the risk for other major diseases, including heart disease, chronic lung disease, and stroke.

While the majority of ever-smokers in the US have quit smoking, rates of adult smoking cessation remained stable between 1998 and 2008.[20]

- In 2009, an estimated 49.9 million adults were former smokers, representing 52% of living persons who ever smoked.[36]
- Smokers with an undergraduate or graduate degree are more likely to quit than less educated smokers.[20]

Annual Number of Cancer Deaths Attributable to Smoking by Sex and Site, US, 2000-2004



Source: Centers for Disease Control and Prevention. Smoking-attributable mortality, years of potential life lost, and productivity losses – United States, 2000-2004. *MMWR Morb Mortal Wkly Rep.* 2008;57(45):1226-1228.

- Among those who smoked in 2009, an estimated 21.8 million (or 47%) had stopped smoking at least one day during the preceding 12 months because they were trying to quit.[36]
- In 46 states and the District of Columbia the majority of adults (50% or more) who ever smoked have quit smoking.[37]
- In 2009, among high school students who were current cigarette smokers, national data showed that one-half (51%) had tried to quit smoking cigarettes during the 12 months preceding the survey; female students (54%) were more likely to have made a quit attempt than male students (48%).[24]

Tobacco dependence is a chronic disease and should be treated with effective treatments that may double or triple smokers' chances of long-term abstinence.[38] Certain racial and ethnic groups (Hispanics and non-Hispanic African Americans) and those with low socioeconomic status are significantly less likely to receive cessation services.[30] Improving access to these services by promoting coverage for these treatments through government health programs, including Medicaid and Medicare, and private health insurance mandates can help reduce these disparities.

Secondhand Smoke

Secondhand smoke (SHS), or environmental tobacco smoke, contains numerous human carcinogens for which there is no safe level of exposure. It is estimated that more than 88 million nonsmoking Americans 3 years of age and older were exposed to SHS in 2007-2008.[17] Numerous scientific consensus groups have reviewed data on the health effects of SHS.[39-44] In 2006, the US Surgeon General published a comprehensive report titled *The Health Consequences of Involuntary Exposure to Tobacco Smoke.*[39] Public policies to protect people from SHS are based on the following detrimental effects:

- SHS contains more than 7,000 chemicals, at least 69 of which cause cancer.[2]
- Each year, about 3,400 nonsmoking adults die of lung cancer as a result of breathing SHS.[6]
- SHS causes an estimated 46,000 deaths from heart disease in people who are not current smokers.[6]
- SHS may cause coughing, wheezing, chest tightness, and reduced lung function in adult nonsmokers.[39]
- Some studies have reported an association between SHS exposure and breast cancer. The US Surgeon General has designated this evidence suggestive rather than conclusive.[39] In any case, women should be aware that there are many health reasons to avoid exposure to tobacco smoke.

Laws that prohibit smoking in public places and create smoke-free environments are an extremely effective approach to prevent exposure to and harm from SHS. An additional benefit of smoke-free policies is the modification of smoking behaviors among current smokers. Momentum to regulate public smoking began to increase in 1990, and these laws have become increasingly common and comprehensive.[45]

- In the past decade, the largest decline in SHS exposure among nonsmokers occurred between 1999-2000 (52.5%) to 2001-2002 (41.7%), with estimates remaining relatively unchanged till present (2007-2008: 40.1%).[17]

- In the US, as of January 2011, 3,198 municipalities have passed smoke-free legislation, and 35 states, the District of Columbia, the Northern Mariana islands, Puerto Rico, American Samoa, and the US Virgin Islands have either implemented or enacted statewide smoking bans that prohibit smoking in workplaces and/or restaurants and/or bars.[46]
- Currently, approximately 79% of the US population is covered by a smoke-free policy or provision in workplaces and/or restaurants and/or bars.[46]
- Nationally, coverage of all indoor workers by smoke-free policies increased substantially from 1992-1993 (46%) to 2006-2007 (75%).[47]
- Workplace smoking restrictions vary by geographic area; 72% of Southern residents reported working under a smoke-free policy, compared to 81% of workers in the Northeast.[48]
- In addition to providing protection against harmful exposure to secondhand smoke, there is strong evidence that smoke-free policies decrease the prevalence of both adult and youth smoking.[49]

Costs of Tobacco

The number of people who die prematurely or suffer illness from tobacco use impose substantial health-related economic costs to society. It is estimated that in the US, between 2000 and 2004, smoking accounted for 3.1 million years of potential life lost in men and 2.0 million years of potential life lost in women. Smoking, on average, reduces life expectancy by approximately 14 years.[6]

In addition:

- Between 2000 and 2004, smoking, on average, resulted in more than $193 billion in annual health-related economic costs, including smoking-attributable medical economic costs and productivity losses.[6]
- Smoking-attributable health care expenditures totaled an estimated $96 billion annually between 2000 and 2004, up $24 billion from $75.5 billion spent during 1997 and 2001.[6]
- Smoking-attributable productivity losses in the US amounted to $96.8 billion annually during 2000-2004, up about $4.3 billion from the $92 billion lost annually during 1997-2001.[6,50]

Worldwide Tobacco Use

During the past 25 years, while the prevalence of smoking has been slowly declining in the US and many other high-income countries, smoking rates have been increasing in many low- and middle-income nations, where about 85% of the world population resides.

- Tobacco is projected to cause more than175 million deaths between 2005 and 2030, increasing from 5.4 million in 2005 to 6.4 million in 2015 and 8.3 million in 2030.[51,52] Tobacco-attributable deaths are projected to decline by 9% between 2002-2030 in high-income countries, but to double from 3.4 million to 6.8 million in low- and middle-income countries in the same time period.[51]
- In 2003, the number of smokers in the world was estimated at about 1.3 billion (more than 1 billion men and 250 million women). This figure is expected to rise to at least 1.7 billion (1.2 billion men and 500 million women) by 2025, with the doubling in the number of female smokers making the greatest contribution to the increase.[53,54]
- Female smoking prevalence rates have peaked and are decreasing in most high-income countries, such as Australia, Canada, and the United Kingdom; however, in many Southern, central and, eastern European countries, female smoking rates show no evidence of decline or are increasing.[53] Female smoking rates in developing nations are expected to converge at 20%-25% by 2030.[55,56]
- Data from the Global Youth Tobacco Survey conducted during 2000-2007 found that among youth 13 to 15 years of age, 12% of boys and 7% of girls reported smoking cigarettes, and 12% of boys and 8% of girls reported using other tobacco products.[57] In every region of the world, the ratio of male-to-female smoking among youth was smaller than the ratio reported among adults, reflecting a global trend of increased smoking among female youth.[58]
- According to the World Health Organization (WHO), less than 10% of the world's population is covered by an evidence-based tobacco control measure.[59] The WHO estimates that 5% of the world's population is covered by smoke-free environments, 8% by cessation programs, 8% by health warnings on tobacco products, 9% by tobacco advertising bans, and 6% by taxation policies.[59]

The first global public health treaty, the Framework Convention on Tobacco Control (FCTC), was unanimously adopted by the World Health Assembly on May 21, 2003, and subsequently entered into force as a legally binding accord for all ratifying states on February 27, 2005.[60] The FCTC features specific provisions to control both the global supply and demand for tobacco, including regulation of tobacco product contents, packaging, labeling, advertising, promotion, sponsorship, taxation, smuggling, youth access, exposure to secondhand tobacco smoke, and environmental and agricultural impacts.[60] Parties to the treaty are expected to strengthen national legislation, enact effective tobacco control policies, and cooperate internationally to reduce global tobacco consumption.[61,62] As of January 2011, out of 195 eligible countries, 183 have signed the FCTC and 172 have ratified the treaty, representing approximately 87% of the world's population.[60] A number of major tobacco-producing nations, including Argentina, Indonesia, Malawi, the US, and Zimbabwe, have not ratified the treaty.[60]

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Nutrition and Physical Activity

It's been estimated that approximately one-third of the cancer deaths that occur in the US each year are due to poor nutrition and physical inactivity, including excess weight. Eating a healthy diet, being physically active on a regular basis, and maintaining a healthy body weight are as important as not using tobacco products in reducing cancer risk. The American Cancer Society's Nutrition and Physical Activity Guidelines emphasize the importance of weight control, physical activity, and dietary patterns in reducing cancer risk and helping people stay well; unfortunately, the majority of Americans are not meeting these recommendations. Increasing trends in unhealthy eating and physical inactivity – and resultant increases in overweight and obesity – have largely been influenced by the environments in which people live, learn, work, and play. As a result, the guidelines include an explicit Recommendation for Community Action to promote the availability of healthy food choices and opportunities for physical activity in schools, workplaces, and communities.

The following recommendations reflect the best nutrition and physical activity evidence available to help Americans reduce their risk not only of cancer, but also of heart disease and diabetes.

Recommendations for Individual Choices

1. Maintain a healthy weight throughout life.

- Balance caloric intake with physical activity.
- Avoid excessive weight gain throughout life.
- Achieve and maintain a healthy weight if currently overweight or obese.

In the US, overweight and obesity contribute to 14%-20% of all cancer-related mortality. Overweight and obesity are associated with increased risk for developing many cancers, including cancers of the breast in postmenopausal women, colon, endometrium, kidney, pancreas, and adenocarcinoma of the esophagus. Evidence is suggestive that obesity also increases risk for cancers of the gallbladder, thyroid, ovary, and cervix, as well as for myeloma, Hodgkin lymphoma, and aggressive forms of prostate cancer. Increasing evidence also suggests that being overweight increases the risk for cancer recurrence and decreases the likelihood of survival for many cancers. Some studies have shown that surgery to treat morbid obesity reduces mortality from major chronic diseases, including cancer. Although knowledge about the relationship between weight loss and cancer risk is incomplete, individuals who are overweight should be encouraged and supported in their efforts to reduce weight.

At the same time that evidence connecting excess weight to increased cancer risk has been accumulating, trends in overweight and obesity have been increasing. The prevalence of obesity in the US more than doubled between 1976-1980 and 2003-2006. Although rates appear to have stabilized in the most recent time period (2007-2008), more than one-third of adults – more than 72 million people – are currently obese. These trends are likely already impacting cancer trends: in the midpoint assessment of its 2015 Challenge Goals, American Cancer Society researchers reported that while the incidence of both colorectal cancer and post-menopausal breast cancer had been declining, it is likely that the declines in both would have started earlier and would have been steeper had it not been for the increasing prevalence of obesity.

Similar to adults, obesity among adolescents has tripled over the past several decades. Increases occurred across race, ethnicity, and gender. As in adults, obesity prevalence stabilized between 2003-2006 and 2007-2008. Because overweight in youth tends to continue throughout life, efforts to establish healthy body weight patterns should begin in childhood. The increasing prevalence of overweight and obesity in preadolescents and adolescents may increase incidence of cancer in the future.

2. Adopt a physically active lifestyle.

- **Adults:** Engage in at least 30 minutes of moderate to vigorous physical activity, in addition to usual activities, on 5 or more days of the week. Forty-five to 60 minutes of intentional physical activity is preferable.
- **Children and adolescents:** Engage in at least 60 minutes per day of moderate to vigorous physical activity at least 5 days per week.

Living a physically active lifestyle is important to reduce the risk of a variety of types of cancer, as well as heart disease and diabetes. Physical activity is associated with a 20% to 30% reduction in the risk of colon cancer. Studies also show that physical activity reduces the risk of breast cancer, especially vigorous activity. Physical activity also indirectly reduces the risk of developing the many types of obesity-related cancers because of its role in helping to maintain a healthy weight. Being active is thought to reduce cancer risk largely by improving energy metabolism and reducing circulating concentrations of estrogen, insulin, and insulin-like growth factors. Physical activity also improves the quality of life of cancer patients and is associated with a reduction in the risk of breast cancer recurrence, breast cancer-specific mortality, and all-cause mortality.

Despite the wide variety of health benefits from being active, 25% of adults report no leisure-time activity, and only 49% meet minimum recommendations for moderate activity. Similarly, only 35% of youth meet recommendations.

3. Consume a healthy diet with an emphasis on plant sources.

- Choose foods and beverages in amounts that help achieve and maintain a healthy weight.
- Eat 5 or more servings of a variety of vegetables and fruits each day.
- Choose whole grains in preference to processed (refined) grains.
- Limit consumption of processed and red meats.

There is strong scientific evidence that healthy dietary patterns, in combination with regular physical activity, are needed to maintain a healthy body weight and to reduce cancer risk. Many epidemiologic studies have shown that populations that eat diets high in vegetables and fruits and low in animal fat, meat, and/or calories have reduced risk of some of the most common cancers. Moreover, evidence that a diet high in red and processed meats is associated with a higher risk of developing gastrointestinal cancers has increased over the years. Despite the known benefits of a healthy diet, Americans are not following recommendations. According to the US Department of Agriculture, the majority of Americans would need to substantially lower their intake of added fats, refined grains, sodium and added sugars, and increase their consumption of fruits, vegetables, whole grains, and low-fat dairy products in order to meet the 2005 Dietary Guidelines for Americans.

At this time, individual nutritional supplements are not recommended for cancer prevention, as the results of recently completed randomized clinical trials of antioxidant supplements and selenium have shown no reduction in risk for cancer, at least in generally well-nourished populations. Results from ongoing studies of other nutrients are awaited before any recommendations can be made.

The scientific study of nutrition and cancer is highly complex, and many important questions remain unanswered. It is not presently clear how single nutrients, combinations of nutrients, over-nutrition, and energy imbalance, or the amount and distribution of body fat at particular stages of life affect a person's risk of specific cancers. Until more is known about the specific components of diet that influence cancer risk, the best advice is to consume a mostly plant-based diet emphasizing a variety of vegetables, fruits, and whole grains, while limiting red and processed meats. A special emphasis should be placed on controlling total caloric intake to help achieve and maintain a healthy weight.

4. If you drink alcoholic beverages, limit consumption.

People who drink alcohol should limit their intake to no more than two drinks per day for men and one drink per day for women. Alcohol consumption is an established cause of cancers of the mouth, pharynx, larynx, esophagus, liver, and breast. For each of these cancers, risk increases substantially with the intake of more than two drinks per day. Even a few drinks per week may be associated with a slightly increased risk of breast cancer in women. The mechanism for how alcohol can affect breast cancer is not known with certainty, but it may be due to alcohol-induced increases in circulating estrogen or other hormones in the blood, reduction of folic acid levels, or a direct effect of alcohol or its metabolites on breast tissue. Alcohol consumption combined with tobacco use increases the risk of cancers of the mouth, larynx, and esophagus far more than either drinking or smoking alone.

The American Cancer Society's Recommendation for Community Action

While many Americans would like to adopt a healthy lifestyle, many encounter substantial barriers that make it difficult to make healthy food and physical activity choices. Increased portion sizes, especially of restaurant meals; marketing and advertising of foods and beverages high in calories, fat, and added sugar, particularly to kids; schools and worksites that are not conducive to good health; community design that hinders physical activity; economic and time constraints, as well as other influences, have collectively contributed to increasing trends in obesity.

Because of the tremendous influence that the surrounding environment has on individual food and activity choices, the Society's nutrition and physical activity guidelines include a Recommendation for Community Action. Acknowledging that turning the obesity trends around will require extensive policy and environmental changes, the Society calls for public, private, and community organizations to create social and physical environments that support the adoption and maintenance of healthy nutrition and physical activity behaviors to help people stay well. This includes implementing strategies that increase access to healthy foods in schools, workplaces, and communities, and that provide safe, enjoyable, and accessible environments for physical activity in schools and for transportation and recreation in communities.

Achieving this Recommendation for Community Action will require multiple strategies and bold action, ranging from the implementation of community and workplace health promotion programs to policies that affect community planning, transportation, school-based physical education, and food services. The Centers for Disease Control and Prevention (CDC), the Institute of Medicine, the World Health Organization (WHO), and others have outlined a variety of evidenced-based approaches in schools, worksites, and communities to halt and ultimately turn around the obesity trends. Following are some specific approaches that have been proposed:

- Limit the availability, advertising, and marketing of foods and beverages of low nutritional value, particularly in schools.
- Strengthen nutrition standards in schools for foods and beverages served as part of the school meals program and for competitive foods and beverages served outside of the program.
- Increase and enforce physical education requirements in grades K-12.
- Ensure that worksites have healthy food and beverage options and that physical environments are designed or adapted and maintained to facilitate physical activity and weight control.
- Encourage restaurants to provide nutrition information on menus, especially calories.
- Invest in community design that supports development of sidewalks, bike lanes, and access to parks and green space.

The tobacco control experience has shown that policy and environmental changes at the national, state, and local levels are critical to achieving changes in individual behavior. Measures such as clean indoor air laws and increases in cigarette excise taxes are highly effective in deterring tobacco use. To avert an epidemic of obesity-related disease, similar purposeful changes in public policy and in the community environment will be required to help individuals maintain a healthy body weight and remain physically active throughout life.

Environmental Cancer Risks

Two major classes of factors influence the incidence of cancer: hereditary factors and acquired (environmental) factors. Hereditary factors come from our parents and cannot be modified. Environmental factors, which include behavioral choices, are potentially modifiable. They include tobacco use, poor nutrition, physical inactivity, obesity, certain infectious agents, certain medical treatments, excessive sun exposure, and exposures to carcinogens (cancer-causing agents) that exist as pollutants in our air, food, water, and soil. Some carcinogens occur naturally, and some are created or concentrated by human activity. Radon, for example, is a naturally occurring carcinogen present in soil and rock; however, occupational exposure occurs in underground mines and substantial exposures also occur in poorly ventilated basements in regions where radon soil emissions are high. Environmental (as opposed to hereditary) factors account for an estimated 75%-80% of cancer cases and deaths in the US. Exposure to carcinogenic agents in occupational, community, and other settings is thought to account for a relatively small percentage of cancer deaths, about 4% from occupational exposures and 2% from environmental pollutants (man-made and naturally occurring). Although the estimated percentage of cancers related to occupational and environmental carcinogens is small compared to the cancer burden from tobacco smoking (30%) and the combination of nutrition, physical activity, and obesity (35%), the relationship between such agents and cancer is important for several reasons. First, even a small percentage of cancers can represent many deaths: 6% of cancer deaths in the US in 2011 corresponds to approximately 34,320 deaths. Second, the burden of exposure to occupational and environmental carcinogens is borne disproportionately by lower-income workers and communities, contributing to disparities in the cancer burden across the population. Third, although much is known about the relationship between occupational and environmental exposure and cancer, some important research questions remain. These include the role of exposures to certain classes of chemicals (such as hormonally active agents) during critical periods of human development and the potential for pollutants to interact with each other, as well as with genetic and acquired factors.

How Carcinogens Are Identified

The term carcinogen refers to exposures that can increase the incidence of malignant tumors (cancer). The term can apply to a single chemical such as benzene; fibrous minerals such as asbestos; metals and physical agents such as x-rays or ultraviolet light; or exposures linked to specific occupations or industries (e.g.,

nickel refining). Carcinogens are usually identified on the basis of epidemiological studies or by testing in animals. Studies of occupational groups (cohorts) have played an important role in understanding many chemical carcinogens – as well as radiation – because exposures are often higher among workers, who can be followed for long periods of time. Some information has also come from studies of persons exposed to carcinogens during medical treatments (such as radiation and estrogen), as well as from studies conducted among individuals who experienced large, short-term exposure to a chemical or physical agent due to an accidental or intentional release (such as survivors of the atomic bomb explosions of Hiroshima and Nagasaki). It is more difficult to study the relationship between exposure to potentially carcinogenic substances and cancer risk in the general population because of uncertainties about exposure and the challenge of long-term follow up. Moreover, relying upon epidemiological information to determine cancer risk does not fulfill the public health goal of prevention since, by the time the increased risk is detected, a large number of people may have been exposed. Thus, for the past 40 years, the US and many other countries have developed methods for identifying carcinogens through animal testing using the "gold standard" of a 2-year or lifetime bioassay in rodents. This test is expensive and time-consuming, but it can provide information about potential carcinogens so that human exposure can be reduced or eliminated. Many substances that are carcinogenic in rodent bioassays have not been adequately studied in humans, usually because an acceptable study population has not been identified. Among the substances that have proven carcinogenic in humans, all have shown positive results in animals when tested in well-conducted 2-year bioassays.[1] Between 25%-30% of established human carcinogens were first identified through animal bioassays. Since animal tests necessarily use high-dose exposures, human risk assessment usually requires extrapolation of the exposure-response relationship observed in rodent bioassays to predict effects in humans at lower doses. Typically, regulatory agencies in the US and abroad have adopted the default assumption that no threshold level (level below which there is no increase in risk) of exposure exists for carcinogenesis.

Evaluation of Carcinogens

The National Toxicology Program (NTP) plays an important role in the identification and evaluation of carcinogens in the US, and the International Agency for Research on Cancer (IARC) plays a similar role internationally. The NTP was established in 1978 to coordinate toxicology testing programs within the federal government, including tests for carcinogenicity. The NTP is also responsible for producing the *Report on Carcinogens*, an informational scientific and public health document that identifies agents, substances, mixtures, or exposure circumstances that may increase the risk of developing cancer.[2] For a list of substances listed in the *11th Report on Carcinogens* as known or reasonably anticipated to be human carcinogens, see ntp.niehs.nih.gov/ntp/roc/toc11.html. The IARC is a branch of the World Health Organization that regularly convenes scientific consensus groups to evaluate potential carcinogens. After reviewing published data from laboratory, animal, and human research, these committees reach consensus about whether the evidence should be designated "sufficient," "limited," or "inadequate" to conclude that the substance is a carcinogen. For a list of substances that have been reviewed by the IARC monograph program, visit monographs.iarc.fr/ENG/Publications/internrep/07-001.pdf. The American Cancer Society does not have a formal program to review and evaluate carcinogens. However, information on selected topics can be found at cancer.org.

Although the relatively small risks associated with low-level exposure to carcinogens in air, food, or water are difficult to detect in epidemiological studies, scientific and regulatory bodies throughout the world have accepted the principle that it is reasonable and prudent to reduce human exposure to substances shown to be carcinogenic at higher levels of exposure. Although much public concern about the influence of man-made pesticides and industrial chemicals has focused on cancer, pollution may adversely affect the health of humans and ecosystems in many other ways. Research to understand the short- and long-term impact of environmental pollutants on a broad range of outcomes, as well as regulatory actions to reduce exposure to recognized hazards, has contributed to the protection of the public and the preservation of the environment for future generations. It is important that this progress be recognized and sustained. For more information on environmental cancer risks, see the article published by Fontham et al. in *CA: A Cancer Journal for Clinicians*.[3]

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The Global Fight against Cancer

The ultimate mission of the American Cancer Society is to eliminate cancer as a major health problem. Because cancer knows no boundaries, this mission extends around the world.

Cancer is an enormous global health burden, touching every region and socioeconomic level. Today, cancer accounts for one in every eight deaths worldwide – more than HIV/AIDS, tuberculosis, and malaria combined. In 2008, there were an estimated 12.7 million cases of cancer diagnosed and 7.6 million deaths from cancer around the world. More than 60 percent of all cancer deaths occur in low- and middle-income countries, many of which lack the medical resources and health systems to support the disease burden. Moreover, the global cancer burden is growing at an alarming pace; in 2030 alone, about 21.4 million new cancer cases and 13.2 million cancer deaths are expected to occur, simply due to the growth and aging of the population. The future burden may be further increased by the adoption of behaviors and lifestyles associated with economic development and urbanization (e.g., smoking, poor diet, physical inactivity, and reproductive patterns) in low- and middle-income countries.

Tobacco use is the most preventable cause of death worldwide, and is responsible for the deaths of approximately half of long-term users. Tobacco use killed 100 million people in the 20th century and will kill 1 billion people in the 21st century if current trends continue. Each year, tobacco use kills approximately 5 million people, and by 2030 this number is expected to increase to 10 million, 70% of whom will reside in low- and middle-income countries.

With nearly a century of experience in cancer control, the American Cancer Society is uniquely positioned to lead the global fight against cancer and tobacco, assisting and empowering the world's cancer societies and anti-tobacco advocates. The Society's Global Health and Research departments are raising awareness about the growing global cancer burden and promoting evidence-based cancer and tobacco control programs.

The American Cancer Society has established three integrated goals to reduce the global burden of cancer:

- **Make cancer control a political and public health priority.** The Society has become actively involved in working with global partners, including the Union for International Cancer Control (UICC), the International Diabetes Federation, the World Heart Federation, Livestrong Foundation, and others to prioritize cancer and noncommunicable diseases (NCDs) on the global health agenda. We were among many nonprofits in the global health community to advocate for a special United Nations High-level Meeting on NCDs to take place in September 2011. NCDs account for more than 60% of the world's deaths, yet they receive less than 3% of the public and private funding for health. This historic meeting could be instrumental in balancing global health funding and advocating for the integration of low-cost interventions for cancer and other NCDs into existing health care systems.
- **Reduce tobacco use, with a particular focus on sub-Saharan Africa.** Through a $7 million (US) grant received from the Bill & Melinda Gates Foundation in 2010, the Society and its partners, including the Africa Tobacco Control Regional Initiative, Africa Tobacco Control Alliance, the Framework Convention Alliance, the Campaign for Tobacco-Free Kids, and the International Union Against Tuberculosis and Lung Disease, support and assist national governments and civil societies in Africa to implement tobacco control policies such as advertising bans, tobacco tax increases, graphic warning labels, and the promotion of smoke-free environments. The partners on this project actively advocate for further tobacco control resources in sub-Saharan Africa and help establish mechanisms to protect existing laws from tobacco industry efforts to overturn them.
- **Increase awareness about the burden of cancer and its leading risk factor, tobacco use.** The Society continues to work with global partners to increase awareness about the growing global cancer and tobacco burdens and their impact on low- and middle-income countries.

In addition to print publications, the American Cancer Society provides cancer information to millions of individuals throughout the world on its Web site, cancer.org. More than 20% of the visitors to the Web site come from outside the US. Information is currently available in English, Spanish, Mandarin, and several other Asian languages, with plans to include more languages in the near future.

For more information on the global cancer burden, visit the Society's Global Health program Web site at cancer.org/international. Also, see the following publications available on cancer.org:

- *Global Cancer Facts & Figures 2nd Edition*
- *The Tobacco Atlas, Third Edition*
- *The Cancer Atlas*

The American Cancer Society

In 1913, 10 physicians and five laypeople founded the American Society for the Control of Cancer. Its purpose was to raise awareness about cancer symptoms, treatment, and prevention; to investigate what causes cancer; and to compile cancer statistics. Later renamed the American Cancer Society, Inc., the organization now works with its more than 3 million volunteers to save lives and create a world with less cancer and more birthdays by helping people stay well, helping people get well, by working to find cures, and by fighting back against the disease. By working relentlessly to bring cancer under control, the Society is making remarkable progress in cancer prevention, early detection, treatment, and patient quality of life. The overall cancer death rate has steadily declined since the early 1990s, and the 5-year survival rate is now 68%, up from 50% in the 1970s. Thanks to this progress, more than 11 million cancer survivors in the US will celebrate another birthday this year.

How the American Cancer Society Is Organized

The American Cancer Society consists of a National Home Office with 12 chartered Divisions and a local presence in nearly every community nationwide.

The National American Cancer Society

A National Assembly of volunteer representatives from each of the American Cancer Society's 12 Divisions elects a national volunteer Board of Directors and the nominating committee. In addition, the Assembly approves corporate bylaw changes and the organization's division of funds policy. The Board of Directors sets and approves strategic goals for the Society, ensures management accountability, approves Division charters and charter requirements, and provides stewardship of donated funds. The National Home Office is responsible for overall planning and coordination of the Society's programs, provides technical support and materials to Divisions and local offices, and administers the Society's research program.

American Cancer Society Divisions

The Society's 12 Divisions are responsible for program delivery and fundraising in their regions. They are governed by Division Boards of Directors composed of both medical and lay volunteers in their regions.

Local Offices

The Society has a presence in nearly every community nationwide, with local offices responsible for raising funds at the community level and delivering programs that help people stay well and get well from cancer, as well as rally communities to fight back against the disease.

Volunteers

More than 3 million volunteers carry out the Society's work in communities across the country. These dedicated people donate their time and talents in many ways to help bring cancer under control as early as possible. Some volunteers choose to educate people about things they can do to prevent cancer or find it early to stay well. Some choose to offer direct support to patients, like driving them to treatment or providing guidance and emotional support. Others work to make cancer a top priority for lawmakers and participate in local community events to raise funds and awareness to fight cancer. No matter how volunteers choose to fight back, they are all saving lives while fulfilling their own.

How the American Cancer Society Saves Lives

The American Cancer Society has set aggressive challenge goals to dramatically decrease cancer incidence and mortality rates by 2015 while increasing the quality of life for all cancer survivors. The Society is uniquely qualified to make a difference in the fight against cancer and to save more lives by continuing its leadership position in supporting high-impact research; improving the quality of life for those affected by cancer; preventing and detecting cancer; and reaching more people, including the medically underserved, with the reliable cancer-related information they need. Simply stated, the American Cancer Society saves lives by helping people stay well and get well, by finding cures, and by fighting back against cancer.

Helping People Stay Well

The American Cancer Society provides information that empowers people to take steps that help them prevent cancer or find it early, when it is most treatable.

Prevention

The Society helps people quit tobacco through the American Cancer Society Quit For Life® Program, managed and operated by Alere Wellbeing. The two organizations have 35 years of combined experience in tobacco cessation coaching and have helped more than 1 million tobacco users.

Choose You® is a national movement created by the American Cancer Society that encourages women to put their own health

first in the fight against cancer. The movement challenges women to make healthier choices and supports them in their commitment to eat right, get active, quit smoking, and get regular health checks.

The Society offers many programs to companies to help their employees stay well and reduce their cancer risk, too. These include Freshstart®, a group-based tobacco cessation counseling program designed to help employees plan a successful quit attempt by providing essential information, skills for coping with cravings, and group support; Content Subscription Service, an online resource of health awareness and cancer information that educates employees about the steps they can take to stay well and get well; *Healthy Living*, a monthly electronic newsletter produced by the American Cancer Society that teaches the importance of making healthy lifestyle choices; the American Cancer Society Workplace Solutions Assessment, which surveys a company's health and wellness policies and practices and recommends evidence-based strategies that help improve employee health behaviors, control health care costs, and increase productivity; and Active For Life®, a 10-week online program that uses individual and group strategies to help employees become more physically active.

Across the nation, the Society works with its nonprofit, nonpartisan advocacy affiliate, the American Cancer Society Cancer Action Network℠ (ACS CAN), to create healthier communities by protecting people from the dangers of secondhand smoke so they can stay well. As of January 1, 2011, 47.8% of the US population was covered by comprehensive smoke-free laws and 79.4% was covered by some sort of smoke-free law. In 2009, the Family Smoking Prevention and Tobacco Control Act was signed into law. A decade in the making, the law, grants the US Food and Drug Administration the authority to regulate the manufacturing, selling, and marketing of tobacco products. Strong implementation of the law is vital to reducing death and disease from tobacco products.

For the majority of Americans who do not smoke, the most important ways to reduce cancer risk are to maintain a healthy weight, be physically active on a regular basis, and eat a mostly plant-based diet, consisting of a variety of vegetables and fruit, whole grains, and limited amounts of red and processed meats. The Society publishes guidelines on nutrition and physical activity for cancer prevention in order to review the accumulating scientific evidence on diet and cancer; to synthesize this evidence into clear, informative recommendations for the general public; to promote healthy individual behaviors, as well as environments that support healthy eating and physical activity habits; and, ultimately, to reduce cancer risk. These guidelines form the foundation for the Society's communication, worksite, school, and community strategies designed to encourage and support people in making healthy lifestyle behavior changes.

Early Detection

Finding cancer at its earliest, most treatable stage gives patients the greatest chance of survival. To help the public and health care providers make informed decisions about cancer screening, the American Cancer Society publishes a variety of early detection guidelines. These guidelines are assessed regularly to ensure that recommendations are based on the most current scientific evidence.

The Society currently provides screening guidelines for cancers of the breast, cervix, colorectum, prostate, and endometrium, and general recommendations for a cancer-related component of a periodic checkup to examine the thyroid, mouth, skin, lymph nodes, testicles, and ovaries.

Throughout its history, the American Cancer Society has implemented a number of aggressive awareness campaigns targeting the public and health care professionals. Campaigns to increase usage of Pap testing and mammography have contributed to a 70% decrease in cervical cancer incidence rates since the introduction of the Pap test in the 1950s and a steady decline in breast cancer mortality rates since 1990. More recently, the Society launched ambitious multimedia campaigns to encourage adults 50 years of age and older to get tested for colorectal cancer. The Society also continues to encourage the early detection of breast cancer through public awareness and other efforts targeting poor and underserved communities.

Helping People Get Well

For the 1.6 million cancer patients diagnosed this year and more than 11 million US cancer survivors, the American Cancer Society is here every minute of every day and night to offer free information, programs, services, and community referrals to patients, survivors, and caregivers to help them make decisions through every step of a cancer experience. These resources are designed to help people facing cancer on their journey to getting well.

Information, 24 Hours a Day, Seven Days a Week

The American Cancer Society is available 24 hours a day, seven days a week online at cancer.org and by calling 1-800-227-2345. Callers are connected with a Cancer Information Specialist who can help them locate a hospital, understand cancer and treatment options, learn what to expect and how to plan, help address insurance concerns, find financial resources, find a local support group, and more. The Society can also help people who speak languages other than English or Spanish find the assistance they need, offering services in 170 languages in total.

Information on every aspect of the cancer experience, from prevention to survivorship, is also available through the Society's Web site, cancer.org. The site includes an interactive cancer resource center containing in-depth information on every major cancer type. The Society also publishes a wide variety of pamphlets and books that cover a multitude of topics, from patient education,

quality-of-life, and caregiving issues to healthy living. A complete list of Society books is available for order at cancer.org/bookstore.

The Society publishes a variety of information sources for health care providers, including three clinical journals: *Cancer, Cancer Cytopathology,* and *CA: A Cancer Journal for Clinicians.* More information about free subscriptions and online access to *CA* and *Cancer Cytopathology* articles is available at cancer.org/journals. The American Cancer Society also collaborates with numerous community groups, nationwide health organizations, and large employers to deliver health information and encourage Americans to adopt healthy lifestyle habits through the Society's science-based worksite programs.

Day-to-day Help and Emotional Support

The American Cancer Society can help cancer patients and their families find the resources they need to make decisions about the day-to-day challenges that can come from a cancer diagnosis, such as transportation to and from treatment, financial and insurance needs, and lodging when having to travel far from home for treatment. The Society also connects people with others who have been through similar experiences to offer emotional support.

Help with the health care system: Learning how to navigate the cancer journey and the health care system can be overwhelming for anyone, but it is particularly difficult for those who are medically underserved, those who experience language or health literacy barriers, or those with limited resources. The American Cancer Society Patient Navigator Program was designed to reach those most in need. As the largest oncology-focused patient navigator program in the country, the Society has specially trained patient navigators at 140 cancer treatment facilities across the nation. Patient navigators work in cooperation with these facilities' staff to connect patients with information, resources, and support to decrease barriers and ultimately to improve health outcomes. In 2010, more than 82,000 people relied on the Patient Navigator Program to help them through their diagnosis and treatment. The Society collaborates with a variety of organizations, including the National Cancer Institute's Center to Reduce Cancer Health Disparities, the Center for Medicare and Medicaid Services, numerous cancer treatment centers, and others to implement and evaluate this program.

Transportation to treatment: Cancer patients cite transportation to and from treatment as a critical need, second only to direct financial assistance. The American Cancer Society Road To Recovery® program matches these patients with specially trained volunteer drivers. This program offers patients an additional key benefit of companionship and moral support during the drive to medical appointments.

The Society's transportation grants program allows hospitals and community organizations to apply for resources to administer their own transportation programs. In some areas, primarily where transportation assistance programs are difficult to sustain, the Society helps patients or their drivers via pre-paid gas cards to help defray costs associated with transportation to treatment.

Lodging during treatment: When someone diagnosed with cancer must travel far from home for the best treatment, where to stay and how to afford accommodations are immediate concerns and can sometimes affect treatment decisions. American Cancer Society Hope Lodge® facilities provide free, home-like, temporary lodging for patients and their caregivers close to treatment centers, thereby easing the emotional and financial burden of finding affordable lodging. In 2010, the 30 American Cancer Society Hope Lodge locations provided 225,000 nights of free lodging to more than 55,000 patients and caregivers – saving them $20 million in lodging expenses.

Breast cancer support: Breast cancer survivors provide one-on-one support, information, and inspiration to help people facing the disease cope with breast cancer through the American Cancer Society Reach To Recovery® program. Volunteer survivors are trained to respond in person or by telephone to people facing breast cancer diagnosis, treatment, recurrence, or recovery.

Prostate cancer support: Men facing prostate cancer can find one-on-one or group support through the American Cancer Society Man To Man® program. The program also offers men the opportunity to educate their communities about prostate cancer and to advocate with lawmakers for stronger research and treatment policies.

Cancer education classes: People with cancer and their caretakers need help coping with the challenges of living with the disease. Doctors, nurses, social workers, and other health care professionals provide them with that help by conducting the American Cancer Society I Can Cope® educational classes to guide patients and their families through their cancer journey.

Hair-loss and mastectomy products: Some women wear wigs, hats, breast forms, and bras to help cope with the effects of mastectomy and hair loss. The American Cancer Society *"tlc" Tender Loving Care®*, which is a magazine and catalog in one, offers helpful articles and a line of products to help women battling cancer restore their appearance and dignity at a difficult time. All proceeds from product sales go back into the Society's programs and services for patients and survivors.

Support during treatment: When women are in active cancer treatment, they want to look their best, and Look Good...Feel Better® helps them do just that. The free program, which is a collaboration of the American Cancer Society, the Personal Care Products Council Foundation, and the Professional Beauty Association | National Cosmetology Association, helps women learn beauty techniques to restore their self-image and cope with appearance-related side effects of cancer treatment. Certified beauty professionals, trained as Look Good...Feel Better volunteers, provide tips on makeup, skin care, nail care, and head coverings. Additional information and materials are available for men and teens.

Finding hope and inspiration: People with cancer and their loved ones do not have to face their cancer experience alone. They can connect with others who have "been there" through the American Cancer Society Cancer Survivors Network®. The online community is a welcoming and safe place that was created by and for cancer survivors and their families.

Finding Cures

The goals of the American Cancer Society's research program are to determine the causes of cancer and to support efforts to prevent, detect, and cure the disease. The Society is the largest private funder of cancer research in the US, second only to the federal government in total dollars spent. The Society spends more than $130 million on research each year and has invested more than $3.6 billion in cancer research since the program began in 1946. The Society's comprehensive research program consisting of extramural grants, as well as intramural programs in epidemiology, surveillance and health policy research, behavioral research, and statistics and evaluation. Intramural research programs are led by the Society's own staff scientists.

Extramural Grants

The American Cancer Society's extramural grants program supports research in a wide range of cancer-related disciplines at about 230 US medical schools and universities.

Grant applications are solicited through a nationwide competition and are subjected to a rigorous external peer review process, ensuring that only the most promising research is funded. The Society primarily funds investigators early in their research careers, a time when they are less likely to receive funding from the federal government, thus giving the best and the brightest a chance to explore cutting-edge ideas at a time when they might not find funding elsewhere. In addition to funding research across the continuum of cancer research, from basic science to clinical and quality-of-life research, the Society also focuses on needs that are unmet by other funding organizations. For instance, for 10 years, the Society supported a targeted research program to address the causes of the higher cancer mortality in the poor and medically underserved.

To date, 44 Nobel Prize winners have received grant support from the Society early in their careers, a number unmatched in the nonprofit sector, and proof that the organization's approach to funding young researchers truly helps launch high-quality scientific careers.

Intramural Research

For more than 60 years, the Society's intramural research program has conducted and published high-quality epidemiologic research to advance understanding of the causes and prevention of cancer and monitored and disseminated surveillance information on cancer occurrence, risk factors, and screening.

Epidemiology

As a leader in cancer research, the Society's Epidemiology Research program has been conducting studies to identify factors that cause or prevent cancer since 1951. The first of these, the Hammond-Horn Study, helped to establish cigarette smoking as a cause of death from lung cancer and coronary heart disease, and also demonstrated the Society's ability to conduct very large prospective cohort studies. The Cancer Prevention Study (CPS) I was launched in 1959 and included more than 1 million men and women recruited by 68,000 volunteers. Results from CPS-I clearly demonstrated that the sharp increase in lung cancer death rates among US women between 1959-1972 occurred only in smokers, and was the first to show a relationship between obesity and risk of mortality.

In 1982, Cancer Prevention Study II (CPS-II) was established through the recruitment of 1.2 million men and women by 77,000 volunteers. The more than 480,000 lifelong nonsmokers in CPS-II provide the most stable estimates of lung cancer risk in the absence of active smoking. CPS-II data are used extensively by the Centers for Disease Control and Prevention (CDC) to estimate deaths attributable to smoking. The CPS-II study also made important contributions in establishing the link between obesity and cancer. A subgroup of CPS-II participants, the CPS-II Nutrition Cohort has been particularly valuable for clarifying associations between cancer risk and obesity, physical activity, diet, aspirin use, and hormone use. Blood samples from this group allow Society investigators and their collaborators at other institutions to study how genetic, hormonal, nutritional, and other blood markers are related to cancer risk and/or progression.

The Cancer Prevention Studies have resulted in more than 400 scientific publications and have provided unique contributions both within the Society and the global scientific community. In addition to key contributions to the effects of the tobacco epidemic over the past half-century, other important findings from these studies include:

- The association of obesity with increased death rates for at least 10 cancer sites, including colon and postmenopausal breast cancer
- The link between aspirin use and lower risk of colon cancer, opening the door to research on chronic inflammation and cancer
- The relationships between other potentially modifiable factors, such as physical inactivity, prolonged hormone use, and certain dietary factors, with cancer risk
- The association between air pollution, especially small particulates and ozone, with increased death rates from heart and lung conditions, which helped to motivate the Environmental Protection Agency to propose more stringent limits on air pollution

While landmark findings from the CPS-II Nutrition Cohort have informed multiple areas of public health policy and clinical practice, the cohort is aging. A new cohort is needed to explore the effects of changing exposures and to provide greater opportunity to integrate biological measurements into studies of genetic and environmental risk factors. In 2006, Society epidemiologists began the enrollment of a new cohort, CPS-3, with the goal of recruiting and following approximately 300,000 men and women. All participants are providing blood samples at the time of enrollment. Following on the long history of partnering with Society volunteers and supporters for establishing a cohort, the Society's community-based Relay For Life® events are the primary venues for recruiting and enrolling participants. Although similar large cohorts are being established in some European and Asian countries, there are currently no studies of this magnitude in the US; therefore, the data collected from CPS-3 participants will provide unique opportunities for research in the US.

Surveillance Research

Through the Surveillance Research program, the Society publishes the most current cancer statistics in *CA: A Cancer Journal for Clinicians* (caonline.amcancersoc.org), as well as a variety of *Cancer Facts & Figures* publications. These publications are the most widely cited sources for cancer statistics and are available in hard copy from Division offices and online through the Society's Web site at cancer.org/statistics. Society scientists also monitor trends in cancer risk factors and screening and publish these results annually – along with Society recommendations, policy initiatives, and evidence-based programs – in *Cancer Prevention & Early Detection Facts & Figures*. In 2010, Surveillance Research collaborated with the Global Health department to publish *Global Cancer Facts & Figures 2nd Edition*, an international companion to *Cancer Facts & Figures*.

Since 1998, the Society has collaborated with the National Cancer Institute, the Centers for Disease Control and Prevention, the National Center for Health Statistics, and the North American Association of Central Cancer Registries to produce the Annual Report to the Nation on the Status of Cancer, a peer-reviewed journal article that reports current information related to cancer rates and trends in the US.

Epidemiologists in Surveillance Research also conduct and publish high-quality epidemiologic research in order to advance the understanding of cancer. Research topics include the causes of cancer, the population burden in the US and abroad, and how differences in patient characteristics, such as race, age, and socioeconomic status, affect cancer incidence and mortality. Recent studies have focused on the relationship between education and cancer mortality, temporal trends in breast cancer mortality by state, and trends in colorectal cancer internationally and by socioeconomic status and age in the US.

Health Services Research

Interest in developing a Health Services Research (HSR) program within the American Cancer Society National Home Office began in the late 1990s, motivated by several factors including increasing disparities in the quality and outcomes of cancer care. These factors indicated the need to develop methods and systems to monitor quality of cancer care as well as interventions to improve cancer care and patient outcomes, issues of great importance to Society stakeholders. The HSR program was founded in 2006, and since that time the group has developed into a highly productive multidisciplinary research team consisting of five full-time and one part-time staff members, including both clinician and non-clinician staff.

The primary objective of the HSR program is to perform high-quality, high-impact research that supports the Society's mission and program initiatives. Additional, related objectives include identifying critical gaps in evaluating and improving quality of cancer patient care, and taking leadership in policy and technical initiatives to address these gaps. The HSR program is uniquely positioned to respond rapidly to critical information needs by Society personnel, as well as national and international policy makers. The HSR program analyzes cancer treatment patterns and outcomes and has examined the role of health insurance in explaining disparities in access to care, quality of care among patients with access, and outcomes such as morbidity and mortality.

To accomplish its objectives, HSR's work has primarily involved the use secondary data sources. The National Cancer Data Base (NCDB), jointly sponsored by the American Cancer Society and the American College of Surgeons, has been key to HSR's research on the impact of insurance on cancer status, treatments, and outcomes, as well as for broader surveillance of cancer incidence/prevalence and treatment patterns. Other databases used to support HSR's objectives include linked SEER-Medicare data, linked state registry and Medicaid enrollment data, and Medical Expenditure Panel Survey Data linked with National Health Interview Survey Data.

International Tobacco Control Research

The predecessor of the International Tobacco Control Research Program (ITCRP), the International Tobacco Surveillance unit, was created in 1998 to support collaborative international tobacco surveillance efforts involving the Society, the WHO Tobacco Free Initiative, the World Bank and the Centers for Disease Control and Prevention's (CDC) Office of Smoking and Health. Its special publications, the *Tobacco Control Country Profiles*, 1st and 2nd editions, were distributed during the 11th and 12th World Conference on Tobacco or Health in 2000 and in 2003, respectively.

Since 2006, ITCRP has begun to focus on economic research in tobacco control, taking advantage of established partnerships with numerous academic and nonprofit organizations. In addition to original research, the program helps build capacity for the collection and analysis of economic data to provide the evidence base for tobacco control in low- and middle-income countries. To that end, ITCRP received funding from the Bloomberg Global Initiative to Reduce Tobacco Use, the Gates Foundation, and a grant from the National Institutes of Health Fogarty International Center.

The most important service publication of the ITCRP is *The Tobacco Atlas*, which is produced in collaboration with the Society's Global Health department, Georgia State University, and the World Lung Foundation. *The Tobacco Atlas, Fourth Edition* will be released at the 15th World Conference on Tobacco or Health in 2012 in Singapore.

Behavioral Research Center

The American Cancer Society was one of the first organizations to recognize the importance of behavioral and psychosocial factors in the prevention and control of cancer and to fund extramural research in this area. In 1995, the Society established the Behavioral Research Center (BRC) as an intramural department. The BRC's work currently focuses on cancer survivorship, quality of life, and tobacco research. It also addresses the issues of special populations, including minorities, the poor, rural populations, and other underserved groups. The BRC's ongoing projects include:

- Studies of the quality of life of cancer survivors. These studies include an ongoing, nationwide longitudinal study and a cross-sectional study, both of which explore the physical and psychosocial adjustment to cancer and identify factors affecting quality of life.
- Studies of family caregivers that explore the impact of the family's involvement in cancer care on the quality of life of the cancer survivor and the caregiver.
- Efforts to establish and implement a process to measure the effective control of pain, other symptoms, and side effects for those who have been affected by cancer. Several methods for the systematic collection of patient-reported symptom data are under consideration or in development.
- Studies of African American-white disparities in cancer-related behaviors among Georgians. One study investigates the role of sociocultural factors and neighborhood barriers in disparities in smoking, poor diet, lack of exercise, and cancer screening among a statewide sample of more than 1,000 African Americans.
- Studies investigating how social, psychological, and other factors impact smokers' motivation and ability to quit. Knowledge gained is used to improve existing Society programs for smoking cessation (e.g., FreshStart, Great American Smokeout®) or to develop new technology-based interventions for smokers who seek cessation assistance.

Statistics and Evaluation Center

The Statistics & Evaluation Center (SEC) provides expert statistical, survey, study design, and evaluative consultation services to the American Cancer Society National Home Office and its Divisions. The SEC has two groups, Statistics and Survey Research, that work independently or in tandem depending upon the nature of the project, the service to be rendered, or the problem to be solved. The SEC's mission is to improve the Society's programs and processes, based on good science. The center always seeks to capture data systematically, and objectively deliver valid, reliable, accurate, and timely information to its stakeholders for evidence-based decision-making.

SEC staff designs and conducts process and outcome evaluations of Society programs, projects, and initiatives, and conducts focus groups, structured/semi-structured interviews, and needs assessments. All evaluations are logic model driven. The SEC continues to be engaged in evaluations of the Society's national survivorship, quality-of-life, early detection, prevention, global health, and extramural grants funding programs. The center's professional staff is involved in multiple projects across the Society, where their extensive statistical, study design, survey research skills, and experience are applied to evaluation and quantitative problem solving. The results of these studies improve Society mission and income delivery.

In the past year, the SEC has worked with staff from the Health Promotions department to evaluate aspects of the Man To Man, Look Good ... Feel Better, I Can Cope, and Let's Talk About It® programs and on the evaluation of web matching technologies for use with the Reach To Recovery and Road To Recovery programs. In addition, the SEC has worked with the Extramural Grants program to evaluate the Society's collaboration with the Canary Foundation on innovation in cancer screening and detection technology.

SEC staff also worked with the Global Health program and the Surveillance and Health Policy Research program to successfully obtain a grant from the Gates Foundation to fund smoking cessation work in Africa. In addition, the center collaborated with the Society's Office of Health Disparities to design and pilot a geographic information system- (GIS) based decision support tool.

Fighting Back

Conquering cancer is as much a matter of public policy as scientific discovery. Whether it's advocating for quality, affordable health care for all Americans, increasing funding for cancer research and programs, or enacting laws and policies that help decrease tobacco use, government action is constantly required. The American Cancer Society and its nonprofit, nonpartisan advocacy affiliate, the American Cancer Society Cancer Action Network (ACS CAN), use applied policy analysis, direct lobbying, grassroots action, and media outreach to ensure elected officials nationwide pass laws furthering the organizations' shared

mission to create a world with less cancer. Created in 2001, ACS CAN is the force behind a new movement uniting and empowering cancer patients, survivors, caregivers, and their families. ACS CAN is a community-based grassroots movement that unites cancer survivors and caregivers, volunteers and staff, health care professionals, researchers, public health organizations, and other partners. ACS CAN gives ordinary people extraordinary power to fight back against cancer. In recent years, the Society and ACS CAN have successfully partnered to pass a number of laws at the federal, state, and local levels focused on preventing cancer and detecting it early, increasing research on ways to prevent and treat cancer, improving access to lifesaving screenings and treatment, and improving quality of life for cancer patients. Some of our recent advocacy accomplishments impacting cancer patients include:

- Passage of the Affordable Care Act (ACA) of 2010, comprehensive legislation that:
  - Prohibits insurance companies from denying insurance coverage based on a pre-existing conditions (children starting in 2010, adults in 2014)
  - Prohibits insurance coverage from being rescinded when a patient gets sick
  - Removes lifetime limits from all insurance plans
  - Allows children and young adults to be covered under their parents' insurance plans until they turn 26
  - Makes coverage for routine care costs available to patients who take part in clinical trials
  - Establishes a National Institutes of Health Interagency Pain Research Advisory Committee to coordinate pain management research initiatives and an Institute of Medicine Pain Conference series that will be important to relieving cancer-related pain and other chronic pain conditions
  - Establishes a National Prevention and Health Promotion Strategy; a National Prevention, Health Promotion and Public Health Council; and a Prevention and Public Health Fund with mandatory funding to prioritize, coordinate, oversee, and fund prevention-related activities nationwide
  - Requires all new health insurance plans and Medicare to cover preventive services rated "A" or "B" by the US Preventive Services Task Force (USPTF) at no cost to patients (including breast, cervical, and colorectal cancer screening and smoking cessation treatment).
  - Requires state Medicaid programs to provide pregnant women with tobacco cessation treatment at no cost
  - Protects children and families against states rules that limit program eligibility or increase premiums or enrollment fees in Medicaid
  - Provides new funding to states to make expansions or improvements to Medicaid
  - Saves states money in uncompensated care by replacing local dollars with new federal subsidies
  - Expands coverage to all low-income adults below 133% of the federal poverty level eligible for Medicaid beginning in 2014
  - Prioritizes health disparities at the National Institutes of Health, establishes a network of federal-specific offices of minority health, and creates an Office of Women's Health
  - Enhances data collection and reporting to ensure racial and ethnic minorities are receiving appropriate, timely, and quality health care
  - Authorizes grants to help states and local jurisdictions address health workforce needs
  - Secures coverage for a new annual wellness visit with a personalized prevention plan and gradually reduces out-of-pocket costs for prescription drugs for Medicare beneficiaries
  - Creates incentives for health care providers to deliver more coordinated and integrated care to beneficiaries enrolled in Medicare and Medicaid
  - Requires chain restaurants to provide calorie information on menus and have other nutrition information available to consumers upon request and requires chain vending machine owners or operators to display calorie information for all products available for sale

  Please refer to *The Affordable Care Act: How It Helps People with Cancer and their Families* for more information (http://action.acscan.org/site/DocServer/Affordable_Care_Act_Through_the_Cancer_Lens_Final.pdf?docID=18421).
- Supporting legislation that focuses on preventing cancer by reducing tobacco use, obesity, and sun exposure, improving nutrition, and increasing physical activity. By successfully working with partners, the Society and ACS CAN have:
  - Empowered the FDA with authority over tobacco products, resulting in new federal tobacco regulations that ban "light," "low," and "mild" descriptors on cigarettes; ban sales to youth; and impose new labeling requirements for smokeless tobacco. We have also helped defend this authority against legal challenges in court.
  - Passed comprehensive smoke-free laws in 23 states and the District of Columbia that require all workplaces, restaurants, and bars to be smoke free, covering nearly half of the US population, and defended these laws in court
  - Increased taxes on tobacco products to an average state cigarette tax of $1.45 per pack
  - Continued our role as interveners in the US government's lawsuit against the tobacco industry, in which manufacturers have been convicted as racketeers for decades of fraud associated with marketing of tobacco products

- Passed strong legislation to reauthorize the federal child nutrition programs, which improve school meals, establish nutrition standards for foods sold in schools outside of meal programs, and strengthen local wellness policies to include health, nutrition, and physical education
- Secured millions of dollars in new federal and state funding for cancer research, prevention, early detection, and education, and implemented comprehensive state cancer control plans and fought efforts to cut funding
- Worked to improve access to essential cancer screening services, especially among low-income, uninsured, and underinsured populations
- Advocated for full funding for the National Breast and Cervical Cancer Early Detection Program (NBCCEDP), which provides free breast and cervical cancer screenings and treatment to low-income, uninsured, and medically underserved women
- Advocated for legislation to create a new nationwide colorectal screening and treatment program modeled after NBCCEDP

- Improving quality of life for cancer patients by ensuring that patients and survivors receive the best cancer care that matches treatments to patient and family goals across their life course. The Society and ACS CAN have:
  - Fought for reauthorization of the Health Resources and Services Administration (HRSA) Patient Navigator Program, which supports health care outreach in medically underserved communities for cancer patients and others suffering from chronic diseases
  - Advocated for more balanced pain policies in multiple states and at the federal level to ensure patients and survivors have access to the pain medicines and care they need to ease their suffering from cancer-related pain
  - Advocated for federal legislation to promote patient- and family-centered quality cancer care, survivorship care planning, pain and symptom management, and care coordination to improve quality of life for patients, survivors, and their families
  - Monitored legal cases of employment discrimination brought by cancer survivors as a result of wrongful termination in the workplace

Some efforts in the fight against cancer are more visible than others, but each successful battle is an important contribution to what will ultimately be victory over the disease. The Society, working together with ACS CAN and its grassroots movement, is making sure the voice of the cancer community is heard in the halls of government and is empowering communities everywhere to fight back. The Society is also rallying people to fight back against the disease through our Relay For Life, Making Strides Against Breast Cancer, and DetermiNation events.

Sources of Statistics

New cancer cases. The estimated numbers of new US cancer cases in 2011 are projected using a spatio-temporal model based on incidence data from 46 states and the District of Columbia for the years 1995-2007 that met the North American Association of Central Cancer Registries' (NAACCR) high-quality data standard for incidence, which covers about 95% of the US population. This method considers geographic variations in socio-demographic and lifestyle factors, medical settings, and cancer screening behaviors as predictors of incidence, as well as accounting for expected delays in case reporting. (See "B" in Additional Information on page 54 for more detailed information.)

Incidence rates. Incidence rates are defined as the number of people per 100,000 who are diagnosed with cancer during a given time period. State incidence rates presented in this publication are published in NAACCR's publication *Cancer Incidence in North America, 2003-2007.* Trends in cancer incidence rates and incidence rates by race/ethnicity were originally published in the *SEER Cancer Statistics Review (CSR) 1975-2007* and/or the 2010 Annual Report to the Nation on the Status of Cancer. (See "D" in Additional Information on page 54 for full reference.) Incidence rates in this publication are age adjusted to the 2000 US standard population to allow comparisons across populations with different age distributions. Incidence trends described in this publication are based on delay-adjusted incidence rates. Incidence rates that are not adjusted for delays in reporting may underestimate the number of cancer cases in the most recent time period. Cancer rates most affected by reporting delays are melanoma of the skin, leukemia, and prostate because these cancers are frequently diagnosed in non-hospital settings.

Cancer deaths. The estimated numbers of US cancer deaths are calculated by fitting the numbers of cancer deaths for 1969-2007 to a statistical model that forecasts the numbers of deaths expected to occur in 2011. The estimated numbers of cancer deaths for each state are calculated similarly, using state-level data. For both US and state estimates, data on the numbers of deaths are obtained from the National Center for Health Statistics (NCHS) at the Centers for Disease Control and Prevention.

Mortality rates. Mortality rates or death rates are defined as the number of people per 100,000 dying of a disease during a given year. In this publication, mortality rates are based on counts of cancer deaths compiled by NCHS for 1930-2007 and population data from the US Census Bureau. Death rates in this publication are age adjusted to the 2000 US standard population to allow comparisons across populations with different age distributions. These rates should be compared only to other statistics that are age adjusted to the US 2000 standard population. The trends in cancer mortality rates reported in this publication were first published in the *CSR 1975-2007.* (See "C" in Additional Information for full reference.)

Important note about estimated cancer cases and deaths for the current year. The estimated numbers of new cancer cases and deaths in the current year are model-based and may produce numbers that vary considerably from year to year for reasons other than changes in cancer occurrence. For this reason, the use of our estimates to track year-to-year changes in cancer occurrence or deaths is strongly discouraged. Incidence and mortality rates reported by the Surveillance, Epidemiology, and End Results (SEER) program and NCHS are more informative statistics to use when tracking cancer incidence and mortality trends for the US. Rates from state cancer registries are useful for tracking local trends.

Survival. Unless otherwise specified, 5-year relative survival rates are presented in this report for cancer patients diagnosed between 1999 and 2006, followed through 2007.

Relative survival rates are used to adjust for normal life expectancy (and events such as death from heart disease, accidents, and diseases of old age). Relative survival is calculated by dividing the percentage of observed 5-year survival for cancer patients by the 5-year survival expected for people in the general population who are similar to the patient group with respect to age, sex, race, and calendar year of observation. Five-year survival statistics presented in this publication were originally published in *CSR 1975-2007.* In addition to 5-year survival rates, 1-year, 10-year, and 15-year survival rates are presented for selected cancer sites. These survival statistics are generated using the National Cancer Institute's SEER 17 database and SEER*Stat software version 6.6.2. (See "G" in Additional Information.) One-year survival rates are based on cancer patients diagnosed between 2003 and 2006, 10-year survival rates are based on diagnoses between 1994 and 2006, and 15-year survival rates are based on diagnoses between 1989 and 2006; all patients were followed through 2007.

Probability of developing cancer. Probabilities of developing cancer are calculated using DevCan (Probability of Developing Cancer) software version 6.5.0, developed by the National Cancer Institute. (See "H" in Additional Information.) These probabilities reflect the average experience of people in the US and do not take into account individual behaviors and risk factors. For example, the estimate of 1 man in 13 developing lung cancer in a lifetime underestimates the risk for smokers and overestimates risk for nonsmokers.

Additional information. More information on the methods used to generate the statistics for this report can be found in the following publications:

A. For information on data collection methods used by the North American Association of Central Cancer Registries: Copeland G, Lake A, Firth R, et al. (eds). *Cancer in North America, 2003-2007. Volume One: Combined Cancer Incidence for the United States and Canada.* Springfield, IL: North American Association of Central Cancer Registries, Inc. June 2010. Available at naaccr.org.

B. For information on the methods used to estimate the numbers of new cancer cases: Pickle L, Hao Y, Jemal A, et al. *CA Cancer J Clin.* 2007; 57:30-42.

C. For information on data collection methods used by the SEER program: Altekruse SF, Kosary CL, Krapcho M, et al. (eds). *SEER Cancer Statistics Review, 1975-2007.* National Cancer Institute. Bethesda, MD, 2010. Available at seer.cancer.gov.

D. For information on cancer incidence trends reported herein: Kohler BA, Ward EM, et al. *J Natl Cancer Inst.* 2011; 103:1-23.

E. For information on data collection and processing methods used by NCHS: cdc.gov/nchs/deaths.htm.

F. For information on the methods used to estimate the number of cancer deaths: Tiwari, et al. *CA Cancer J Clin.* 2004; 54:30-40.

G. For information on the methods used to calculate relative survival rates: software – Surveillance Research Program, National Cancer Institute SEER*Stat software (seer.cancer.gov/seerstat) version 6.6.2; database – Surveillance, Epidemiology, and End Results (SEER) Program (seer.cancer.gov) SEER*Stat Database: Incidence – SEER 17 Regs Limited-Use, Nov 2009 Sub (1973-2007 varying) – Linked to County Attributes – Total US, 1969-2007 Counties, National Cancer Institute, DCCPS, Surveillance Research Program, Cancer Statistics Branch, released April 2010, based on the November 2009 submission.

H. For information on the methods used to calculate the probability of developing cancer: DevCan 6.5.0. Probability of developing or dying of cancer. Statistical Research and Applications Branch, NCI, 2010. Available at: srab.cancer.gov/devcan/.

Screening Guidelines for the Early Detection of Cancer in Average-risk Asymptomatic People

Cancer Site	Population	Test or Procedure	Frequency
Breast	Women, age 20+	Breast self-examination	Beginning in their early 20s, women should be told about the benefits and limitations of breast self-examination (BSE). The importance of prompt reporting of any new breast symptoms to a health professional should be emphasized. Women who choose to do BSE should receive instruction and have their technique reviewed on the occasion of a periodic health examination. It is acceptable for women to choose not to do BSE or to do BSE irregularly.
		Clinical breast examination	For women in their 20s and 30s, it is recommended that clinical breast examination (CBE) be part of a periodic health examination, preferably at least every three years. Asymptomatic women aged 40 and over should continue to receive a clinical breast examination as part of a periodic health examination, preferably annually.
		Mammography	Begin annual mammography at age 40.*
Colorectal†	Men and women, age 50+	*Tests that find polyps and cancer:* Flexible sigmoidoscopy,‡ or	Every five years, starting at age 50
		Colonoscopy, or	Every 10 years, starting at age 50
		Double-contrast barium enema (DCBE),‡ or	Every five years, starting at age 50
		CT colonography (virtual colonoscopy)‡	Every five years, starting at age 50
		Tests that mainly find cancer: Fecal occult blood test (FOBT) with at least 50% test sensitivity for cancer, or fecal immunochemical test (FIT) with at least 50% test sensitivity for cancer‡§ or	Annual, starting at age 50
		Stool DNA test (sDNA)‡	Interval uncertain, starting at age 50
Prostate	Men, age 50+	Prostate-specific antigen test (PSA) with or without digital rectal exam (DRE)	Asymptomatic men who have at least a 10-year life expectancy should have an opportunity to make an informed decision with their health care provider about screening for prostate cancer after receiving information about the uncertainties, risks, and potential benefits associated with screening. Prostate cancer screening should not occur without an informed decision-making process.¶
Cervix	Women, age 18+	Pap test	Cervical cancer screening should begin approximately three years after a woman begins having vaginal intercourse, but no later than 21 years of age. Screening should be done every year with conventional Pap tests or every two years using liquid-based Pap tests. At or after age 30, women who have had three normal test results in a row may get screened every two to three years with cervical cytology (either conventional or liquid-based Pap test) alone, or every three years with an HPV DNA test plus cervical cytology. Women 70 years of age and older who have had three or more normal Pap tests and no abnormal Pap tests in the past 10 years and women who have had a total hysterectomy may choose to stop cervical cancer screening.
Endometrial	Women, at menopause	At the time of menopause, women at average risk should be informed about risks and symptoms of endometrial cancer and strongly encouraged to report any unexpected bleeding or spotting to their physicians.	
Cancer-related checkup	Men and women, age 20+	On the occasion of a periodic health examination, the cancer-related checkup should include examination for cancers of the thyroid, testicles, ovaries, lymph nodes, oral cavity, and skin, as well as health counseling about tobacco, sun exposure, diet and nutrition, risk factors, sexual practices, and environmental and occupational exposures.	

*Beginning at age 40, annual clinical breast examination should be performed prior to mammography.

†Individuals with a personal or family history of colorectal cancer or adenomas, inflammatory bowel disease, or high-risk genetic syndromes should continue to follow the most recent recommendations for individuals at increased or high risk.

‡Colonoscopy should be done if test results are positive.

§For FOBT or FIT used as a screening test, the take-home multiple sample method should be used. A FOBT or FIT done during a digital rectal exam in the doctor's office is not adequate for screening.

¶Information should be provided to men about the benefits and limitations of testing so that an informed decision can be made with the clinician's assistance.

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Attachment I

Clinical Journal Articles in Support of Project Need

Effects of Adaptive Section Collimation on Patient Radiation Dose in Multisection Spiral CT[1]

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Michael Lell, MD
Willi A. Kalender, PhD

Purpose: To evaluate the potential effectiveness of adaptive collimation in reducing computed tomographic (CT) radiation dose owing to z-overscanning by using dose measurements and Monte Carlo (MC) dose simulations.

Materials and Methods: Institutional review board approval was not necessary. Dose profiles were measured with thermoluminescent dosimeters in CT dose index phantoms and in an Alderson-Rando phantom without and with adaptive section collimation for spiral cardiac and chest CT protocols and were compared with the MC simulated dose profiles. Additional dose measurements were performed with an ionization chamber for scan ranges of 5–50 cm and pitch factors of 0.5–1.5.

Results: The measured and simulated dose profiles agreed to within 3%. By using adaptive section collimation, a substantial dose reduction of up to 10% was achieved for cardiac and chest CT when measurements were performed free in air and of 7% on average when measurements were performed in phantoms. For scan ranges smaller than 12 cm, ionization chamber measurements and simulations indicated a dose reduction of up to 38%.

Conclusion: Adaptive section collimation allows substantial reduction of unnecessary exposure owing to z-overscanning in spiral CT. It can be combined in synergy with other means of dose reduction, such as spectral optimization and automatic exposure control.

Supplemental material: *http://radiology.rsnajnls.org/cgi/content/full/252/1/140/DC1*

[1] From the Institute of Medical Physics (P.D.D., O.L., W.A.K.) and Department of Radiology (M.L.), University Erlangen-Nürnberg, Henkestrasse 91, 91052 Erlangen, Germany. Received October 16, 2008; revision requested November 14; revision received December 23; accepted January 29, 2009; final version accepted February 25. **Address correspondence to** W.A.K. (e-mail: *willi.kalender@imp.uni-erlangen.de*).

Patient radiation dose resulting from computed tomographic (CT) examinations is a topic of great concern. The use of CT has increased largely over the past 2 decades because of the introduction of spiral CT in the early 1990s and the transition from single–detector row to multi–detector row technology. According to recent surveys, CT is estimated to contribute approximately 50%–67% of the total collective dose to the population in Western countries owing to medical use of ionizing radiation (1–3). Therefore, there is considerable interest in reducing patient dose to the minimum necessary for a reliable diagnosis (ie, in optimizing CT applications). There is also particular interest in avoiding or at least reducing any unnecessary exposure during CT examinations.

One cause of unnecessary exposure often cited to make a significant contribution to total dose during spiral CT procedures is the z-overscanning effect (4–8). z-Overscanning is associated with spiral CT and relates to the fact that the z-interpolation necessary for image reconstruction requires data acquired above and below each image position (9–11). For a given scan length (ie, imaged volume) covered in the spiral mode, at least an additional one-half of a rotation (180° in parallel ray geometry) is necessary at the beginning and at the end of the scan to ensure that complete data sets are obtained for the reconstruction of the first and the last sections. As a result, additional tissue is exposed to radiation above and below the volume displayed by images. For single–detector row scanners, z-overscanning effects are considered negligible. However, the effect increases with the number of detector rows. As increasingly larger z-coverage is provided by modern multisection CT scanners, z-overscanning effects increase and have to be taken into account properly.

A method that promises potential for reduction of z-overscanning effects and consequently also for dose saving is the concept of adaptive section collimation. In this concept, parts of the x-ray beam exposing tissue outside of the volume to be imaged are blocked in the z-direction by dynamically adjusted collimators at the beginning and at the end of the CT scan (Fig 1). The aim of this study was to evaluate the potential effectiveness of adaptive collimation in reducing CT radiation dose owing to z-overscanning by using dose measurements and MC dose simulations.

Advances in Knowledge

- Adaptive collimation allows elimination of unnecessary radiation dose contributions owing to z-overscanning in spiral CT.
- Depending on scan range and spiral scanning protocol used, dose reductions between 2% and 38% are expected.
- For a typical chest spiral scan of 30 cm and pitch factor of 1.0, the dose reduction can amount to typically 10% when dynamic collimators are used.

Materials and Methods

For this study, institutional review board approval was not necessary. The effect of z-overscanning is illustrated in Figure 2: The irradiated range is larger than the nominal scan length because of the interpolation required for spiral image reconstruction. For a given scan length, the exposed range increases linearly with the pitch value according to $R = A \cdot p + L$, where R is the exposed range, A is a constant independent of pitch, p is the pitch value, and L is the scan length from the start to the stop positions. The relative effect is higher for smaller scan ranges (eg, at $L = 5$ cm), where the irradiated length is approximately double the nominal scan length for higher pitch values (Figs 2, E1 *[http://radiology.rsnajnls.org/cgi/content/full/252/1/140/DC1]*). The effect of z-overscanning increases with the collimation width; that is, the problem increases for scanners with larger z-coverage, which is usually achieved by increasing the number of detectors.

Implications for Patient Care

- Unnecessary radiation exposure of the patient owing to z-overscanning largely can be avoided when adaptive section collimation is applied.
- Especially in cardiac and pediatric CT examinations, the use of adaptive section collimation can substantially reduce the dose to the patient from z-overscanning.

CT Scanner

An implementation of dynamic or adaptive section collimation was recently introduced on a newer 64-section CT scanner (Somatom Definition AS; Siemens Healthcare, Forchheim, Germany). All dose simulations and measurements were performed for and with this scanner. It is equipped with cone-beam collimators that allow adaptive modification of the shape of the x-ray cone beam in the z-direction during scanning, as described later. Further technical details can be found in Appendix E1 *(http://radiology.rsnajnls.org/cgi/content/full/252/1/140/DC1)*.

When spiral scanning is performed, the shape of the cone beam in the z-direction is adapted by two collimators made of x-ray–absorbent material that can be adjusted independently, as indicated in Figure 1. The concept is explained here for the example of a thoracic scan obtained in the craniocaudal direction. For simplicity, we refer to the two collimators as "cranial" and "caudal" collimators to indicate their position with respect to the central ray relative to patient anatomy. At the start

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Abbreviations:
MC = Monte Carlo
TLD = thermoluminescent dosimeter

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W.A.K. is a consultant for Siemens Healthcare.

position of the scan, the cone beam is blocked out nearly completely by closing the cranial collimator except for an offset of 5 mm measured at the center of rotation; the caudal collimator is completely opened. When advancing the patient during spiral scanning, the cranial collimator is progressively retracted with a speed proportional to the table speed; it will be fully opened after a distance equal to the total collimation and will remain so until the end of the scanning. Both collimators will remain completely retracted, allowing for the standard full cone-beam acquisition during scanning. When the couch reaches the end position less the collimation width, the caudal collimator will start moving in progressively; at the end position, it will block out the caudally oriented cone beam nearly completely. The trapezoid in Figure 1b represents the collimator opening when adaptive collimation is used compared with the acquisition of a conventional scan without adaptive collimation, as depicted by the shaded region on either side of the trapezoid.

Figure 1

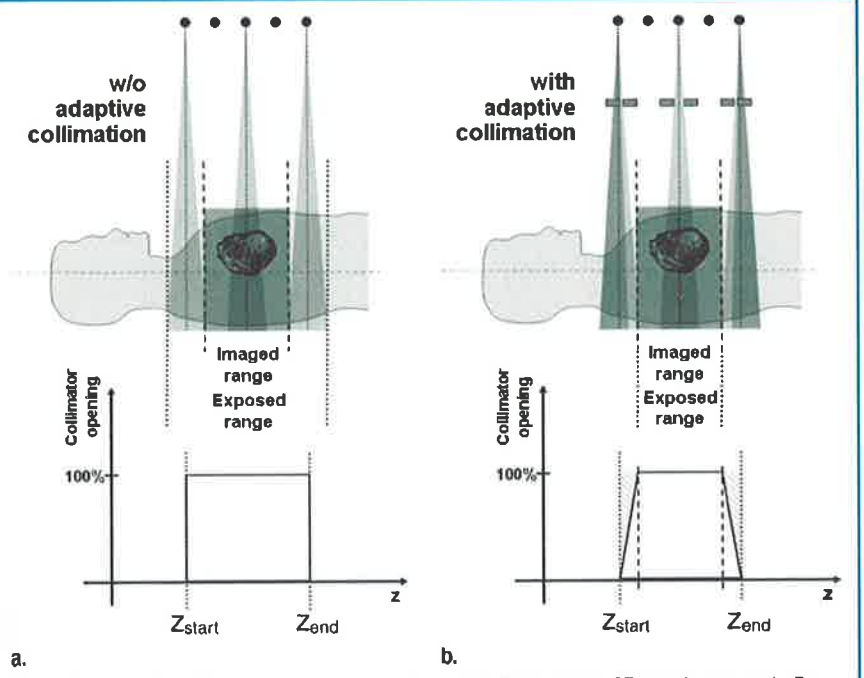

Figure 1: Examples of **(a)** conventional and **(b)** adaptive section collimation CT scanning protocols. For adaptive section collimation, shape of x-ray cone beam at beginning and end of spiral acquisition is controlled by two collimators made of absorbent material.

Dose Measurements

CT dose index values and dose profiles were measured in a CT dose index polymethyl methacrylate body phantom of 32-cm diameter, as well as free in air. To include larger scan ranges and also to adapt to the wide-beam collimation, extended CT dose index phantoms of a total length of 60 cm were used (Figs E1–E4 *([http://radiology.rsnajnls.org/cgi/content/full/252/1/140/DC1])*. Dose profiles were measured by using thermoluminescent dosimeters (TLDs) with spatial dimensions of $1 \times 1 \times 6$ mm^3 (LiF:Mg, Ti; Harshaw-Bicron, Solon, Ohio) placed in a special custom-made holder designed for the extended CT dose index phantoms. Before use, the TLDs were calibrated by using a 28-mL active-volume ionization chamber (PM-30; Capintec, Ramsey, NJ). A linear fit was performed to correlate the TLD value readout with the dose given by the ionization chamber.

TLD dose profile measurements in the CT dose index phantom were performed separately at the center of the phantom and at the periphery (12-

Figure 2

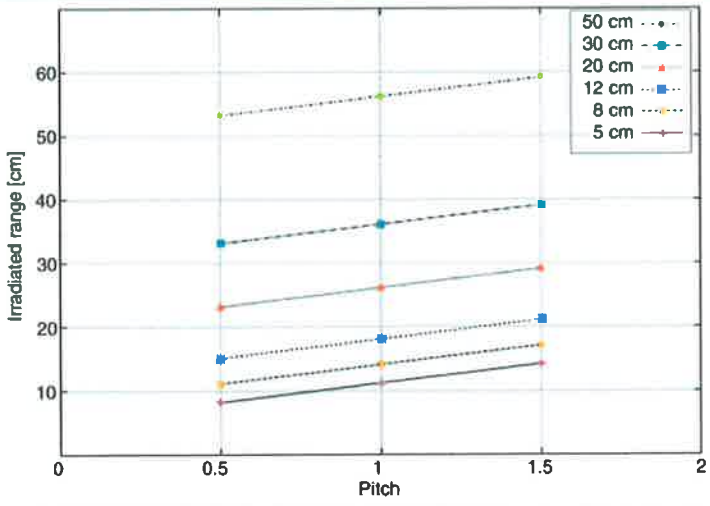

Figure 2: *z*-Overscanning effect for 64–detector row multisection CT scanner and total collimation of 38.4 mm. Exposed range is plotted as function of pitch values (ie, 0.5, 1.0, and 1.5) for several lengths of imaged volume (ie, nominal scan length) ranging from 5 to 50 cm.

o'clock position). The midplane of the CT dose index phantom was set to coincide with the central plane of the x-ray cone beam by using the laser light–positioning system. After each measurement, the TLDs were separated and labeled according to the protocol that was used for measurement. The procedure was repeated for all protocols used. Depending on the scan length, the number of TLDs used varied between 53 TLDs for the 12-cm scan length to 83 TLDs for the 30-cm scan length.

The dose profiles in air were measured at the scanner rotation center by placing 45 and 73 TLDs for the 12-cm and 30-cm dose profiles, respectively, on a custom-made holder of polyurethane foam to minimize scattering effects. Table 1 summarizes the scanning parameters for dose profile measurements. For air and CT dose index phantom measurements, two spiral scanning protocols that are routinely used in clinical practice were evaluated corresponding to a cardiac and a chest examination. The scan length for chest and cardiac examinations was 30 and 12 cm, respectively. The cardiac scanning protocol was performed for a pitch value of 0.5, whereas for the chest examination, the pitch value was 1.0. All dose measurements were performed for a tube voltage of 120 kV and a total collimation of 38.4 mm. For each scanning protocol, the dose profiles were recorded with and without the adaptive section collimation activated.

Dose profiles also were measured in an Alderson-Rando phantom by using the same technique as described before (Appendix E1 *([http://radiology.rsnajnls.org/cgi/content/full/252/1/140/DC1])*. Table 1 summarizes the scanning parameters used for the measurements with the Alderson-Rando phantom. As in the previous case, the dose profiles were recorded with and without adaptive section collimation activated.

To determine the dose reduction without the confounding influence of scattered radiation, air kerma dose measurements were performed free in air by using a 10-cm ionization chamber (type 30009; PTW, Freiburg, Germany), with active volume of 3.14 cm^3, connected to an electrometer (Unidose; PTW) for scan ranges of 5–50 cm and pitch values of 0.5–1.5. The ionization chamber was placed at the isocenter of the scanner and aligned by using the CT laser system. To avoid potential influence of the patient table on dose measurements, the ionization chamber was placed on a tripod at the opposite side of the gantry. Thus, the position of the ionization chamber remained constant during acquisition of scans with the chamber center permanently exposed. Prior to each air kerma measurement, a test scan was obtained to ensure that the table did not enter the x-ray beam and did not obstruct the ionization chamber. The dose savings was determined as the percentage difference between both measurements.

MC Calculations

The MC calculations were performed for all measurement scenarios by using a version of an MC software package (ImpactMC; VAMP, Erlangen, Germany) modified at our institute to take into account the adaptive section collimation concept described before. Details of the implementation and validation of the tool are reported elsewhere (12,13). All MC calculations were performed in accordance with the protocols given in Table 1.

In the case of CT dose index evaluation, the three-dimensional dose distributions were computed for CT dose index phantoms generated as mathematic phantoms consisting of cylinders filled with polymethyl methacrylate material surrounded by air (14). The CT dose index profiles (ie, central and peripheral profiles) were obtained from the three-dimensional dose distributions by evaluating regions of interest corresponding to the positions where the measurements were performed. Afterward, the computed profiles were compared with the corresponding profiles obtained with TLDs. Extended scan ranges of up to 50 cm were simulated in addition to the protocols mentioned before for CT dose index evaluation.

In the same manner as described before, dose profiles were obtained from the three-dimensional dose distribution in the Alderson-Rando phantom and compared with the corresponding profiles obtained from TLD measurements.

In all simulations, the number of simulated photon histories was in the range of 10^8–10^9, depending on the volume size (ie, number of voxels), and this factor resulted in a precision for all simulations of 1% or better.

Table 1

Scanning Protocols for TLD Measurements in Air and Phantoms

	Air		Phantoms	
Parameter	Cardiac Protocol	Chest Protocol	Cardiac Protocol	Chest Protocol
Tube voltage (kV)	120	120	120	120
Tube current (mA)	400	200	400	200
Collimation (mm)	38.4	38.4	38.4	38.4
Pitch	0.5	1.0	0.5	1.0
Scan length (cm)	12	30	12	30
TLD profile length (cm)	30	60	60	60
Rotation time (sec)	0.3	0.3	0.3	0.3
No. of scans	2	2	6	6

Note.—The CT dose index and Alderson-Rando phantoms were used.

Results

The correlation factor that resulted from the linear fit between the TLD value readout and the dose values given by the ionization chamber measured simultaneously in fluoroscopic mode was found to be 27.6 mGy/100 mAs (Appendix E1 *([http://radiology.rsnajnls.org/cgi/content/full/252/1/140/DC1])*. This correlation factor was used as a scale factor in to obtain the absolute dose values for all measured dose profiles.

Measured and simulated dose profiles along the z-axis in air and in CT dose index phantoms are shown in

Figure 3

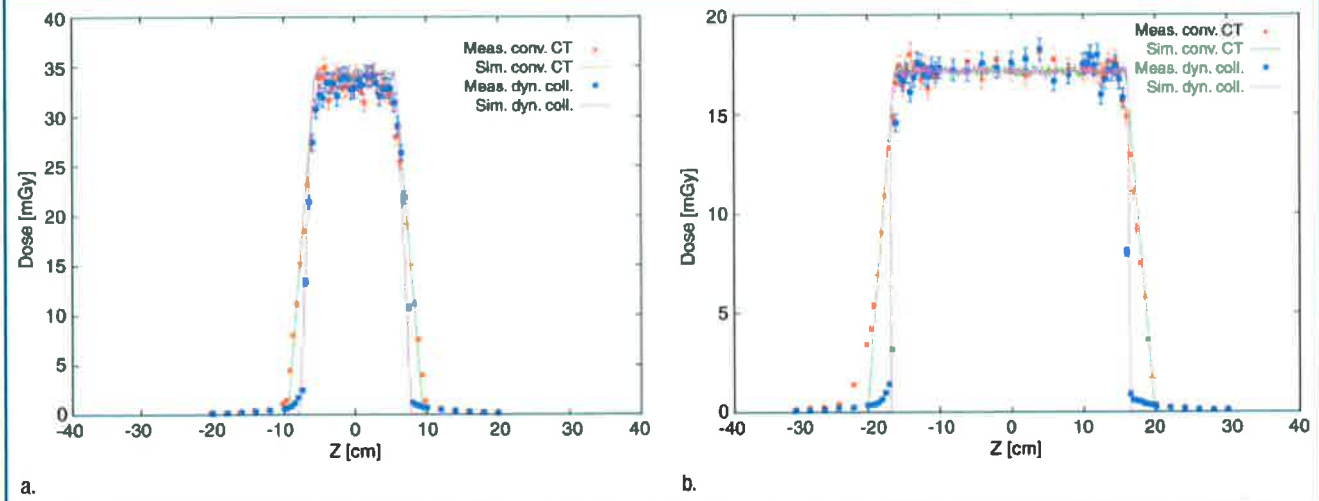

Figure 3: Measured and simulated dose profiles free in air along z-axis with and without dynamic collimation at **(a)** 12-cm scan length and pitch of 0.5 for cardiac protocol and **(b)** 30-cm scan length and pitch of 1.0 for chest protocol.

Figure 4

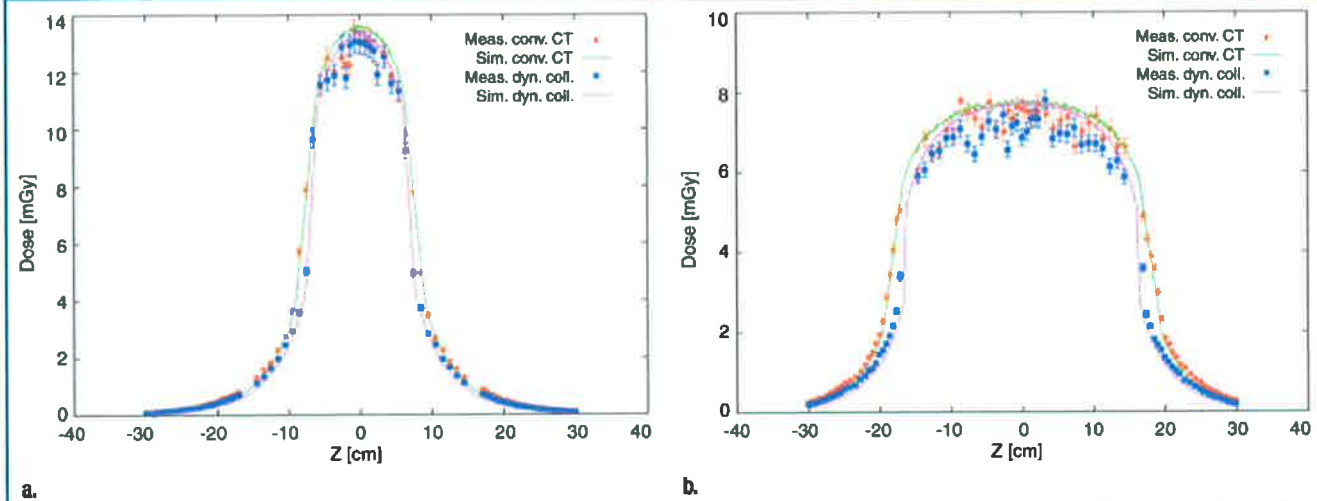

Figure 4: Measured and simulated dose profiles along z-axis with and without dynamic collimation in CT dose index body phantom at **(a)** 12-cm scan length and pitch of 0.5 for cardiac protocol and **(b)** 30-cm scan length and pitch of 1.0 for chest protocol.

Figures 3 and 4, respectively, for the cardiac (12-cm scan length, pitch of 0.5) and the chest (30-cm scan length, pitch of 1.0) protocols. Both figures demonstrate good agreement typically to within 3% between simulated and measured data. As expected, the dose profiles in air (Fig 3) are almost rectangular because there are no tails owing to scattered radiation. Especially for the scans with dynamic collimation, the desired perfect rectangle is reached in good approximation. The differences without and with dynamic collimation are best illustrated by the slopes of the tails, which conform very well to expectations. For the dose profiles measured and simulated with the CT dose index phantom (Fig 4), the differences between dynamic and conventional collimation are less pronounced because of the confounding superposition of scattered radiation. Peak values in Figure 4 are slightly reduced for the case of dynamic collimation, which can be attributed to the fact that scatter contributions are reduced because of sparing exposure at the start and the end of the scanning. Errors in dose measurements by using TLDs were found to be low over three

consecutive measurements. The coefficient of variation, defined as the ratio between standard deviation and mean value expressed as a percentage, was between 2% and 5% for both in-air and in-phantom measurements; they are depicted accordingly as error bars in the measured dose profile curves. The same order of magnitude was found for the coefficient of variation of ionization-chamber measurements in air. As mentioned before, the reproducibility of simulated dose values was better than 1% for all cases. Thus, the overall statistical error in simulations can be considered negligible; accordingly, the errors are not depicted in the dose profile curves.

Table 2 summarizes the weighted CT dose index values from measured and simulated dose profiles, along with the relative reduction, expressed as a percentage, resulting from the use of adaptive z-collimation in comparison with the collimation used with the standard approach, determined in air, CT dose index phantoms, and in the Alderson-Rando phantom on the basis of TLD dose profile measurements and simulations. Generally, the results of measurements and of simulations were in good agreement. For the measured scan lengths of 12 and 30 cm, the dose assessments by using TLD profiles also were in very good agreement with the corresponding measurements performed with the ionization chamber. Owing to the contributions by scattered radiation to the dose profiles in the CT dose index and Alderson-Rando phantoms, the dose reduction appears smaller when the reduction is compared with the same results obtained in air, especially for the Alderson-Rando phantom for both scanning protocols, and slightly smaller for the CT dose index phantom when the cardiac protocol was employed. Differences in dose reduction between the CT dose index and Alderson-Rando phantoms can be explained by the differences in material homogeneity. For the Alderson-Rando phantom, both scans cover a considerable region of the lungs where the photons are less attenuated. Thus, there is less scatter than in the CT dose index phantom. Details with respect to dose profiles measured and simulated for the Alderson-Rando phantom can be found in Appendix E1 *(http://radiology.rsnajnls.org/cgi/content/full/252/1/140/DC1)*.

Figure 5 presents the dose savings owing to adaptive collimation expressed as percentage differences in comparison with the dose with conventional collimation as a function of scan length and pitch measured free in air by using the 10-cm ionization chamber and obtained by using simulations for a 60-cm CT dose index phantom. For both cases, the dependence of dose saving on scan length was found to follow a power-law relationship given by using the following equation: $D_s \propto a \cdot L^{-b}$, where D_s is the dose savings, a and b are pitch-dependent variables, and L is scan length. The highest dose savings of about 37% was obtained for a scan length of 50 mm and a pitch value of 1.5. The relative dose reduction decreases with the increase in the scan length and with the decrease in the pitch value.

Table 2

Weighted CT Dose Index Values from Measured and Simulated Dose Profiles in Air and Phantoms

	Cardiac Protocol		Chest Protocol	
Air and Phantom	Measured Dose Profile	Simulated Dose Profile	Measured Dose Profile	Simulated Dose Profile
Air	121.8/133.0 (8.4)	122.0/135.4 (9.9)	147.1/163.6 (10.1)	147.7/161.1 (8.3)
CT dose index phantom	56.4/60.7 (7.1)	55.8/61.8 (9.7)	64.1/71.4 (10.2)	66.7/73.2 (8.9)
Alderson-Rando phantom	104.0/111.7 (6.9)	95.3/104.0 (8.4)	143.4/151.5 (5.3)	128.1/139.4 (8.1)

Note.—The weighted CT dose index phantom radiation doses in milligrays were normalized to 100 mAs. Data are the doses obtained for scans acquired with adaptive section collimation/doses for scans acquired with conventional methods. Numbers in parentheses are the relative percentages of reduction obtained when dynamic collimation was used and were calculated by dividing the difference (calculated by subtracting the doses obtained for scans acquired with adaptive section collimation from the doses obtained with conventional methods) by the dose for scans acquired with conventional methods.

Figure 5

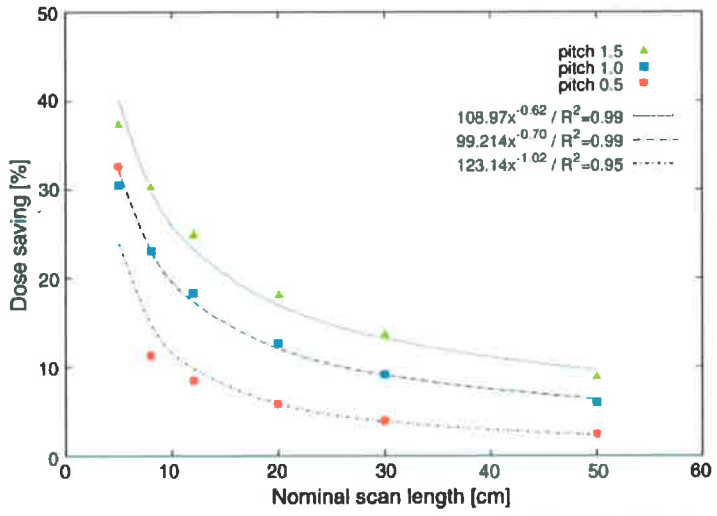

Figure 5: Relative dose reduction measured in air obtained for protocols with dynamic collimation as a function of scan length and pitch value. Measurements were performed by using ionization chamber of 10-cm length.

Discussion

According to the as-low-as-reasonably-achievable, or ALARA, principle (15), every effort should be made to reduce

radiation dose to the patient without compromising the diagnosis. This is also the background and motivation of the work reported here. One of the factors responsible for radiation burden in spiral CT examinations is represented by z-overscanning. Tzedakis et al (4) reported differences in radiation dose between contiguous axial and spiral scans obtained at a pitch of 1.0 of up to 35.8% for a chest examination on the basis of measurements and simulations of CT dose index and differences of up to 70% in the normalized effective dose for a chest examination simulated in phantoms mimicking pediatric patients examined with a 16-section CT scanner (5). Spiral scans provide shorter acquisition time, resulting in fewer motion artifacts, and allow multiplanar reformation of reconstructed images, which are advantageous when compared with axial scans. Although the z-overscanning effect cannot be eliminated completely because of the necessity of data interpolation used by the spiral reconstruction algorithms, the effect of z-overscanning can be minimized.

The approach reported here consists in blocking the x-ray cone beam by means of dynamic collimators at the beginning and at the end of the scan range. The effect of the new concept on dose was evaluated by using measurements and simulations of dose values (ie, CT dose index values) and dose profiles in air and in CT dose index and Alderson-Rando phantoms for different scan ranges and pitch values. For all cases, both dose measurements and simulations confirm that a significant dose reduction is achieved when the adaptive section collimation concept is used. As expected, higher relative dose reduction is obtained for small scan ranges and higher pitch values. For example, the dose reduction obtained with the CT dose index phantom by using MC simulations for a nominal scan range of 12 cm and pitch values of 0.5, 1.0, and 1.5, was 9.7%, 18.1%, and 25.9%, respectively. With increasing scan range and decreasing pitch value, the relative dose reduction decreases. It is well known that, for smaller patient sizes, the absorbed and effective doses increase with decreasing diameter and age (16–18). Thus, for pediatric patients, the dose values are up to 2.4 times higher than they are for the adult for similar CT procedures (18). Dose reduction by using adaptive collimators accordingly is even more important and effective for pediatric CT examinations, where the scan ranges are relatively small. According to Tzedakis et al (5), the scan range in the pediatric chest examination varies between 8 cm for a newborn patient to 24 cm for a 15-year-old patient. Consequently, the dose can be reduced between 32% and 14% when adaptive collimators are used. For CT examinations with a scan length longer than 30 cm (ie, adult trunk scans) the dose reduction is less pronounced. For example, for scans of 50-cm length, the dose reduction is approximately 2.3%, 4.6%, and 6.4% for spiral scanning protocols with pitch values of 0.5, 1.0, and 1.5, respectively.

For the CT protocols considered in this study for which the dose profiles were investigated, good agreement between measurements and simulations was found. Measured and simulated dose profiles in air showed a considerable dose reduction up to 10% when dynamic collimators were used. The results in air represent the reduction in dose that is caused by elimination of the tails of the dose profiles by the adaptive collimation concept. When the same measurement is repeated in phantoms, scattered radiation will be superimposed on the dose profiles both in the central exposed parts and in the vicinity of the exposed parts. The intensity of scatter always depends on the size of the volume exposed; it is reduced by reducing the exposed range. Therefore, patient dose is reduced by two effects when adaptive collimation is used: by exposure of less tissue directly and by reduction of the amount of scattered radiation. Nevertheless, the reduction of patient dose expressed as a percentage is lower for larger objects because the total dose is higher because of the increased scatter contributions. As an example, the dose reduction for the anthropomorphic phantom was lower than it was in air because of the contributions of the scattered radiation for both scanning protocols. Discrepancies in dose profiles between measurements and simulations are caused by the idealized geometry assumed in the MC tool where the penumbra effect generated by the collimators was ignored, and possible errors in measurements with respect to misalignment in phantom positioning and errors in TLD measurements may have occurred.

The limitations of our study were related to the fact that only two scanning protocols were investigated with respect to dose profiles by using pitch factors of 0.5 and 1.0 only. This was caused by the considerable time effort demanded by TLD measurements. However, the ionization-chamber measurements covered the most of the scanning protocols used in daily practice, with scan ranges between 8 and 50 cm and pitch factors of 0.5–1.5. The ionization-chamber measurements were limited to in-air measurements; however, the results were confirmed by using MC simulations performed both in air and in the CT dose index phantom. Other aspects that should be considered in future investigations are related to the effects of z-overscanning and adaptive collimation on effective dose for large patients and for pediatric patients.

In conclusion, adaptive collimation proved to be an effective method to reduce dose owing to CT examinations. Because the dose-saving effect increases with smaller scan ranges and higher pitch factors, it is an innovative and complementary tool in the arsenal of dose reduction measures that is especially effective in pediatric patients and in examinations with a small scan range, such as in cardiac CT.

We validated a method to reduce the z-overscanning influence on patient dose for spiral CT examinations by using adaptive section collimation concepts. The results obtained are promising and can be combined with other available means such as automatic exposure control (19) and optimization of the x-ray spectra (20,21) in full synergy. Exposure reduction values between 2% and more than 30% are possible; values between 5% and 10% appear realistic in most radiologic examinations. How-

ever, it is not the exact percentage value that counts. It is the strict accordance with the as-low-as-reasonably-achievable principle that shows that CT is dose efficient and practiced in a dose-conscious manner.

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Original article

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Comparison of image quality and radiation dose between combined automatic tube current modulation and fixed tube current technique in CT of abdomen and pelvis

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Abstract

Background: Tube current is an important determinant of radiation dose and image quality in X-ray-based examination. The combined automatic tube current modulation technique (ATCM) enables automatic adjustment of the tube current in various planes (*x-y* and *z*) based on the size and attenuation of the body area scanned.

Purpose: To compare image quality and radiation dose of the ATCM with those of a fixed tube current technique (FTC) in CT of the abdomen and pelvis performed with a 16-slice multidetector row CT.

Material and Methods: We reviewed 100 patients in whom initial and follow-up CT of the abdomen and pelvis were performed with FTC and ATCM. All acquisition parameters were identical in both techniques except for tube current. We recorded objective image noise in liver parenchyma, subjective image noise and diagnostic acceptability by using a five-point scale, radiation dose, and body mass index (BMI, kg/m^2). Data were analyzed with parametric and non-parametric statistical tests.

Results: There was no significant difference in image noise and diagnostic acceptability between two techniques. All subjects had acceptable subjective image noise in both techniques. The significant reduction in radiation dose (45.25% reduction) was noted with combined ATCM ($P < 0.001$). There was a significant linear statistical correlation between BMI and dose reduction ($r = -0.78$, $P < 0.05$).

Conclusion: The ATCM for CT of the abdomen and pelvis substantially reduced radiation dose while maintaining diagnostic image quality. Patients with lower BMI showed more reduction in radiation dose.

Keywords: CT, combined automatic tube current modulation, fixed tube current, radiation dose, body mass index

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Recent advances in computed tomography (CT) have greatly increased the clinical application of CT, especially since the advent of multidetector row CT (MDCT) technology (1, 2). However, increasing radiation doses to the population have raised a compelling case for reduction of radiation exposure from CT (2–4). The risk of radiation induced cancer would increase in a linear fashion at lower dose without a 'safe' threshold (5, 6). Increasing awareness of risks associated with radiation exposure mandates lowest possible radiation exposure to patients from CT studies while maintaining optimum image quality (7).

Tube current is an important determinant of radiation dose and image quality in X-ray-based examination. When all other factors are held constant, the radiation dose is linearly related to the current-time value (3). Automatic tube current modulation in CT is analogous to the automatic exposure control, which has been used in conventional radiography for automatically terminating radiographic exposure once the predetermined radiographic density has been obtained. In the automatic tube current modulation (ATCM) technique, tube current can be decreased automatically for regions with lower attenuation while maintaining

an acceptable level of image noise and improving radiation dose efficiency. The ATCM technique enables automatic adjustment of the tube current in various planes (*x-y* and *z*) based on the size and attenuation of the body area scanned (8–13).

The purpose of our study was to compare image quality, diagnostic acceptability, and radiation dose of the ATCM technique with those of a fixed tube current (FTC) technique in CT of abdomen and pelvis performed in the same patient with a 16-slice MDCT.

Material and Methods

Patient and examination protocol

Our institutional review board of the hospital approved this retrospective study with a waiver of informed consent. Between February 2007 and May 2009, 100 consecutive adult patients who underwent follow-up contrast-enhanced CT examination of the abdomen and pelvis with a 16-slice MDCT (Somatom Sensation 16, Siemens Medical Solutions, Erlangen, Germany) by using both FTC techniques and combined or x-y and z axes ATCM techniques (CARE Dose 4D, Siemens) in the same patient were identified. Initial and follow-up CT examinations were indicated for assessment of abdominal or pelvic pathology in all patients. A total of 54 men and 46 women (mean age 60 ± 14 years, age range 21–87 years) were included in this study. Body mass index (BMI, kg/m^2) of subjects in the study group had been recorded prior to CT. Mean weight and BMI of the patients recorded prior to CT with combined ATCM was 58.36 ± 9.59 kg (range of 39.5–83.9 kg) and $22.56 \pm 3.06\ kg/m^2$ (range of 16.04–30.16 kg/m^2), respectively. The mean interval between the two examinations was 5.6 ± 3.69 months (range 1–15 months). There was no significant change in body weight of the patients between two CT exams with ATCM and FTC technique ($P = 0.6327$).

Fixed or constant tube current techniques were used with an effective milliampere-second value of 165 mAs. Combined or *x-y* and *z* axes modulation techniques were used with an image quality reference of 160 mAs for scanning the same patients. The effective milliampere-second setting can be defined as the tube current–time product divided by the pitch factor. The range of tube current in the ATCM technique was 75–142 mAs (minimum and maximum value for the 100 patients).

CARE Dose 4D (Siemens) was used as the ATCM technique, which controls and modulates the current in the *x*, *y*, and *z* directions to achieve and maintain a uniform user selected image quality in the images. For the *z*-axis modulation component, an attenuation profile along the patient's long axis (*z*-axis) is measured in the direction of the projection on the basis of a single localizer radiograph. The attenuation profile consists of information regarding the patient's size, anatomic shape, and density at each position in the *z*-axis. On the basis of these attenuation profiles, axial tube current values are calculated to adapt tube current for *z*-axis modulation. An analytic function defines the correlation between attenuation profile and tube current for slice position in the *z*-axis and adapts the tube current to patient size and attenuation changes. Tube current adjustment is based on a user-defined image quality reference milliampere-second setting to maintain the desired image quality in all images along the scanning direction (*z*-axis modulation component). On the basis of these levels, the technique also modulates the tube current during each tube rotation according to the patient's angular attenuation profile (angular modulation component). The image quality reference mAs value is selected according to the diagnostic requirements and the preference of the radiologist. For a given scanning protocol, this value reflects the effective mAs that is used for a reference patient defined as a typical adult weighing 70–80 kg (for adult protocols). The combined modulation technique adapts tube current to the size of the individual patient on the basis of the image quality reference mAs value, which is changed only if an adjustment to image quality is required and not for individual patient size. The software determines whether a patient is slim or obese from the localizer radiograph and modulates the dose based on the preselected modulation strength for these patients. Image quality and radiation dose can be controlled by selecting an appropriate setting of combined modulation and image quality reference mAs value (12, 14).

Other scanning parameters were in constant use. These included a tube voltage of 120 kVp (peak), 0.5 s gantry rotation time, 16×1.5 mm detector configuration, 24 mm table feed per gantry rotation, 5 mm reconstructed slice thickness, 5 mm slice interval, and B31 medium soft tissue reconstruction kernel, and modulation setting with a strong increase setting for obese patients and a weak decrease modulation for slim patients.

Image quality

Image quality was assessed on the contrast-enhanced portal phase images. Quantitative evaluation of image quality was based on an evaluation of image noise. Image noise was recorded for each examination in the liver parenchyma at the level of the porta hepatis. For measurement of the image noise, a circular or ovoid region of interest with a size of $1.0\ cm^2$ was placed in a homogeneous region of liver parenchyma without obvious vessels or focal liver lesions. The standard deviations (SDs) of the attenuation in these regions of interest were measured three times in three different places and the mean value of SDs was recorded. The SD, in Hounsfield units, of the attenuation in a particular region of interest was used as a noise measurement (8, 12, 14). Qualitative image scoring was performed independently by two subspecialty radiologists (one with 12 years of experience and the other with 4 years of experience) who were unaware of the scanning techniques used. Each radiologist was shown CT image stacks in random order one by one. They independently scored CT images for subjective image noise and diagnostic acceptability by using a five-point scale at five anatomic levels (i.e. the upper liver at the level of the diaphragm, porta hepatis, right kidney hilum, iliac crest, and upper margin of the acetabulum) in an absolute manner. These subjective image

quality parameters were selected on the basis of prior studies (12, 14–16).

The readers were asked to score subjective image noise on a 5-point scale: 1, too much noise; 2, more than acceptable noise; 3, acceptable noise; 4, better than average noise; and 5, very little noise. Image noise was considered as acceptable if there was average mottle or graininess with acceptable visualization of anatomic structures and interfaces between structures with different attenuation.

The readers were also asked to rate diagnostic acceptability using the following 5-point scale: 1, unacceptable; 2, below average; 3, average; 4, above average; 5, excellent. Diagnostic quality was considered as acceptable if sharpness of different structures, contrast resolution, and lesion visualization were satisfactory. Diagnostic quality was described as unacceptable if these image attributes were unsatisfactory, or as excellent if visualization was considerably superior. Images from all examinations were assessed at the same window level and window width (40 and 400 HU, respectively). The degree of graininess or mottle on the image was the main factor considered in the scoring of image noise. Diagnostic acceptability was graded on the basis of confidence in diagnosis of disease at that level. A score of greater than or equal to 3 was considered as an acceptable level of artifacts or as constituting adequate diagnostic acceptability.

Radiation dose

We recorded the CT dose index volume (CTDIvol) and dose-length product (DLP) for contrast-enhanced portal phase images as a CT radiation dose descriptor for comparison of radiation exposure with ATCM and FTC techniques. Dose reduction (mGy) was calculated by equation of CTDIvol of FTC – CTDIvol of ATCM, and percentage dose reduction by (CTDIvol of FTC – CTDIvol of ATCM)/CTDIvol of FTC *100.

Statistical analysis

Objective image noise of ATCM and FTC was compared by using Wilcoxon signed rank test and statistical software (PASW 17.0, by SPSS Inc., Chicago, IL, USA). Image quality scores for subjective image noise and diagnostic acceptability between ATCM and FTC were compared by using the generalized estimating equations method with Bonferroni's correction (17, 18). CTDIvol and DLP of two different techniques were also compared by using paired t-test. Correlation between patient BMI and CTDIvol, DLP, and dose reduction in ATCM compared to FTC were evaluated by using Spearman correlation analysis with Bonferroni's correction.

The cut-off level of BMI of significant dose reduction with preserved quantitative image quality was analyzed by using minimum P value approach with Miller and Siegmund correction to prevent for false-positive error to be inflated due to multiple testing (19). This is the method to find the cut-off value with the minimum P value adjusting inflated false-positive error due to multiple testing. The degree of inter-observer concordance was determined with calculation of κ statistics. A P value of less than 0.05 was considered to indicate a statistically significant difference.

Results

Image quality

The values of objective image noise and the scores of subjective image noise and diagnostic acceptability for studies performed with ATCM and FTC are summarized in Tables 1 and 2. There was no significant difference in the objective image noise values between two acquisition techniques ($P = 0.684$). There was no significant difference in scores for subjective image noise and diagnostic acceptability between images obtained with two different techniques in both readers ($P = 0.6252$ and $P = 0.6832$ in reader 1, and $P = 0.8356$ and $P = 0.7142$ in reader 2, respectively). All of these qualitative image scores were more than 3 considered as an acceptable level of artifacts or as constituting adequate diagnostic acceptability.

Radiation dose

The average and SD values of CTDIvol and DLP for CT examinations performed with different tube current techniques are summarized in Table 1. A significant reduction in radiation dose was noted with the ATCM compared with the FTC technique ($P < 0.0001$). There was a reduction (from 12.87 to 7.05 mGy) in radiation dose for ATCM. The average reduction in radiation dose with ATCM was $45.3 \pm 8.06\%$ compared with the FTC technique (range 22.5–59.2%). The example case with radiation dose reduction of 57.6% using the combined ATCM is illustrated (Fig. 1).

For examinations performed with ATCM technique, a significant linear statistical correlation between patient BMI (kg/m^2) and CTDIvol ($r = 0.78$, $P = 0.0006$) was found (Fig. 2). Significant linear correlations was also found between patient BMI (kg/m^2) and radiation dose reduction in CTDIvol ($r = -0.78$, $P = 0.0006$). For examinations performed with FTC technique, statistical analysis was not possible for correlation between patient BMI and CTDIvol because CTDIvol with FTC were same in all patients. The cut-off level of BMI of significant dose reduction with preserved quantitative image quality was 21.8 kg/m^2 ($P < 0.0001$) using ATCM. Patients with less than 21.8 kg/m^2 showed more significant dose reduction compared to them with more than 21.8 kg/m^2. Objective image noise in patients with more than 21.8 kg/m^2 BMI was higher than that in patients with lesser than the cut-off level of BMI (13.137 ± 1.86 vs. 12.18 ± 1.43, $P = 0.0006$). No significant difference were found in subjective image noise ($P = 0.96$

Table 1 Comparison of average CT dose index volume (CTDIvol), dose-length product (DLP), and objective image noise between ATCM (automatic tube current modulation) and FTC (fixed tube current) techniques

	ATCM	FTC	*P* value
CTDI vol (mGy)	7.05 ± 1.04	12.87	<0.0001
DLP (mGy * cm)	340.7 ± 80	598.3 ± 92	<0.0001
Objective image noise (HU)	12.71 ± 1.74	12.77 ± 1.79	0.6839

Table 2 Comparison of subjective image noise and diagnostic acceptability

	Reader 1			Reader 2		
	ATCM	FTC	*P* value	ATCM	FTC	*P* value
Subjective image noise	4 (3–5)*	4 (3–5)	0.6252	4 (3–5)	4 (3–5)	0.8356
Diagnostic acceptability	4 (3–5)	4 (3–5)	0.6832	4 (3–5)	4 (3–5)	0.7142

*Median (range, minimum and maximum value)
ATCM = automatic tube current modulation; FTC = fixed tube current

in reader 1 and $P = 0.10$ in reader 2) and diagnostic acceptability scores ($P = 0.34$ in reader 1 and $P = 0.80$ in reader 2) between the patients with less than 21.8 kg/m^2 and them with more than 21.8 kg/m^2 in ATCM technique.

Inter-observer agreement

There was a good inter-observer agreement between the two radiologists for assessment of both subjective image noise and diagnostic acceptability (weighted κ coefficient 0.87 and 0.83, $P < 0.0001$).

Discussion

Optimization of scanning techniques to maintain diagnostic image quality at the lowest possible radiation dose has become very important with the concerns about increasing uses of CT and the associated radiation dose (1, 20). Angular or *x-y* modulation techniques automatically adjust the tube current for each projection angle to the attenuation of the patient to minimize X-rays in a particular scanning plane, for example, lower tube current is used in the anteroposterior projection compared to the lateral projection. The *z*-axis modulation technique adjusts the tube current from section to section, depending on regional body anatomy. Combined, or *x-y* and *z* axes, automatic tube current modulation techniques vary the tube current both during gantry rotation and along the *z*-axis of the patient. This is one of the most comprehensive approaches to CT dose reduction because the X-ray dose is adjusted according to patient-specific attenuation in all three planes (8–13).

Results of previous studies with the angular ATCM technique have reported a substantial reduction in radiation dose ranging from 15–50% (21–25). Likewise, the effects of *z*-axis modulation on image quality and radiation dose had been reported. Kalra *et al.* reported 33% of mean tube current-time product reduction with similar noise and

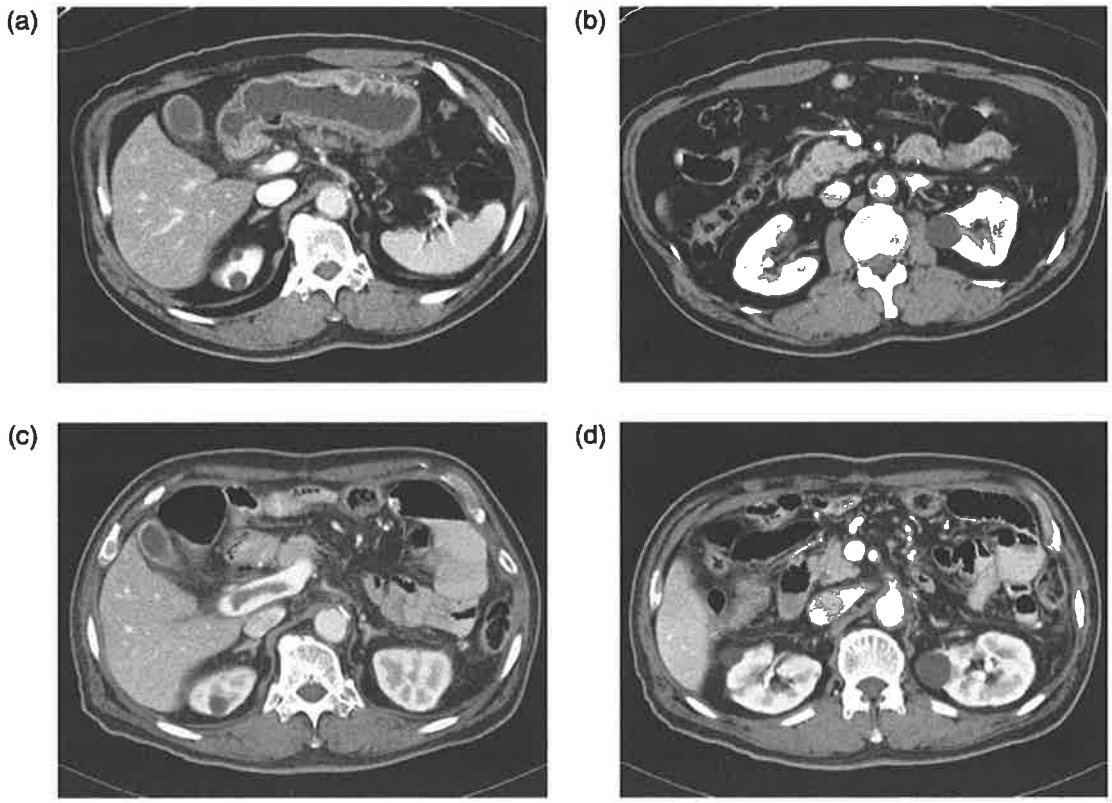

Fig. 1 Transverse CT images acquired with ATCM (a, b) and FTC technique (c, d) in a 66-year-old man (BMI 29.09 kg/m^2, 69 kg). Objective image noise for ATCM and FTC were 12.03 and 13.5, respectively, and all qualitative image scores were more than 3 in two readers. Radiation dose reduction of 57.6% was noted with the combined ATCM

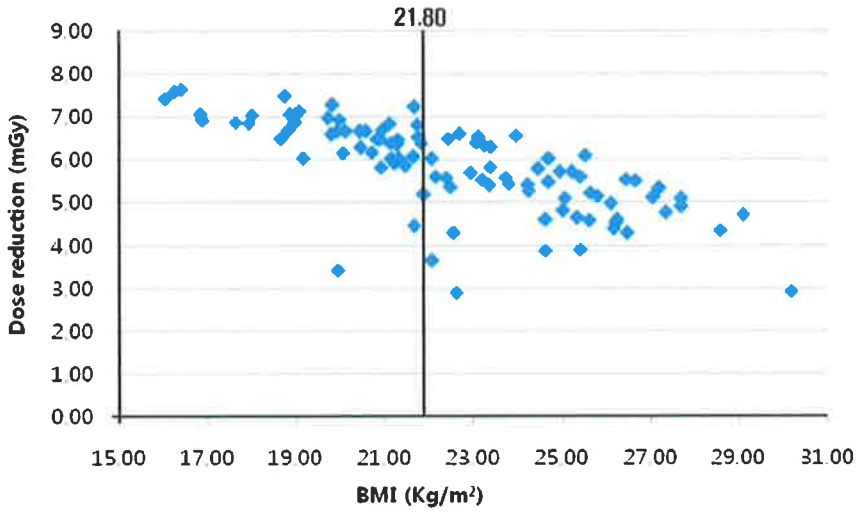

Fig. 2 Linear statistical correlation between patient BMI (kg/m^2) and radiation dose reduction in CTDIvol (mGy). Patients with less than 21.8 kg/m^2 showed more significant dose reduction compared to those with more than 21.8 kg/m^2

diagnostic acceptability for abdominal and pelvic CT by using *z*-axis ATCM compared with FTC technique (16). Radiation dose reduction of 56–77% for urinary tract stone CT study and of 18–26% for chest CT study with use of *z*-axis ATCM without compromising diagnostic acceptability was reported (9, 26).

Rizzo *et al.* reported that the use of a combined modulation technique resulted in a substantial reduction (42–44%) in the radiation dose, with acceptable image artifacts and diagnostic acceptability, compared with using a constant tube current, in scans of the abdomen and pelvis, but different patients were assessed for each technique. They also reported a linear correlation between patient weight and CTDIvol for studies performed with combined modulation (12). Implementation of the *x-y* and *z*-axis dose modulation (ATCM) technique for neuroradiology CT examinations also revealed substantial dose reduction (50.4%) while maintaining image quality, compared with no dose modulation or z-axis modulation only (27). Lee *et al.* reported similar results (18% reduction) comparing ATCM with FTC technique in different patients for each technique. They did not correlate the image quality and radiation exposure with patient weight or cross-sectional dimensions (14).

This study is in agreement with the prior reports for the effects of ATCM on image quality and radiation dose (12, 14, 27, 28). The results suggest that ATCM technique for CT of abdomen and pelvis provided substantial reduction in radiation dose with constant diagnostic image quality compared with the FTC technique. To the best of our knowledge, this is the first study to compare image quality and radiation dose associated with CT of the abdomen and pelvis using both ATCM and FTC technique in the same patient.

In our study, there was no statistically significant difference in objective image noise and scores for subjective image noise and diagnostic acceptability between images obtained with ATCM and FTC, which meant preserved diagnostic performance at images of ATCM. All of qualitative image scores were more than 3, which considered as an acceptable level of artifacts or as constituting adequate diagnostic acceptability.

Our result showed a significant linear statistical correlation between patient BMI and CTDIvol with ATCM technique, which corroborates the findings of other studies (12, 16, 29). In addition, negative linear correlation between patient BMI and radiation dose reduction was found. In other words, patients with lower BMI showed more reduction in radiation dose with ATCM technique. There was no previous report in which correlation between BMI and the amount of reduction in radiation dose at ATCM was investigated. The cut-off level of BMI of the most significant dose reduction with preserved quantitative image quality in this study was 21.8 kg/m^2. The reduction in radiation dose was noted with the ATCM compared with the FTC in all patients with a range of 22.5–59.2%. Even in one patient with the largest BMI more than 30 kg/m^2 (30.16 kg/m^2), dose reduction of 22.77% with 4 points of subjective image noise and 3 points of diagnostic acceptability scores, representing acceptable image quality was noted with the ATCM. These findings may justify the use of the ATCM technique for standard CT of abdomen and pelvis, and especially for the patients with BMI lower than 21.8 kg/m^2.

There were two limitations in this study. We did not estimate the effective dose for ATCM and FTC techniques. However, CTDIvol and DLP are currently the standard parameters used to describe CT-associated radiation doses; thus, we considered these parameters useful in assessing the radiation dose (12, 14, 30, 31). Obese patients with BMI more than 30 kg/m^2 were not included except one patient (30.16 kg/m^2), because majority of our study group were oncologic patients undergoing regular follow-up CT scanning.

In conclusion, the ATCM technique for CT of abdomen and pelvis substantially reduced radiation exposure dose and maintained diagnostic image quality. Patients with lower BMI showed more reduction in radiation dose, and

patients with BMI less than 21.8 kg/m^2 showed more significant reduction in radiation dose. These results justify the use of the ATCM technique for standard CT of abdomen and pelvis, and especially for the patients with BMI less than 21.8 kg/m^2.

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Original Paper

Radiation dose of non-enhanced chest CT can be reduced 40% by using iterative reconstruction in image space

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AIM: To evaluate the image quality and dose reduction capability of non-enhanced chest computed tomography (CT) examinations using iterative reconstruction in image space (IRIS).

MATERIALS AND METHODS: A CT water phantom was scanned at 120 kV/150 mAs and 100 kV/270 mAs as the reference, and the tube current was decreased in 10% intervals down to 40% of the reference value. Image noise was evaluated and compared between filtered back-projection (FBP) and IRIS reconstructed data. In the patient study, 90 patients underwent non-enhanced chest CT examinations; the patients were randomly assigned into three groups: group A ($n = 30$) standard dose protocol, 120 kV/110 mAs; group B ($n = 30$) low dose, 100 kV/110 mAs; group C ($n = 30$) low dose, 120 kV/67 mAs. All images were reconstructed by FBP and IRIS algorithm using matched kernels of B30 and I30. The objective image noise (OIN), signal-to-noise ratio (SNR), and contrast-to-noise ratio (CNR) of the aorta and latissimus dorsi were measured. The subjective image quality and noise were scored using a three-point scale by two experienced radiologists. The results of the subjective and objective image assessment were compared between groups B and C (low dose) IRIS and group A (standard dose) FBP.

RESULTS: The phantom study showed comparable image noise between the scans using 60% dose with IRIS and 100% dose with FBP for both 120 and 100 kV. In the patient study, groups A, B, and C had effective dose of 3.81 ± 0.43, 2.40 ± 0.19, and 2.41 ± 0.15 mSv. IRIS significantly improved the OIN, SNR, and CNR compared with FBP for the same patient. The OIN, SNR, and CNR using IRIS in group B and C were improved or comparable to those in group A using FBP. No significant difference was found in subjective image quality and noise between groups B and C using IRIS and group A using FBP.

CONCLUSION: Compared with FBP, IRIS can maintain or improve image quality on unenhanced chest CT image reconstruction while saving 40% radiation dose.

Introduction

The number of examinations using computed tomography (CT) has grown rapidly throughout the world. It was estimated that the number of CT examinations has increased 23 times, from 3 million in 1980 to more than 68.7 million in 2007 in the United States.[1] Although CT provides significant diagnostic value, the rapid growth of CT usage has raised the public concern regarding radiation exposure and the cancer risk associated with it. Therefore, the optimization of CT protocols and reduction in radiation dose have become an important focus for research.[2,3] Many methods have been developed to minimize the CT dose, such as automated exposure control,[3,4] selective shielding of radiation-sensitive organs,[3,5] and low-dose protocols for specific patients[6–9] and specific clinical indications.[10,11]

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Iterative reconstruction has recently been introduced to routine clinical CT imaging. In principle it allows the radiologist to reduce the radiation dose to the patient during the examination and reconstruct an image with similar or equal quality to a standard dose examination. Alternatively it can be used to improve image quality in a standard dose examination.[12–15] Most commercial CT systems currently use filtered back-projection (FBP) as the standard image reconstruction algorithm. With a FBP algorithm, a filter function or convolution kernel has to be chosen to balance the spatial resolution and image noise[16] in the final images. As a result, the potential to reduce the dose while maintaining image quality using FBP is limited. The iterative reconstruction technique removes this restriction by unlinking spatial resolution and image noise. Although conventional iterative reconstruction was introduced with the first generation CT systems in 1970s,[17] the immense computation power required to complete the reconstructions prohibited it in routine clinical use.

The latest iterative reconstruction technique — iterative reconstruction in image space (IRIS) — is a fast iterative reconstruction algorithm that makes it possible to use in daily clinical practice. IRIS initiates the iteration process with a "master reconstruction". The master reconstruction creates images containing full details, but with significant image noise. IRIS uses an iterative correction loop in the image space, in which the images are corrected to approximate the "true" images. In the correction loop, the image noise is cleaned up and a noise-reduced and edge-preserved image is reconstructed. Because the iterative step is calculated in the image space, the reconstruction speed is faster than the conventional iterative reconstruction. The present study investigated the image quality of IRIS reconstructed data and the associated dose-reduction capability in both a phantom and patient study. The purpose of the study was to investigate whether the diagnostic image quality could be maintained in a low-dose, unenhanced chest CT IRIS protocol compared with the standard dose FBP protocol.

Materials and methods

Phantom study

A CT water phantom (Siemens Model No. 8094745, Wittelsbacherplatz, München, Germany) was scanned 14 times using different combinations of tube voltage and current to test the image quality. The reference images were acquired using 120 kV/150 mAs and 100 kV/270 mAs. The tube voltage and current settings allowed the same CT dose index (CTDI) in 120 kV and 100 kV scans. Then, the tube current was decreased to 40% of the reference level (100%) in six steps by decreasing the reference value by 10% at each step. Therefore, both 120 kV and 100 kV scans had seven series of images at 150–60 and 270–98 mAs. All images were reconstructed using a commercial version of FBP and IRIS with B30f and I30f kernel. To evaluate image noise, a region of interest (ROI) of 150 cm^2 was placed on the image three times. The mean of the standard deviation (SD) of the three measurements was defined as the image noise for the phantom.

Patient study

Ninety consecutive patients were prospectively enrolled in this study between 20 May and 18 June 2010. The patients were referred for a non-enhanced chest CT for the reasons of suspected lesions on plain chest radiography (52/90), cough of unknown cause (21/90), cough with fever but negative chest radiograph (10/90), or follow-up examination after the treatment of pneumonia (7/90). The study was approved by the institutional review board of the Second Affiliated Hospital of Zhejiang University College of Medicine, and informed consent forms were signed by all patients.

The patients were randomly assigned into groups A, B, and C. Group A was examined using 120 kV and 110 mAs, a conventional thorax protocol in our department. Groups B and C were examined using low-dose protocols: group B using 100 kV with 110 mAs and group C using 120 kV with 67 mAs. The patients in three groups had comparable characteristics (Table 1).

Patient CT data acquisition and post-processing

All CT examinations were performed on a 128-section dual-source CT system (SOMATOM Definition Flash, Siemens Healthcare, Forchheim, Germany). The scan range was from the level of the pulmonary apex to the costophrenic angle, and all patients were required to hold their breath during the examination. Examinations were performed at a pitch of 1.2 and collimation of 32 × 1.2 mm. The volume CT dose index (CTDIvol) and dose–length product (DLP) were recorded from the machine after the

Table 1
Patient characteristics and radiation dose.

	Group A ($n = 30$)	Group B ($n = 30$)	Group C ($n = 30$)	p-Value
Male:female	18:12	16:14	18:12	0.833
Median of age (range)	48(30–58)	49(28–72)	49(21–86)	0.039
Height, m	1.66 ± 0.08	1.63 ± 0.08	1.66 ± 0.08	0.154
Weight, kg	65.52 ± 10.86	62.23 ± 12.83	67.68 ± 9.23	0.165
BMI, kg/m^2	23.69 ± 2.63	23.39 ± 3.49	24.44 ± 2.69	0.375
CTDIvol, mGy	7.59 ± 0.01	4.62 ± 0.01	4.63 ± 0.01	<0.001
Scan length, cm	29.50 ± 3.32	30.55 ± 2.37	30.63 ± 1.92	0.181
DLP, mGy.cm	223.86 ± 25.22	141.1 ± 10.90	141.73 ± 8.94	<0.001
Effective dose, mSv	3.81 ± 0.43	2.40 ± 0.19	2.41 ± 0.15	<0.001

The data are listed as mean ± SD. BMI, body mass index; CTDIvol, volume computed tomography dose index; DLP, dose–length product.

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examination. The estimated effective dose was calculated by multiplying DLP by a chest conversion factor (0.017).[18]

After the images were reconstructed using a commercial version of FBP and IRIS, the images were sent to a commercial workstation (Multi-Modality Workplace, Siemens Healthcare) for viewing and image quality evaluation. A medium smooth convolution kernel B30f was selected for FBP. The kernel I30f was used for IRIS, which provides resolution and sharpness impression equivalent to B30f. The mediastinum window was used for viewing the image data (window width 400; window centre 40). The same field of view (FOV = 350 mm) was used in all reconstructions.

Objective and subjective image quality evaluation

The objective image quality was evaluated using objective image noise (OIN), signal-to-noise ratio (SNR), and contrast-to-noise ratio (CNR) on the thoracic soft tissues. An ROI was placed on the aorta (AO), latissimus dorsi (Lats), and subaxillary fat (Fa) at the level of the aorta arch. The placement of the ROI was on a homogeneous area and avoided the small vessels and lymph nodes, e.g. on the subaxillary fat area. The measurement of the ROI was taken at the same place with identical size (1 cm^2) in the images reconstructed by FBP and IRIS. The mean ± SD of the ROI was recorded. The SD was used as OIN. The SNR and CNR were calculated using Equations 1 and 2.

$$SNR_n = \frac{\text{CT attenuation}_n}{SD_n} \quad (1)$$

where n is substituted by AO and Lats for the aorta and latissimus dorsi, respectively.

$$CNR_{AO-Lats} = \frac{\text{CT attenuation}_{AO} - \text{CT attenuation}_{Lats}}{SD_{Fa}} \quad (2)$$

where SD_{Fa} is the standard deviation of the CT value in subaxillary fat.[13]

The subjective image noise and image quality were independently assessed by two experienced readers (W. Z. with 5 years experience and X. H. with 8 years experience) who were blinded to the imaging protocols and the reconstruction algorithms. When there was a discrepancy between the two readers, a joint-session was used to reach consensus in which two readers rated the image together. According to European guidelines on quality criteria for CT,[19] the rating of subjective image noise and quality was based on visual perception of noise/graininess, distinction of anatomic detail, and diagnostic confidence, after the observation of entire chest CT images under mediastinal (window width 400; window centre 40) and lung window settings (window width 1200; window centre −600). The subjective image noise was rated on a three-point scale: score 1, minimal noise; score 2, moderate noise but acceptable for diagnosis; score 3, severe noise that affect interpretation of normal and abnormal structures. The subjective image quality was graded on a three-point scale: score 1, excellent image quality with distinct anatomic detail; score 2, fair to good image quality without impairing diagnostic confidence; score 3, unacceptable image quality without enough diagnostic information.

Statistical analysis

All of the statistical analysis was performed with a commercial statistical package (SPSS 13, SPSS, IL, USA). Pearson's chi-squared test was used on categorical data, such as gender. For numerical data, the normality was tested by Shapiro–Wilk test. If the normality test was passed, the one-way analysis of variance (ANOVA) was used; otherwise, Kruskal–Wallis ANOVA was used to identify the existence of difference among three groups. For the objective image noise, SNR and CNR, a paired *t*-test was used to compare the influence between FBP and IRIS reconstruction within each group. The one-way ANOVA and Tukey honest significant difference method were used to compare SNR and CNR among FBP reconstruction in group A, and the IRIS reconstruction data in group B and C. For the subjective image noise and quality, the chi-squared contingency table test was used. $p < 0.05$ was used to indicate significance. The interobserver agreement was tested by kappa test. The value of kappa was interpreted as moderate for $0.4 < \text{kappa} \leq 0.60$, good for $0.6 < \text{kappa} \leq 0.80$, and excellent for kappa > 0.80.[20]

Results

Phantom study

The results of the phantom study showed that the image noise was reduced using IRIS compared to the FBP algorithm at the same dose level by 15–22% in the 120 kV and 100 kV protocols (Fig 1). Reducing dose to 60% of the

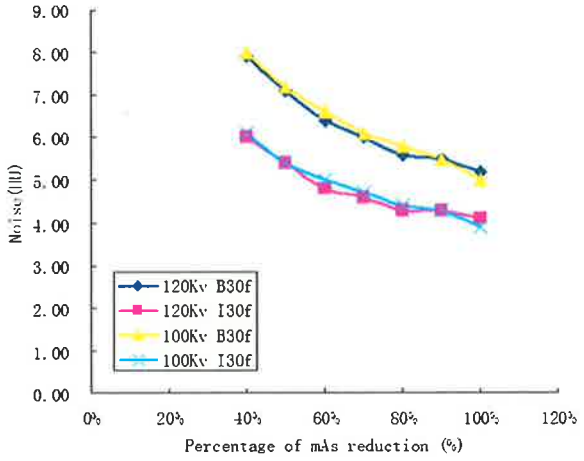

Figure 1 The image noise of phantom using the IRIS algorithm was lower than that using the FBP algorithm for 120 kV and 100 kV protocols. The numbers on *x*-axis are the percentages related to reference level of the tube current. One hundred percent was 150 mAs for 120 kV protocols and 270 mAs for 100 kV protocols. The noise of the IRIS reconstructions at a 60% dose was equivalent to that of FBP reconstruction at a 100% dose.

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Table 2
Objective image quality comparison within groups.

Groups	Group A			Group B			Group C		
	FBP	IRIS	*p*-Value	FBP	IRIS	*p*-Value	FBP	IRIS	*p*-Value
Aorta									
Signal (HU)	43.21 ± 3.95	42.88 ± 3.99	0.751	43.13 ± 3.21	42.82 ± 3.21	0.704	44.17 ± 6.19	43.70 ± 6.23	0.774
Noise (HU)	7.04 ± 1.21	4.72 ± 0.95	<0.001	8.58 ± 1.59	5.64 ± 1.13	<0.001	9.42 ± 2.48	5.95 ± 1.35	<0.001
SNR_{AO}	6.30 ± 1.08	9.40 ± 1.82	<0.001	5.19 ± 1.01	7.92 ± 1.80	<0.001	4.96 ± 1.29	7.69 ± 1.91	<0.001
Latiss-imus dorsi									
Signal (HU)	50.73 ± 4.18	50.62 ± 4.12	0.919	51.94 ± 4.25	51.77 ± 4.13	0.876	51.96 ± 4.88	51.81 ± 4.96	0.902
Noise (HU)	9.01 ± 1.63	7.42 ± 1.60	<0.001	10.49 ± 1.77	8.47 ± 1.65	<0.001	10.67 ± 1.69	8.47 ± 1.59	<0.001
SNR_{Lats}	5.83 ± 1.22	7.15 ± 1.71	<0.01	5.12 ± 1.08	6.39 ± 1.52	<0.001	5.01 ± 1.08	6.37 ± 1.57	<0.001
$CNR_{AO-Lats}$	0.80 ± 0.61	1.04 ± 0.73	<0.001	0.82 ± 0.42	1.01 ± 0.52	<0.001	0.85 ± 0.60	1.06 ± 0.73	<0.001

The mean and standard deviation were given in the format of mean ± SD. FBP, filtered back-projection; IRIS, iterative reconstruction in image space; SNR, signal-to-noise ratio; CNR, contrast-to-noise ratio; signal, CT value.

standard protocol and applying IRIS reconstruction resulted in a noise equivalent to that with 100% radiation dose and FBP reconstruction (Fig 1).

Patient study

The patient characteristics and radiation dose information of groups A, B, and C are listed in Table 1. There were no statistically significant differences between the patients' gender, height, weight, body mass index (BMI), and scan length among the three groups (all $p > 0.05$). The $CTDI_{vol}$, DLP, and estimated effective dose of groups B and C were significantly lower than those of group A (all $p < 0.001$). The $CTDI_{vol}$ was 4.61 and 4.62 mGy in groups B and C, respectively, which was 60% of group A (7.59 mGy). Similarly, the estimated effective dose was 3.81 ± 0.43, 2.40 ± 0.19, and 2.41 ± 0.15 mSv in groups A, B, and C, respectively.

Objective image quality of patient study

The CT value, image noise, SNRs, and CNRs were compared between the IRIS and FBP reconstructions on the same patient within each group using paired *t*-tests (Table 2). Although IRIS produced 0.2–0.4 HU on average lower CT value than FBP, there were no statistically significant differences on the aorta and latissimus dorsi measurements between the two algorithms (all $p > 0.7$). The image noise, SNRs, and CNRs of the aorta and latissimus dorsi were significantly better using IRIS than those using FBP at the same radiation dose level in all groups (all $p < 0.001$).

Table 3
Objective image quality comparison between group A with filtered back-projection (FBP) and groups B and C with iterative reconstruction in image space (IRIS) reconstruction.

	SNR_{AO}	SNR_{Lats}	$CNR_{AO-Lats}$
Group A FBP versus group B IRIS	<0.001	0.292	0.237
Group A FBP versus group C IRIS	<0.01	0.318	0.304

The SNR_{AO}, SNR_{Lats}, and $CNR_{AO-Lats}$ of Group A/B/C were listed in Table 2. The numbers in this table are *p*-values of the comparisons. SNR, signal-to-noise ratio; CNR, contrast-to-noise ratio.

The SNRs and CNRs between group A using FBP and groups B and C using IRIS were compared and the results are listed in Tables 2 and 3. The SNRs of the aorta in groups B and C using the IRIS algorithm were significantly better than those in group A using the FBP algorithm ($p < 0.001$ and $p < 0.01$). The SNRs of the aorta increased by 25.71 and 22.06% in the IRIS datasets of groups B and C compared to the FBP dataset of group A (Table 2). The SNRs of the latissimus dorsi were also improved using IRIS in groups B and C compared to the FBP in group A (Table 2), although the differences were not statistically significant ($p = 0.292$ and 0.318). Similar to the SNR, the CNRs of groups B and C using the IRIS were better than group A using the FBP algorithm, but this was not statistically significant ($p = 0.237$ and 0.304).

Subjective image quality of patient study

The scores of subjective image noise and image quality were not significantly different among group A using FBP, groups B and C using IRIS ($p = 0.73$ and 0.73 for subjective image noise and quality). All images of groups B and C using IRIS were found to be sufficient for diagnosis (Table 4). The anatomical structure and lesions could be clearly depicted using mediastinum and lung window settings (Fig 2). However, the percentage of score 1 was lower in groups B and C for both image noise and quality compared to group A. The inter-reader agreement was good on subjective

Table 4
Subjective image quality comparison between group A using filtered back-projection (FBP) and groups B and C using iterative reconstruction in image space (IRIS) reconstruction.

	Score	Group A FBP	Group B IRIS	Group C IRIS
Subjective image noise	1	17 (56.7%)	16 (53.3%)	14 (46.7%)
	2	13 (43.3%)	14 (46.7%)	16 (53.3%)
	3	0	0	0
Subjective image quality	1	16 (53.3%)	14 (46.7%)	13 (43.3%)
	2	14 (46.7%)	16 (53.3%)	17 (56.7%)
	3	0	0	0

The numbers in the table were the count for the image score and the percentage in parenthesis was the proportion of that score in all scores.

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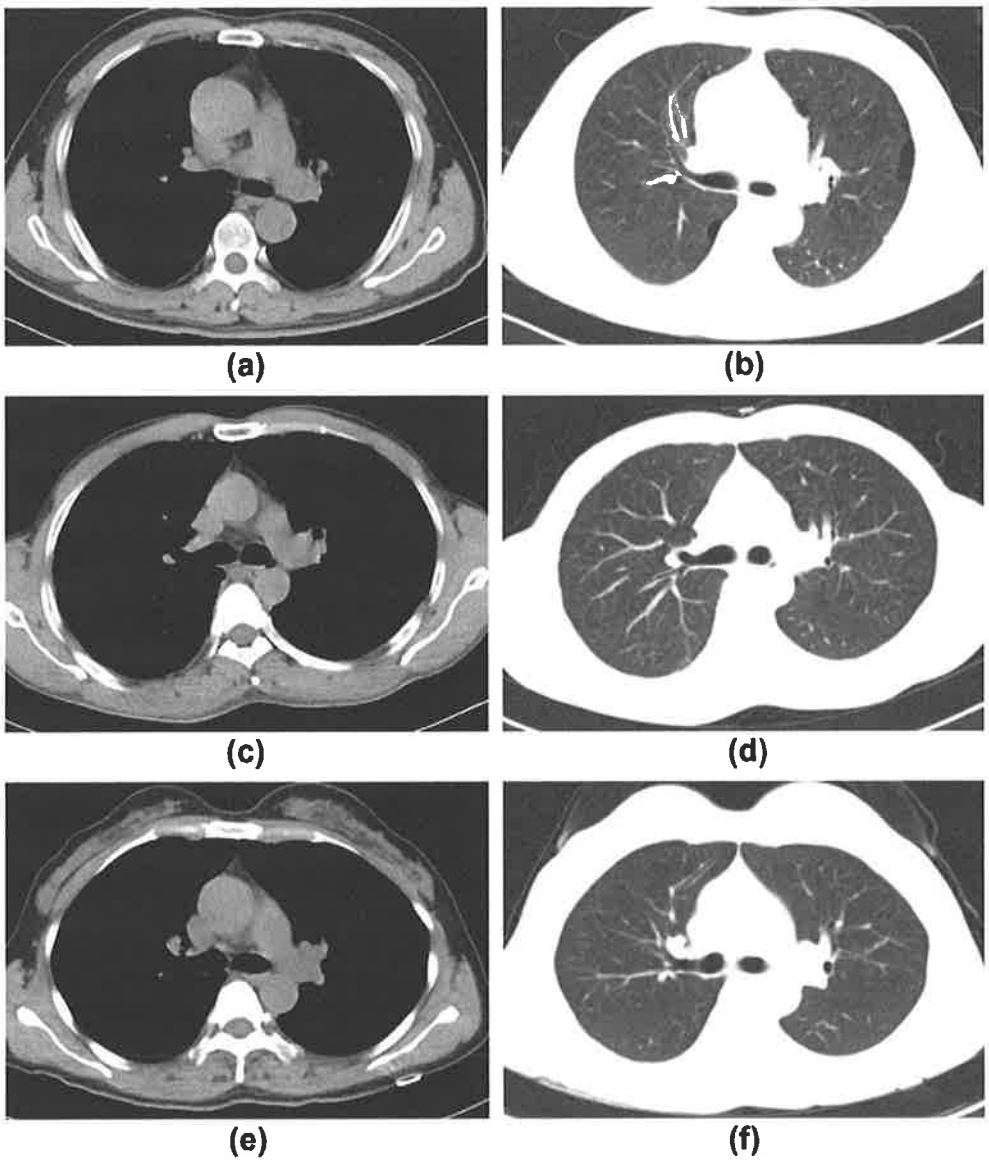

Figure 2 The images of group A using the FBP algorithm (a, b), group B (c, d), and group C (e, f) using the IRIS algorithm showed comparable subjective image quality using mediastinum and lung window settings.

image noise (kappa = 0.758) and subjective image quality (kappa = 0.675).

Discussion

CT exposes the patient to radiation and there after, the risk of cancer,[2] e.g., breast cancer in women[21] and lung cancer for patients undergoing annual CT lung screening.[22] Therefore, the radiology society should be aware of every new option that potentially alleviates the radiation burden without compromising diagnostic image quality. This is especially important for young patients or patients who need multiple diagnostic CT examinations in their lifetime.

The present study investigated the potential of radiation dose reduction using low-dose imaging protocols and IRIS for CT examinations of the chest. To reduce the radiation dose, two low-dose protocols were compared: lowering the tube voltage from 120 to 100 kV, or lowering the tube current from 110 to 67 mAs (based on the recommendation of the American Lung Screening protocol of 60 mAs).[23] Reducing either the tube voltage or the tube current resulted in an average 40% reduction in dose to the patient compared to the standard protocol of our institution. The application of IRIS in groups B and C maintained the image quality of chest CT images compared with FBP reconstruction in group A, and in some cases improved it. The results fit well with the existing literature suggesting a 27–30% reduction in radiation dose is clinically feasible[15,24,25] and even suggests that in smaller patients, such as typically in Asia, the greater dose reductions will be seen using this technique. The results also verify that IRIS is able to clean up the image noise introduced from a low dose protocol

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without compromising image quality, and also show that IRIS is technique that can be used in routine low-dose CT examinations.

The results of the present study also demonstrated the potential to improve image quality using the IRIS algorithm. Compared to the standard FBP reconstruction, the IRIS algorithm significantly decreased the image noise in the aorta and latissimus dorsi, which lead to 50% and 22% increases in the SNRs, respectively. The reason for the improvement may be that the iterative reconstruction can achieve relatively more noise reduction in fine-detail texture than in broad texture.[13] Consistent with the present results, a recent study showed that adaptive statistic iterative reconstruction delivered substantially better visualization of normal and diseased pulmonary structures than FBP.[26]

For many years, the long reconstruction time has been the major disadvantage for the clinical use of iterative reconstruction algorithm. IRIS takes five iterations in image space by system default, which leads to a reconstruction time that is approximately four times longer than FBP using the same hardware and reconstruction parameters. However, IRIS reconstruction for a chest examination can be completed within 1 min. Although a shorter reconstruction time is desired, it has already become practical to use IRIS in routine clinical situations.

Regarding the methods of reducing the radiation dose, both low tube voltage and low tube current–time product were suitable for the IRIS algorithm. Both methods maintained the image SNRs and CNRs on the soft tissues in the thorax. It should be noted that generally lowering the tube voltage is usually suggested for enhanced CT and CT angiography because the lower tube voltage increases the x-ray absorption of iodine.[13,27,28] For example, a low tube voltage protocol was applied during coronary CT angiography and the tube voltage was adapted to the body mass index (BMI) of patients to decrease the radiation dose.[29–32] It is not a common practice to use low tube voltage protocols in unenhanced CT examinations as in the present study, due to the lower penetration of 100 kV and the potential noise in the resulting images. However, because of the relatively small size of patients in our department and low BMI, 100 kV imaging protocols are possible for most patients. Further investigation is still required to determine to what extent IRIS can recover image quality during 100 kV examinations of patients with larger BMIs. In future studies the present authors intend to investigate a BMI-adaptive low tube voltage technique with IRIS to reduce radiation dose of unenhanced CT.

The present study has some limitations. Although the study group consisted of 90 patients, each subgroup had only 30 patients and larger study groups are always desirable. Scientifically the ideal comparison for this type of study is to have standard and low-dose examinations performed on the same patient, to compare dose saving and image quality in a precise way. However, ethical principles make this impossible in a patient study. The participants in each group were different, although there was no significant difference in patient characteristics among the groups to explain why the standard deviations of measurement were notable, especially the standard deviations of CNRs between soft tissues.

In summary, the present study demonstrated that IRIS allowed significant reductions in the dose applied to the patient while maintaining image quality in the resulting image for unenhanced chest CT. Dose reduction was achieved by either a reduction in tube voltage or tube current from the standard protocol, saving an average of 40% radiation exposure. The image quality using IRIS technique was preserved as defined by the image noise, SNR, and CNR.

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AuntMinnie

Hybrid imaging can accurately predict cardiac events

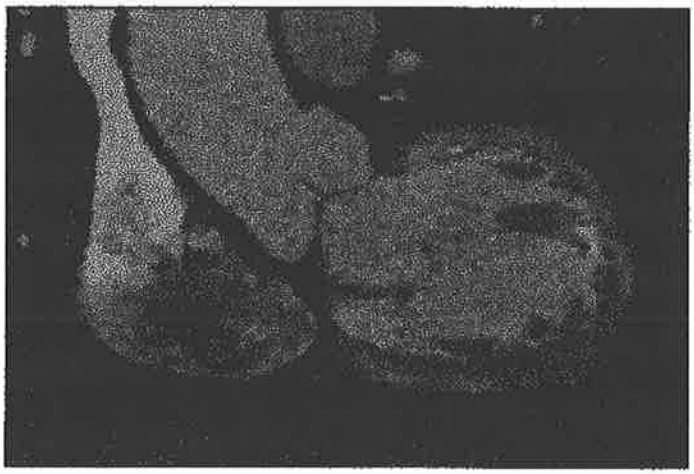
By John Brosky, AuntMinnieEurope.com contributing writer

October 3, 2011 -- CT alone is not enough to unseat invasive coronary angiography as the gold standard for assessing coronary artery disease, but combining CT with a modality such as SPECT or PET serves as a predictive gatekeeper that can replace unnecessary diagnostic angiography and help avoid ineffective revascularization.

At the recent congress of the European Society of Cardiology (ESC), Dr. Aju Paul Pazhenkottil, a cardiac imaging specialist from Zurich University Hospital, demonstrated the predictive value of SPECT/CT for fusing myocardial perfusion imaging from SPECT with the complementary anatomical CT image.

Pazhenkottil is the lead author of "Prognostic value of cardiac hybrid imaging integrating single-photon emission computed tomography with coronary computed tomography angiography," published in June 2011 in the *European Heart Journal* (Vol. 32:12, pp. 1465-1471), which was among the first studies to demonstrate the predictive value of combining perfusion and anatomical data.

For the study, 324 patients were divided into three types according to the results of the hybrid exam, a matched group with a finding of stenosis by coronary CT angiography (CTA) and a matching reversible SPECT defect, patients with unmatched coronary CTA and SPECT finding, and then patients found to be normal by both coronary CTA and SPECT.



Hybrid techniques are making steady progress in cardiac imaging. In these cardiac PET/CT images, FDG was used as the radiotracer, along with coronary CTA. Above: Multiplanar reconstruction of fused image. Below: 3D reconstruction. All images courtesy of Dr. Gerald Antoch, department of diagnostic and interventional radiology, University Hospital Duesseldorf, Germany.

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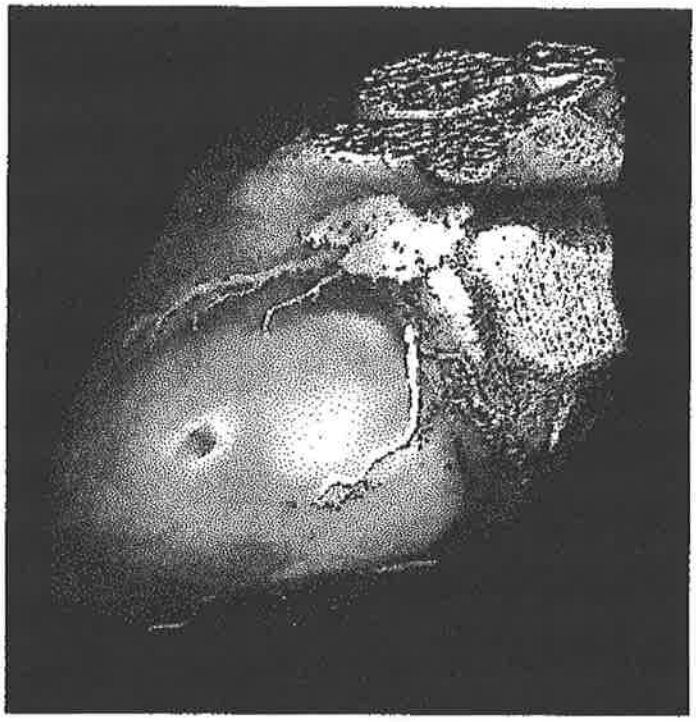

At a median follow-up of 2.8 years, a corresponding matched hybrid image finding was associated with a significantly higher incidence of death or myocardial infarction (MI), proving to be an independent predictor for major adverse cardiac events. The annual death/MI rate was 6.0% for patients with matched coronary CTA-SPECT findings, 2.8% for those with unmatched results and 1.3%, among those with normal findings.

Pazhenkottil told *AuntMinnieEurope.com* his group originally studied matched findings for PET and CT, though the assessment of ischemia by PET is not reimbursed in Switzerland. This preliminary work, "Integrated PET/CT for the assessment of coronary artery disease: a feasibility study," was published in the *Journal of Nuclear Medicine* in June 2005 (Vol. 46:6, pp. 930-935).

The lack of reimbursement "is too bad because PET is much better, more sensitive and specific," he said, adding that several vendors are combining these two techniques for a faster acquisition in a single scan with lower radiation levels. The combined SPECT/CT test is also available on commercial platforms, he noted.

Responding to concerns from the ESC audience over radiation using hybrid examinations, Pazhenkottil said radiation dose was substantially lowered during the course of the study thanks to the introduction of new CT imaging techniques. The reported levels of the effective radiation dose for stress/rest SPECT and myocardial perfusion imaging (SPECT/MPI) was 10.1 mSv. The estimated radiation dose for the coronary CTA was 17.9 mSv ± 5.8 mSv for 248 patients in which helical scanning was used.

After introducing prospective triggering for coronary CTA, the effective radiation dose for the next 70 patients was systematically recorded at 1.9 mSv ± 0.5 mSv.

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Attachment J

Curriculum Vitae

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Bruce D. Cummings

Mr. Cummings was named Chief Executive Officer at Lawrence & Memorial Hospital on October 31, 2005. Prior to that, he served as President and Chief Executive Officer of Olean General Hospital in Olean, New York. From September 1990 to March 2002, Mr. Cummings served as the CEO of Blue Hill Memorial Hospital in Maine. Mr. Cummings also spent 10 years at Mid-Maine Medical Center in Waterville, Maine as Director of Ambulatory Care; and from November 1985 to 1990 as Vice President for Strategic Planning, Marketing and Corporate Development. From 1978 to 1980, Mr. Cummings served as the City of Danbury's first full-time Director of Health.

Mr. Cummings received a Bachelor of Arts in Sociology from Colby College and a Master of Public Health degree from Yale University School of Medicine, Department of Epidemiology and Public Health. He is board-certified in healthcare management through the American College of Healthcare Executives, a member of the Board of Directors of the Connecticut Hospital Association, a director of the Visiting Nurse Association of Southeastern Connecticut, and a delegate to the American Hospital Association's Regional (New England) Policy Board.

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January 2003 to June 2006; Olean General Hospital; Vice President for Medical Affairs
March 2002 to August 2002: Blue Hill Memorial Hospital; Interim Chief Executive Officer
1990 to 2002: Blue Hill Memorial Hospital; Medical Director (full time since 1998); Chief of Staff
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2003-2006: Olean General Hospital, Olean, New York; active medical staff
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860-444-5151

Education	1973 – 1977	Fordham University, Bronx, NY B.S. in Biology, 1977
	1979-1981	New York Medical College School of Basic Medical Science, Valhalla, NY 29 Credits in Master's Degree Program
	1981 – 1985	New York Medical College Doctor of Medicine, 1985
Honors	1984	Elected to Alpha Omega Alpha Medical Honor Society
Training	1985 – 1986	Flexible Internship Jersey Shore Medical Center, Neptune, NJ
	1986 – 1990	Residency in Diagnostic Radiology George Washington University Medical Center Washington, DC
	1990 - 1991	Fellowship in Cross Sectional Imaging Brown University Rhode Island Hospital, Providence, RI
Certification	1990	Diplomate American Board of Radiology
Employment	1991 – Present	Radiologist/Section Head/Nuclear Medicine Safety Officer Ocean Radiology Associates at L&M Hospital New London, CT 06320
Professional Memberships		Radiological Society of North America

Lawrence & Memorial Hospital

Vice President / Chief Financial Officer

Lugene Inzana, MBA, CPA

Mr. Inzana became Vice President/Chief Financial Officer at Lawrence & Memorial Hospital in January 2008. Prior to joining Lawrence & Memorial, he served as Vice President of Finance/CFO 2004-2007 at Olean General Hospital, a 186 bed Rural Referral Center located in Olean, NY. From 2002-2004, Mr. Inzana was Vice President Finance – MIS/CFO at Jones Memorial Hospital in Wellsville, NY. From 1991 to 2002 he served as Controller of Olean General Hospital and from 1989 to 1991 he served as Controller of St. Francis Hospital in Olean, NY.

Mr. Inzana holds an Associate's Degree in Accounting from the State University of New York, a Bachelors Degree in Accounting and a Masters Degree in Finance, both from St. Bonaventure University and is a Certified Public Accountant.

Mr. Inzana is the Past President of the Western New York Chapter of Healthcare Financial Management Association, representing approximately 200 financial executives across Western New York.

Donna-Marie Blakely
104 Satari Drive
Coventry, CT 06238
(860) 742-0743 or (860) 742-1945

Objective: Director Radiology
Professional Experience

Administrative Director, 09/06 to Present
Lawrence and Memorial Hospital, New London, CT

- Returned to Lawrence and Memorial Hospital in my previous position after 3 plus years at Jefferson Radiology.
- Responsible for 10 cost centers including: 4 satellite outpatient centers, MRI (2), Radiology, Ultrasound (cardiac, vascular, Ob, GYN, Abdominal), CAT Scan (4), Nuclear Medicine (general and cardiac), Special Procedures and Digital Mammography.
- Over 170,000 procedures performed annually.
- Participate in strategic planning, renovations, CON, equipment/vendor negotiation and selection.
- Operational reorganization and improvements.
- Human resource issues for over 100 FTE. (Union environment).
- Direct supervision of 8 Modality Managers
- Supervision of student education and rotation through hospital with the Gateway Community College (US and Nuclear Med), Quinnipiac College (US and Radiology), University of Hartford (MRI and CT), and Windham Hospital School or Radiologic Technology (Radiology).
- Digital film-less environment. Sectra PACS, McKesson CPACS and Fuji CR.

Director of Operations, 06/03 to 08/06
Jefferson Radiology Group, P.C., East Hartford, CT

- Responsible for overseeing day-to-day operational activities of 175 FTEs in 6 full service offices and for overall operational success in meeting quality, productivity and financial goals. Equipment and operations include 6 MRIs, 5 CT Scanners, 7 digital mammography units, 11 ultrasound units, 4 nuclear medicine cameras and numerous other x-ray and fluoroscopy systems. Total volume in excess of 150,000 procedures per year.
- Ensure optimal work environment for JXR physicians and staff, ensuring that appropriate facilities, equipment, and other required resources are available to support service delivery goals in the most cost-effective manner.
- Manage staff of 10-15 supervisors and/or managers. Handle day to day human resource issues for staff of 175 FTEs.
- Strong financial analysis skills and experience with corporate budget management and business plans. Negotiate all capital equipment purchases and non salary contracts system wide.

- Strategic thinker, strong decision maker, knowledgeable of trends in healthcare industry. Participate in Certificate of Need process and Performa development for new projects and offices.
- Successfully implemented new RIS. Participated in PACS selection and implementation team. PACS go live Fall 2005.
- Oversaw opening of new Enfield Office and significant expansion of an existing office in Wethersfield. In the planning stages for additional full service office in Farmington.
- Co-Chairman of the Operations Committee. Member of the Planning and IT committees.
- ACR and FDA Accreditation process.
- Introduced student rotations with University of Hartford (MRI and CT), Windham Hospital and Hartford Hospital Schools of Radiologic Technology, resulting in lower recruitment costs and filled positions.

Administrative Director, 01/01 to 05/03
Lawrence and Memorial Hospital, New London, CT

- See current job responsibilities
- Passed Diagnostic and Nuclear Medicine State, JCAHO, Medicare and NRC inspections with no recommendations or citations including Quality Improvement initiatives.
- Salary, non-salary and capital budgets and cost containment.
- Pro forma/business plan development.
- C.P.T. Coding/Reimbursement.
- PACs Committee Co-chair.

Executive Director 5/98 to 12/00
Women's Center for Wellness, Vernon, CT
Separate Corporation under ECHN umbrella

- Services include: Gynecological well women exams, mammography, bone density, massage, nutritional counseling, behavioral health, exercise, educational programs, and complementary therapy.
- Billing, CPT4, ICD9 and E&M coding.
- Computerized billing and scheduling systems; selection and implementation.
- Planning and marketing of Center.
- FDA and ACR accreditation of mammography program.
- Pro forma/business development.
- Complete financial responsibility for Center.
- Human Resource issues.
- State inspections.
- Direct Board responsibility.

Director of Business Development, Medical Imaging 5/98 to 12/00
Eastern Connecticut Healthcare Network *(ECHN)*

- Negotiate, select, purchase and install all capital equipment for ECHN Medical Imaging sites (MMH, RGH, GWC, WCW).
- Vendor contract negotiations.
- Planning and marketing of imaging services.
- Reimbursement and coding (interventional price master, superbills, APCs).
- Information Technology: PACs project, transcription systems and RIS.
- Special Projects: Project planning, renovations, capital equipment installs, new business ventures, C.O.N.'s.

Administrative Director, Medical Imaging 11/89 to 5/98
Manchester Memorial Hospital, Manchester, CT
Part of Eastern Connecticut Health Network (*ECHN)*

- Administration of 6 cost centers: M.R.I., Diagnostic, C.T., Ultrasound (Vascular Lab), Nuclear Medicine, Echocardiography
- C.O.N. development and long-range planning.
- Selection and negotiation of equipment purchases.
- Salary, non-salary, and capital budgets.
- Director of 50+ full-time employees.
- Quality Assessment (physician and technical components).
- Market analysis and marketing.
- Construction and renovation of major projects.
- C.P.T. Coding/Reimbursement.
- R.I.S. Selection.
- Passed Diagnostic and Nuclear Medicine State, JCAHO, Medicare and NRC inspections with no recommendations or citations.
- Passed ACR and FDA mammography accreditation process.
- Medical Imaging Transcription.
- New Office Development.
- Pro forma/business plan development.

Assistant Director, Medical Imaging 12/88 to 11/89
Manchester Memorial Hospital, Manchester, CT

- Responsible for diagnostic portion of Medical Imaging.
- Reduced overtime and over-budgeted hours.
- Scheduling/Payroll
- Quality Control and Quality Assurance
- Equipment maintenance
- Personnel issues, including: merit reviews, interviews, disciplinary measures and staff meetings.

Technical Manager 9/87 to 12/88
Medical Imaging Centers, Bloomfield, CT

- Supervision of over 20 technologists in five offices.
- Developed Quality Control and Quality Assurance to meet State standards.
- Implemented in-service education and staff meetings.
- Scheduling/Payroll
- Personnel issues, including: hiring and disciplinary measures.
- Involved in design and layout of additional office.
- Participated in design of new Imaging Center.

CT Scan and Special Procedure Technologist 1987
Bradley Memorial Hospital, Southington, CT

Clinical Instructor, School of Radiologic Technology 8/85 to 4/87
Responsible for teaching the clinical portion of the program, including positioning and anatomy classes. Supervised clinical rotations and check offs. Film Critique.
Middlesex Memorial Hospital, Middletown, CT

Head of Special Procedures and Quality Control Technologist 9/81 to 8/85
Bradley Memorial Hospital, Southington, CT

Education

July 2002 **Certified Radiology Administrator** Boards by the American Healthcare Radiology Administrators.

October 1995 **Mammography Certification Boards** by American Registry of Radiologic Technology

Hartford Graduate Center, Hartford, CT GPA: 4.0.
June 1994 **Master of Science**, Health Care Management

New Hampshire College, Springfield, MA
May 1989 **Bachelor of Science**, Human Services; Administration

New Britain General Hospital, School of Radiologic Technology
May 1980 **Registered** by American Registry of Radiologic Technology

Personal Achievements and Professional Affiliations

2010 Member, American Healthcare Radiology Administrators (AHRA)
Member, American Society of Radiologic Technology (ASRT)
Member, Radiology Business Management Society
AHRA Liaison to RSNA Associate Sciences Consortium

1997 Chairperson, Manchester Memorial Hospital Quality Assessment Committee

1996 Vice Chairperson, Manchester Memorial Hospital Quality Assessment Committee
Recipient, "AHRA Partners in Learning" Program
Chairman, American Healthcare Radiology Administrators (AHRA) Membership Committee, North Atlantic Region.
Member, Membership Committee of American Healthcare Radiology Administrators (AHRA), North Atlantic Region.

1994 Recipient, Rotary International, "Team Finland", Business Exchange Program.
Chairperson, Membership Committee, AHRA, North Atlantic Region

1993 Chairperson, Connecticut Hospital Association, Directors of Diagnostic Imaging Conference.
Member, Membership Committee, American Healthcare Radiology Administrators
Member, Educational Committee, American Healthcare Radiology Administrators
Recipient, Connecticut Society of Radiologic Technologists Scholarship Award
Winner, First Place in New England Conference of Radiologic Technologists Essay Contest.

1992 Educational Chairperson, Connecticut Hospital Association, Directors of Diagnostic Imaging Conference

1989 Vice President, Connecticut Society of Radiologic Technologists

1988 District Representative, Connecticut Society of Radiologic Technologists

1985 Employee of the Quarter, Bradley Memorial Hospital (July)

WORK HISTORY

Lawrence & Memorial Hospital, New London, CT 1999-Present
Manager Nuclear Medicine/PET CT Services 2001-Present

Gateway Community College Radiology Advisory Board 2005-Present

South County Hospital, Wakefield, RI 1998
Radiology Manager
Operation and administrative responsibilities for Diagnostic Radiology

Waterbury Hospital Health Center, Waterbury, CT 1975-1998
Imaging Division Supervisor 1990-1998
Direct operations, QA programs, equipment purchases and managed all Human resource issues for Nuclear Medicine, Nuclear Cardiology, CT, Ultrasound, Radiation Therapy and Special Procedures
Successfully completed and passed numerous Nuclear Regulatory Commission inspections, JCAHO surveys, and State inspections

Nuclear Medicine Supervisor 1983-1990
Responsible for operations, budget, and QA programs, managed all human resource issues, and performed all aspects of Nuclear Medicine procedures using ADAC Single & Dualhead Gensys cameras including SPECT Cardiac Imaging.

Lead Nuclear Medicine Technologists 1975-1983
Responsible for updating equipment and department standards, developed QA programs, and performed all aspects of Nuclear Medicine procedures.

Griffin Hospital, Derby, CT 1972-1975
Nuclear Medicine/Radiology Technologist

St. Ann's Hospital, Fall River, MA 1969-1972
Student Staff Radiology Technologist

U.S. Government-Army 1967-1969
Honorable Discharge-Sergeant Infantry
Bronze Star and 3 Purple Hearts

EDUCATION

Quinnipiac College, Hamden, CT – Bachelor of Science Degree – Radiologic Sciences
Northeastern University, Boston, MA – Certificate in Radiologic Sciences
St. Ann's Hospital, Fall River, MA – Certificate in Radiologic Sciences

BOARD CERTIFICATIONS

Nuclear Medicine Technology Certification Board ,C.N.M.T.
American Registry of Radiological Technologists (R),(NM)
State of Rhode Island Nuclear Medicine License # NMT00095
State of Connecticut Radiological License - Pending

MARCI J GWIAZDOWSKI
180 NEWENT ROAD
LISBON, CT 06351
860-917-9909

POSITION DESIRED	Management
OBJECTIVE	To utilize my experience in MRI to improve department by capitalizing on new capabilities. Work as a liason between radiologists, technical staff, and senior leadership to provide best service possible
EDUCATION	Windham Community Memorial Hospital 10/85-10/87 Program of RT
EXPERIENCE	Had 2100 clinical hours. Performed routine radiographic and Fluoroscopic exams. Training included OR, portables and mammo.
EMPLOYMENT	**Jan 2009 – PRESENT Manager CT/MRI Dept. L&M Hospital** Responsibilities include staffing 4 CT units and 2 MR units at 3 different facilities, payroll, budgeting, scheduling, planning, QA/QC projects, continued ACR accreditation for 6 units, training /orienting staff, managing 30 techs and 4 secretaries,scanning, venipuncture. **Sept 2000- Jan 2009 Manager MRI dept. L&M Hospital** Responsibilities included are same as above for 2 MR units **March 1995- Sept 2000 MRI technologist** Duties include daily operation of machine, screening and scanning Patients, venipuncture, scheduling add on exams. Working with Other dept to maximize patient through put. **August 1991-March 1995 MRI Technologist Signal Medical Services** Technologist on busy mobile route. Sites include WW BACKUS, DAY

KIMBALL HOSPITAL and L&M. Daily operation with limited supervision.

QUALITIES

Work well with others. Maintain positive outlook and attitude

Empathetic, lead by example

REFERENCES

Faruk Soydan MD L&M Hospital

Ira Sitko MD L&M Hospital

Arun Basu MD L&M Hospital

Attachment K

Department of Public Health License

STATE OF CONNECTICUT

Department of Public Health

License No. 0047

General Hospital

In accordance with the provisions of the General Statutes of Connecticut Section 19a-493:

Lawrence and Memorial Corporation of New London, CT, d/b/a Lawrence and Memorial Hospital is hereby licensed to maintain and operate a General Hospital.

Lawrence and Memorial Hospital is located at 365 Montauk Avenue, New London, CT 06320

The maximum number of beds shall not exceed at any time:

28 Bassinets
280 General Hospital beds

This license expires **March 31, 2013** and may be revoked for cause at any time.

Dated at Hartford, Connecticut, April 1, 2011. RENEWAL.

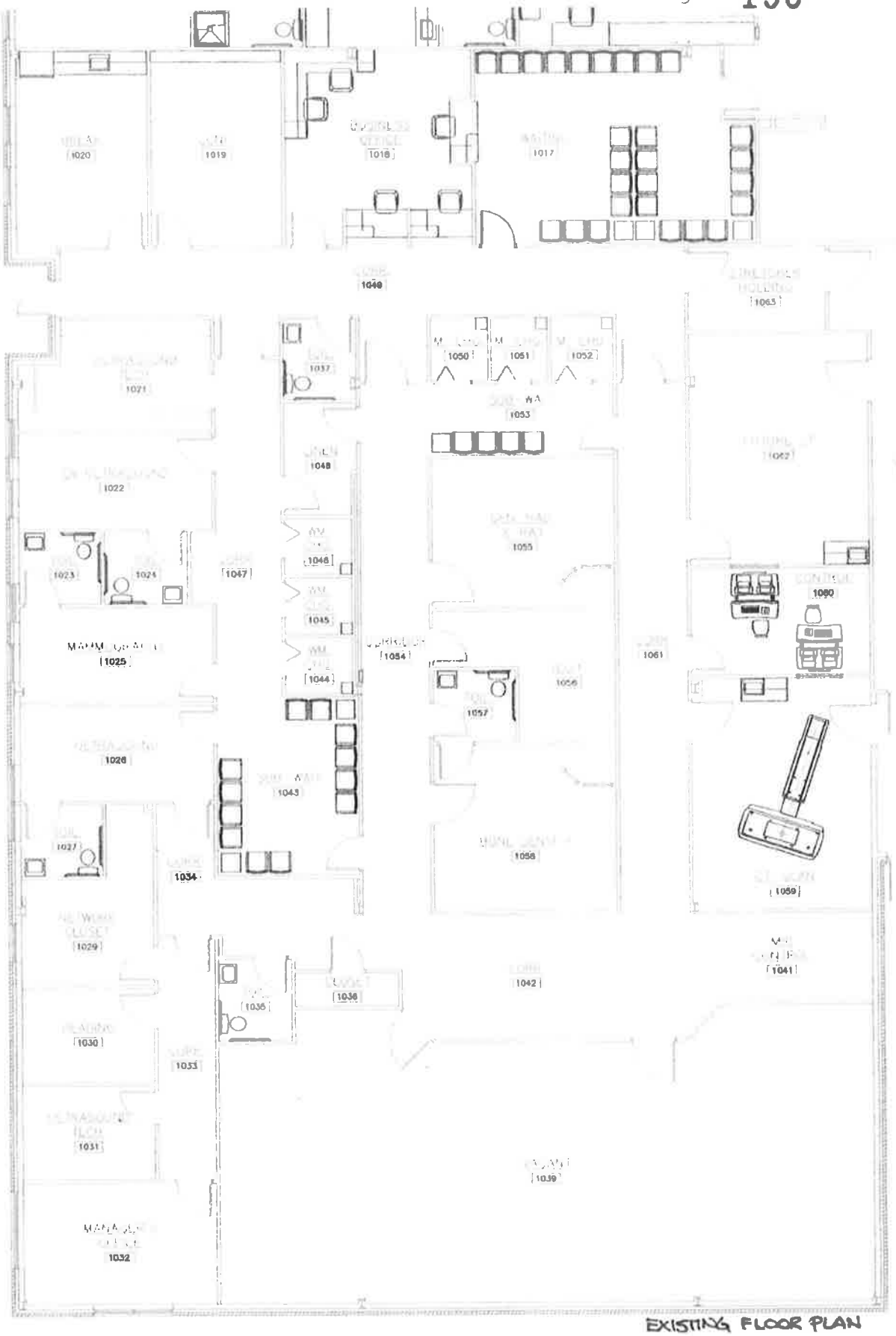
Satellites

Joslin Diabetes Center, 14 Clara Drive, Mystic, CT
Outpatient Surgery Center, 52 Hazelnut Hill Road, 2nd Floor, Groton, CT
Pequot Health Center, 52 Hazelnut Hill Road, 1st Floor, Groton, CT

Jewel Mullen, MD, MPH, MPA
Commissioner

Attachment L

Existing Floor Plan

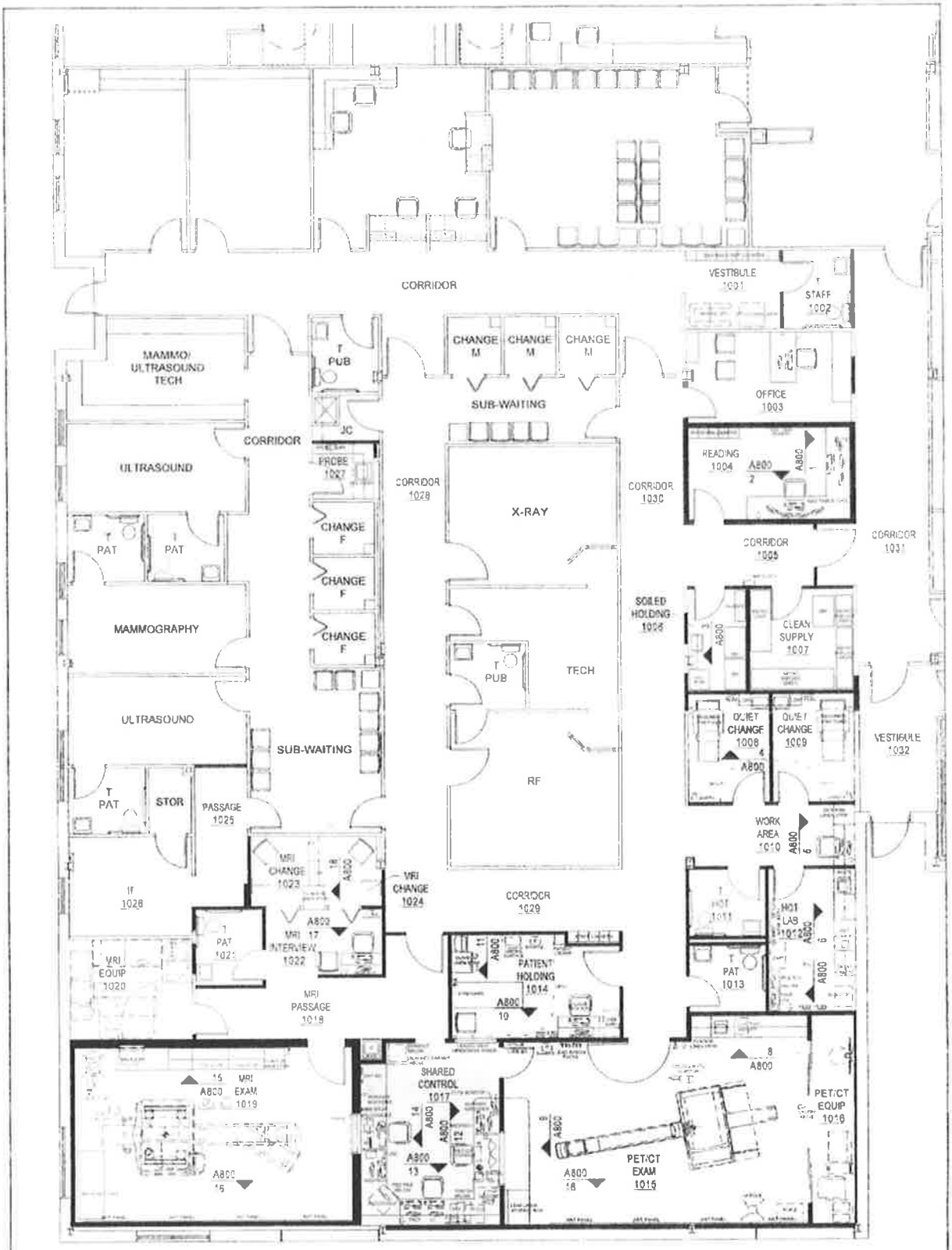


EXISTING FLOOR PLAN

L&M IMAGING AT CROSSROADS

Attachment M

Proposed Floor Plan



Lawrence & Memorial Hospital

PET / CT Scanner & MRI Unit at Crossroads Imaging Center

Proposed Floor Plan

Attachment N

Equipment Vendor Quotation

SIEMENS

Siemens Medical Solutions USA, Inc.
51 Valley Stream Parkway, Malvern, PA 19355
Fax: (781) 203-6025

SIEMENS REPRESENTATIVE
John Hubbard - (603) 801-4879

Customer Number: 0000007432

Date: 2/23/2011

LAWRENCE & MEMORIAL HOSPITALS
365 MONTAUK AVE.
NEW LONDON, CT 06320

Siemens Medical Solutions USA, Inc. is pleased to submit the following quotation for the products and services described herein at the stated prices and terms, subject to your acceptance of the terms and conditions on the face and back hereof, and on any attachment hereto.

Table of Contents **Page**

Proposal valid until 4/09/2011

Should the customer desire to upgrade this mCT40 system over the next three years from date of completion of installation, the purchase price for such upgrade shall not exceed $280,000 for a 64 slice PET/CT system or $540,000 for a 128-slice mCT PET/CT scanner.

Proposal pricing ONLY valid if a muli-unit purchase is made.

Accepted and Agreed to by:

Siemens Medical Solutions USA, Inc.

By (sign): John Hubbard GRF
Name: John Hubbard
Title: Product Sales Executive
Date: 3/30/11

LAWRENCE & MEMORIAL HOSPITALS

By (sign):
Name: Daniel Ridley
Title: VP CMO
Date: 3/25/11

All pages of the signed proposal must be returned to Siemens to process the order - Thank you.

SIEMENS
Siemens Medical Solutions USA, Inc.
51 Valley Stream Parkway, Malvern, PA 19355
Fax: (781) 203-6025

SIEMENS REPRESENTATIVE
John Hubbard - (603) 801-4879

Quote Nr:	**1-JQ02O Rev. 2**
Terms of Payment:	00% Down, 90% Delivery, 10% Installation Free On Board: Destination
Purchasing Agreement:	NOVATION (UHC, VHA, Provista)
	NOVATION (UHC, VHA, Provista) terms and conditions apply to Quote Nr 1-JQ02O

Biograph mCT S/X

All items listed below are included for this system: *(See Detailed Technical Specifications at end of Proposal.)*

Qty	Part No.	Item Description
1	10248473	**Biograph mCT-S(40)**
1	10249462	**TrueV PET - mCT** The Biograph mCT TrueV option provides improved PET productivity and performance by extending the axial PET coverage.
1	14415351	**Install Kit with PDU - mCT** Items necessary for install. Includes power distribution unit for connecting entire system to a single 3-phase power drop.
1	14415353	**PET Gantry UPS - mCT** Uninterruptible Power Supply (UPS) option providing 10 minutes of backup power enabling proper shutdown of the PET system in the event of power loss. Specifications: 8.0 KVA, 230 Volts, 50/60 Hz.
1	10249096	**Cooling System Water/Air - mCT** Water-to-air heat exchanger for the dissipation of heat loss generated in the gantry to the outside air. System operating temperature:20 - 26 degrees C, 15 - 75 % rel. humidity (not condensing). Ideal for installation far from the scan room. Cooling system contains to units, water/water exchanger close to the scan room and an additional remote water/air exchanger. Maximum distance between water/water unit and remote water/air exchanger up to 40 meters enabled by thin diameter of water transferring pipes.
1	10249267	**Cooling System US Install Kit - mCT** Kit for installation of the Cooling System Water/Air in US Includes: - Transformer for powering the Cooling System Water/Air - Service switch to shut off the outdoor cooling unit for maintanance or in case of emergency
1	10249560	**Biograph Ge-68 Sources** Calibration sources for the Biograph mCT. These sources are to be purchased with a new Biograph mCT scanner.
1	10097286	**Biogr. Uni. Phantom Shield-Fixed** Contains shield for the Biograph TrueV Uniform Phantom.
1	10249159	**Keyboard, English - mCT** Keyboard in the above-mentioned language.
1	10249566	**HD-PET # mCT (AWP)**
1	14415389	**CT IRIS #AWP** Iterative Reconstruction in Image Space (IRIS) allows to enhance spatial resolution and to reduce image noise by introducing multiple iteration steps in the reconstruction process, thus enabling dose reduction by up to 60%.
1	10412855	**Installation (US/CAN)**

SIEMENS

Siemens Medical Solutions USA, Inc.
51 Valley Stream Parkway, Malvern, PA 19355
Fax: (781) 203-6025

SIEMENS REPRESENTATIVE
John Hubbard - (603) 801-4879

Qty	Part No.	Item Description
1	10249181	**English Manual - mCT** Hardcopy of English Operator's Manual for Biograph mCT
1	MI_PET_PM	**MI PET Project Management**
1	MI_PET_INITIAL_32	**Initial onsite training 32 hrs**
1	MI_PET_FLWUP_32	**Follow-up training 32 hrs**
2	MI_PET_BCLS	**Basic Biograph Class**
2	MI_PET_CTCRSTR	**CT Cross Trainer**
3	MI_PET_ADD_16	**Additional onsite training 16 hours**
2	MI_PET_ADD_CLS	**Additional Training Class**
1	7568103L	**Project Mgmt/Site Planning (US only)**
1	NU_PET_MISC_MATL	**Relocation Quote ASM029122210 $30,389**

System Total: $2,168,286

OPTIONS:

Qty	Part No.	Item Description	Extended Price	Initial to Accept
1	M2SCT211PET	**Stellant D PET/CT Injector (stand)**	+ $27,753	X_____
1	10504243	**PET Time-of-Flight-mCT (AWP)** Utilizing timing information (time-of-flight) between the two PET coincidence events, PET Time-of-Flight option provides improved image signal-to-noise which can be used to either enhance image quality and/or reduce patient acquisition time. With a system timing resolution of 555 ps, the PET Time-of-Flight option allows clinicians to realize the benefits of time-of-flight reconstruction.	+ $259,290	X_____
1	14415354	**RTP Pallet** RTP Flat pallet for Biograph mCT. The carbon fiber table top utilizes a quick release latch for easy on/off. Varian Exact(tm) compatible indexing for accessories.	+ $12,127	X_____

FINANCING: The equipment listed above may be financed through Siemens. Ask us about our full range of financial products that can be tailored to meet your business and cash flow requirements. For further information, please contact your local Sales Representative.

ACCESSORIES: Don't forget to ask us about our line of OEM imaging accessories to complete your purchase. All accessories can be purchased or financed as part of this order. To purchase accessories directly or to receive our accessories catalog, please call us directly at 1-888-222-9944 ext. 7 or contact your local Sales Representative.

COMPLIANCE: Compliance with legal and internal regulations is an integral part of all business processes at Siemens. Possible infringements can be reported to our Helpdesk "Tell us" function at www.siemens.com/tell-us.

SIEMENS
Siemens Medical Solutions USA, Inc.
51 Valley Stream Parkway, Malvern, PA 19355
Fax: (781) 203-6025

SIEMENS REPRESENTATIVE
John Hubbard - (603) 801-4879

Siemens Medical Solutions USA, Inc. General Terms and Conditions

1. GENERAL

1.1 Contract Terms. These terms and conditions constitute an integral part of any contract between the Seller identified on the first page hereof to sell products ("Products") and Purchaser and shall govern the sale of the Products. Seller shall not be bound by, and specifically objects to, any terms, conditions or other provisions which are different from or in addition to the provisions of this Agreement (whether or not it would materially alter this Agreement) which is proffered by Purchaser in any purchase order, receipt, acceptance, confirmation, correspondence or otherwise (even if provided to Seller concurrently with this Agreement), unless Seller specifically agrees to any such provision in a writing signed by Seller. Neither Seller's lack of objection to any such terms, nor delivery of the Products or provision of any services hereunder, shall constitute the agreement of Seller to any such terms. Purchaser acknowledges that this is a commercial and not a consumer transaction.

1.2 Acceptance. Purchaser shall be deemed to have assented to, and waived any objection to, this Agreement upon the earliest to occur of any of the following: Purchaser's completion or execution of this Agreement; Purchaser's acceptance of all or any part of the Products subject to this Agreement; Purchaser's issuance of a purchase order for any Products identified on Seller's quotation or proposal; or delivery of the Products to the common carrier for shipment pursuant hereto.

1.3 Refurbished/Used Products. For Products identified on the Agreement as used or refurbished Products, these Products have been previously owned and used. When delivered to Purchaser, the Products may have received mechanical, electrical and/or cosmetic reconditioning, as needed, and will comply with the manufacturer's specifications. Since pre-owned Products may be offered simultaneously to several customers, the sale of such Products to Purchaser cannot be guaranteed and is subject to continuing availability at the time Purchaser accepts Seller's offer to sell the Products. If the Products are no longer available, Seller will use its best efforts to identify other products in its inventory that may be suitable for purchase by Purchaser, and if substitute products are not acceptable to Purchaser, then Seller will cancel the order and refund to Purchaser any deposits previously paid. The warranty period for any used or refurbished Products will be separately stated on the quotation.

1.4 Third Party Products. If this Agreement includes the sale of third party products not manufactured by Seller, then Purchaser agrees and acknowledges that (a) Purchaser has made the selection of these products on its own, (b) the products are being acquired by Seller solely at the request of and for the benefit of Purchaser, in order to eliminate the need for Purchaser to issue a separate purchase order to the manufacturer of the products, (c) no representation, warranty or guarantee has been made by Seller with respect to the products, (d) the obligation of Purchaser to pay Seller for the products is absolute and unconditional, (f) Purchaser will assert no claim whatsoever against the Seller with respect to the products, and will look solely to the manufacturer regarding any such claims, (g) Purchaser will indemnify and hold Seller harmless from and against any and all claims, regardless of the form of action, related to, resulting from or caused by the products or any work or service provided by the manufacturer of the products or any other party, (h) use of the products may be subject to the Purchaser's agreement to comply with any software licensing terms imposed by the manufacturer, as well as any applicable laws, rule and regulations; and (i) the manufacturer, and not Seller, is solely responsible for any required installation, testing, validation, tracking, product recall, warranty service, maintenance, support, and complaint handling, as well as any other applicable FDA regulatory requirements.

2. PRICES

2.1 Quotations. Unless otherwise agreed to in writing or set forth in the quotation, all prices quoted by Seller are based on U.S. dollars, and include standard and customary packaging. F.O.B. terms are set forth in Section 6.2 hereof. Domestic prices apply only to purchasers located in, and who will use the Products in, the U.S. International prices apply to all purchasers located outside of, or who will use or ship or facilitate shipment of the Products outside of, the U.S. Unless otherwise stated, the quotation shall only be valid for forty-five (45) days from the date of the quotation.

2.2 Delay in Acceptance of Delivery. Should the agreed delivery date be postponed by Purchaser, Seller shall have the right to deliver to storage at Purchaser's risk and expense, and payments due upon delivery shall become due when Seller is ready to deliver.

2.3 Escalation. Unless otherwise agreed to in writing, except as to goods to be delivered within six (6) months of Seller's acceptance of Purchaser's order, Seller reserves the right to increase its prices to those in effect at the time of shipment.

3. TAXES

3.1 Any sales, use or manufacturer's tax which may be imposed upon the sale or use of Products, or any property tax levied after readiness to ship, or any excise tax, license or similar fee required under this transaction, shall be in addition to the quoted prices and shall be paid by Purchaser. Notwithstanding the foregoing, Seller agrees to honor any valid exemption certificate provided by Purchaser.

4. TERMS OF PAYMENT

4.1 Payments; Due Date. Unless otherwise set forth in the quotation, Seller's payment terms are as follows: an initial deposit of 10% of the purchase price for each Product is due upon submission of the purchase order, an additional 80% of the purchase price is due upon delivery of each Product, and the final 10% of the purchase price is due upon completion of installation or when the Products are available for first patient use, whichever occurs first. Unless otherwise agreed, all payments other than the initial deposit are due net thirty (30) days from the date of invoice. Seller shall have no obligation to complete installation until the payment due upon delivery of the Product is received. All amounts payable pursuant to this Agreement are denominated in United States dollars, and Purchaser shall pay all such amount in lawful money of the United States. Partial shipments shall be billed as made, and payments for such shipments will be made in accordance with the foregoing payment terms. In the event that Purchaser makes any payments hereunder by credit card, Seller has the right to charge the Purchaser any credit card fees imposed on the Seller by the financial institution.

4.2 Late Payment. A service charge of 1½% per month, not to exceed the maximum rate allowed by law, shall be made on any portion of Purchaser's outstanding balance which is not paid within thirty (30) days after invoice date, which charge shall be determined and compounded on a daily basis from the due date until the date paid. Payment of such service charge shall not excuse or cure Purchaser's breach or default for late payment. In addition, in the event that Purchaser fails to make any payment to Seller within this thirty (30) day period, including but not limited to any payment under any service contract, promissory note or other agreement with Seller, then Seller shall have no obligation to continue performance under any agreement with Purchaser.

4.3 Payment of Lesser Amount. If Purchaser pays, or Seller otherwise receives, a lesser amount than the full amount provided for under this Agreement, such payment or receipt shall not constitute or be construed other than as on account of the earliest amount due Seller. Seller may accept any check or payment in any amount without prejudice to Seller's right to recover the balance of the amount due or to pursue any other right or remedy. No endorsement or statement on any check or payment or in any letter accompanying a check or payment or elsewhere shall constitute or be construed as an accord or satisfaction.

4.4 Where Payment Due Upon Installation or Completion. Should any terms of payment provide for either full or partial payment upon installation or completion of installation or thereafter, and the installation or completion is delayed for any reason for which Seller is not responsible, then the Products shall be deemed installed upon delivery and, if no other terms were agreed upon in writing signed by the parties, the balance of payments shall be due no later than thirty (30) days from delivery regardless of the actual installation date.

4.5 Default;Termination. Each of the following shall constitute an event of default under this Agreement: (i) a failure by Purchaser to make any payment due Seller within ten (10) days of receipt of notice of non-payment from Seller; (ii) a failure by Purchaser to perform any other obligation under this Agreement within thirty (30) days of receipt of notice from Seller; (iii) a default by Purchaser or any affiliate of Purchaser under any other obligation to or agreement with Seller, Siemens Financial Services, Inc. or Siemens Medical Solutions Health Services Corporation, or any assignee of the foregoing (including, but not limited to, a promissory note, lease, rental agreement, license agreement or purchase contract); or (iv) the commencement of any insolvency, bankruptcy or similar proceedings by or against the Purchaser (including any assignment by Purchaser for the benefit of creditors). Upon the occurrence of any event of default, at Seller's election: (a) the entire amount of any indebtedness and obligation due Seller under this Agreement and interest thereon shall become immediately due and payable without notice, demand, or period of grace; (b) Seller may suspend the performance of any of Seller's obligations hereunder, including, but not limited to, obligations relating to delivery, installation and warranty services; (c) Purchaser shall put Seller in possession of the Products upon demand; (d) Seller may enter any premises where the Products are located and take possession of the Products without notice or demand and without legal proceedings; (e) at the request of Seller, Purchaser shall

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assemble the Products and make them available to Seller at a place designated by Seller which is reasonable and convenient to all parties; (f) Seller may sell or otherwise dispose of all or any part of the Products and apply the proceeds thereof against any indebtedness or obligation of Purchaser under this Agreement (Purchaser agrees that a period of 10 days from the time notice is sent to Purchaser shall be a reasonable period of notification of sale or other disposition of the Products by or for Seller); (g) if this Agreement or any indebtedness or obligation of Purchaser under this Agreement is referred to an attorney for collection or realization, Purchaser shall pay to Seller all costs of collection and realization (including, without limitation, a reasonable sum for attorneys' fees, expenses of title search, all court costs and other legal expenses) incurred thereby; and (h) Purchaser shall pay any deficiency remaining after collection of or realization by Seller on the Products. In addition, Seller may terminate this Agreement upon written notice to Purchaser in the event that Purchaser is not approved for credit or upon the occurrence of any material adverse change in the financial condition or business operations of Purchaser.

4.6 Financing. Notwithstanding any arrangement that Purchaser may make for the financing of the purchase price of the Products, the parties agree that any such financing arrangement shall have no effect on the Purchaser's payment obligations under this Agreement, including but not limited to Sections 4.1 and 4.2 above.

5. EXPORT TERMS

5.1 Unless other arrangements have been made, payment on export orders shall be made by irrevocable confirmed letter of credit, payable in U.S. dollars against Seller's invoice and standard shipping documents. Such letter of credit shall be in an amount equal to the full purchase price of the Products and shall be established in a U.S. bank acceptable to Seller. Purchaser shall procure all necessary permits and licenses for shipment and compliance with any governmental regulations concerning control of final destination of Products.

5.2 Purchaser shall not, directly or indirectly, violate any U.S. law, regulation or treaty, or any other international treaty or agreement, relating to the export or reexport of any Product or associated technical data, to which the U.S. adheres or with which the U.S. complies. Purchaser shall defend, indemnify and hold Seller harmless from any claim, damage, liability or expense (including but not limited to reasonable attorney's fees) arising out of or in connection with any violation of the preceding sentence. If Purchaser purchases a Product at the domestic price and exports such Product, or transfers such Product to a third party for export, outside of the U.S., Purchaser shall pay to Seller the difference between the domestic price and the international retail price of such Product pursuant to the payment terms set forth herein. Purchaser shall deliver to Seller, upon Seller's request, written assurance regarding compliance with this section in form and content acceptable to Seller.

6. DELIVERY, RISK OF LOSS

6.1 Delivery Date. Delivery and completion schedules are approximate only and are based on conditions at the time of acceptance of Purchaser's order by Seller. Seller shall make every reasonable effort to meet the delivery date(s) quoted or acknowledged, but shall not be liable for any failure to meet such date(s). Partial shipments may be made.

6.2 Risk of Loss; Title Transfer. Unless otherwise agreed to in writing, the following shall apply:

(a) For Products that do not require installation by Seller or its authorized agent or subcontractor, and for options and add-on products purchased subsequent to delivery and installation of Products purchased under this Agreement, delivery shall be complete upon transfer of possession to common carrier, F.O.B. Shipping Point, whereupon title to and all risk of loss, damage to or destruction of the Products shall pass to Purchaser.

(b) For Products that require installation by Seller or its authorized agent or subcontractor, delivery shall be complete upon delivery of the Products to Purchaser's designated site, F.O.B. Destination; title to and all risk of loss, damage to or destruction of such Products shall pass to Purchaser upon completion of the installation by Seller or its authorized agent or subcontractor.

(c) All freight charges and other transportation, packing and insurance costs, license fees, custom duties and other similar charges shall be the sole responsibility of the Purchaser unless included in the purchase price or otherwise agreed to in writing by Seller. In the event of any loss or damage to any of the Products during shipment, Seller and Purchaser shall cooperate in making a claim against the carrier.

7. SECURITY INTEREST/FILING

7.1 From the F.O.B. point, Seller shall have a purchase money security interest in the Products (and all accessories and replacements thereto and all proceeds thereof) until payment in full by Purchaser and satisfaction of all other obligations of Purchaser hereunder. Purchaser hereby (i) authorizes Seller to file (and Purchaser shall promptly execute, if requested by Seller) and (ii) irrevocably appoints Seller its agent and attorney-in-fact to execute in the name of Purchaser and file, with such authorities and at such locations as Seller may deem appropriate, any Uniform Commercial Code financing statements with respect to the Products and/or this Agreement. Purchaser also agrees that an original or a photocopy of this Agreement (including any addenda, attachments and amendments hereto) may be filed by Seller as a Uniform Commercial Code financing statement. Purchaser further represents and covenants that (a) it will keep the Products in good order and repair until the purchase price has been paid in full, (b) it will promptly pay all taxes and assessments upon the Products or the use thereof, (c) it will not attempt to transfer any interest in the Products until the purchase price has been paid in full, and (d) it is solvent and financially capable of paying the full purchase price for the Products.

8. CHANGES, CANCELLATION, AND RETURN

8.1 Orders accepted by Seller are not subject to change except upon written agreement.

8.2 Orders accepted by Seller are noncancellable by Purchaser except upon Seller's written consent and payment by Purchaser of a cancellation charge equal to 10% of the price of the affected Products, plus any shipping, insurance, inspection and refurbishment charges; the cost of providing any training, education, site evaluation or other services; and any return, cancellation or restocking fees with respect to any Third Party Products ordered by Seller on behalf of Purchaser. Seller may retain any payments received from Purchaser up to the amount of the cancellation charge. In no event can an order be cancelled by Purchaser or Products be returned to Seller after shipment has been made.

8.3 Seller shall have the right to change the manufacture and/or design of its Products if, in the judgment of Seller, such change does not alter the general function of the Products.

9. FORCE MAJEURE

9.1 Seller will make every effort to complete shipment, and installation where indicated, but shall not be liable for any loss or damage for delay in delivery, inability to install or any other failure to perform due to causes beyond its reasonable control including, but not limited to, acts of government or compliance with any governmental rules or regulations, acts of God or the public, war, civil commotion, blockades, embargoes, calamities, floods, fires, earthquakes, explosions, storms, strikes, lockouts, labor disputes, or unavailability of labor, raw materials, power or supplies. Should such a delay occur, Seller may reasonably extend delivery or production schedules or, at its option, cancel the order in whole or part without liability other than to return any unearned deposit or prepayment.

10. WARRANTY

10.1 Seller warrants that the Products manufactured by Seller and sold hereunder shall be free from defects in material or workmanship under normal use and service for the warranty period. The final assembled Products shall be new although they may include certain used, reworked or refurbished parts and components (e.g., circuit boards) that comply with performance and reliability specifications and controls. Seller's obligation under this warranty is limited, at Seller's option, to the repair or replacement of the Product or any part thereof. Unless otherwise set forth in the Product Warranty attached hereto and incorporated herein by reference, the warranty period shall commence upon the earlier of the date that the Products have been installed in accordance with 12.6 hereof, which date shall be confirmed in writing by Seller, or first patient use, and shall continue for 12 consecutive months. Seller makes no warranty for any Products made by persons other than Seller or its affiliates, and Purchaser's sole warranty therefor, if any, is the original manufacturer's warranty, which Seller agrees to pass on to Purchaser, as applicable. The warranty provided by Seller under this Section 10 extends only to the original Purchaser, unless the Purchaser obtains the Seller's prior written consent with respect to any sale or other transfer of the Equipment during the term of the warranty.

10.2 No warranty extended by Seller shall apply to any Products which have been damaged by fire, accident, misuse, abuse, negligence, improper application or alteration or by a force majeure occurrence as described in Section 9 hereof or by the Purchaser's failure to operate the Products in accordance with the manufacturer's instructions or to maintain the recommended operating environment and line conditions; which are defective due to unauthorized attempts to repair, relocate, maintain, service, add to or modify the Products by the Purchaser or any third party or due to the attachment and/or use of non-Seller supplied equipment , parts or software, without Seller's prior written approval; which failed due to causes from within non-Seller supplied equipment, parts or software; which have been damaged from the use of operating supplies or consumable parts not approved by Seller. In addition, no warranty extended by Seller shall apply to any transducer or probe failure due to events such as cracking from high impact drops, cable rupture from rolling equipment over the cable, or delamination from cleaning

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with inappropriate solutions. Seller's obligation under this warranty is limited to the repair or replacement, at Seller's option, of defective parts. Seller may effectuate such repair at Purchaser's facility, and Purchaser shall furnish Seller safe and sufficient access for such repair. Repair or replacement may be with parts or products that are new, used or refurbished. Repairs or replacements shall not interrupt, extend or prolong the term of the warranty. Purchaser shall, upon Seller's request, return the noncomplying Product or part to Seller with all transportation charges prepaid, but shall not return any Product or part to Seller without Seller's prior written authorization. Purchaser shall pay Seller its normal charges for service and parts for any inspection, repair or replacement that is not, in Seller's sole judgment, required by noncompliance with the warranty set forth in Section 10.1. Seller's warranty does not apply to consumable materials, disposables, supplies, accessories and collateral equipment, except as specifically stated in writing or as otherwise set forth in the Product Warranty attached hereto and incorporated herein by reference, nor to products or parts thereof supplied by Purchaser.

10.3 This warranty is made on condition that immediate written notice of any noncompliance be given to Seller and Seller's inspection reveals that the Purchaser's claim is valid under the terms of the warranty (i.e., that the noncompliance is due to traceable defects in original materials and/or workmanship).

10.4 Purchaser shall provide Seller with full and free access to the Products, network cabling and communication equipment as is reasonably necessary for Seller to provide warranty service. This access includes establishing and maintaining connectivity to the Products via VPN IPsec Tunneling (non-client) Peer-to-Peer connection, modem line, internet connection, broadband internet connection or other secure remote access reasonably required by Seller, in order for Seller to provide warranty service, including remote diagnostics, monitoring and repair services.

10.5 Warranty service will be provided without charge during Seller's regular working hours (8:30-5:00), Monday through Friday, except Seller's recognized holidays. If Purchaser requires that service be performed other than during these times, such service can be made available at an additional charge, at Seller's then current rates. The obligations of Seller described in this section are Seller's only obligations and Purchaser's sole and exclusive remedy for a breach of product warranty.

10.6 SELLER MAKES NO WARRANTY OTHER THAN THE ONE SET FORTH HEREIN AND IN THE ATTACHED PRODUCT WARRANTY COVERING THE APPLICABLE PRODUCT CATEGORY. SUCH WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY EXPRESS OR IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR PARTICULAR PURPOSES, AND SUCH CONSTITUTES THE ONLY WARRANTY MADE WITH RESPECT TO THE PRODUCTS AND ANY DEFECT, DEFICIENCY OR NONCONFORMITY IN ANY PRODUCT, SERVICE OR OTHER ITEM FURNISHED UNDER THIS AGREEMENT.

10.7 In the event of any inconsistencies between the terms of this Section 10 and the terms of the attached Product Warranty, the terms of the attached Product Warranty shall prevail.

11. LIMITATION OF LIABILITY

11.1 In no event shall Seller's liability hereunder exceed the actual loss or damage sustained by Purchaser, up to the purchase price of the Products. The foregoing limitation of liability shall not apply to claims for bodily injury or damages to real property or tangible personal property arising as a result of Seller's negligence or a product defect.

11.2 SELLER SHALL NOT BE LIABLE FOR ANY LOSS OF USE, REVENUE OR ANTICIPATED PROFITS, COST OF SUBSTITUTE PRODUCTS OR SERVICES, LOSS OF STORED, TRANSMITTED OR RECORDED DATA, OR FOR ANY INDIRECT, INCIDENTAL, UNFORESEEN, SPECIAL, PUNITIVE OR CONSEQUENTIAL DAMAGES WHETHER BASED ON CONTRACT, TORT (INCLUDING NEGLIGENCE), STRICT LIABILITY OR ANY OTHER THEORY OR FORM OF ACTION, EVEN IF SELLER HAS BEEN ADVISED OF THE POSSIBILITY THEREOF, ARISING OUT OF OR IN CONNECTION WITH THIS AGREEMENT OR THE SALE OR USE OF THE PRODUCTS. THE FOREGOING IS A SEPARATE, ESSENTIAL TERM OF THIS AGREEMENT AND SHALL BE EFFECTIVE UPON THE FAILURE OF ANY REMEDY, EXCLUSIVE OR NOT.

12. INSTALLATION - ADDITIONAL CHARGES

12.1 General. Unless otherwise expressly stipulated in writing, the Products covered hereby shall be installed by and at the expense of Seller except that Seller shall not provide rigging or site preparation services unless otherwise agreed to in writing by Seller for an additional charge. Seller will not install accessory items such as cabinets, illuminators, darkroom equipment or processors for X-Ray and CT equipment, unless otherwise agreed to in writing by Seller.

12.2 Installation by Seller. If Seller specifies it will install the Products, the following applies: subject to fulfillment of the obligations set forth in 12.4 below, Seller shall install the Products covered hereby and connect same to the requisite safety switches and power lines to be installed by Purchaser. Except as otherwise specified below, if such installation and connection are performed by Seller's technical personnel, prices shown include the cost thereof, provided that the installation and connection can be performed within the Continental United States or Puerto Rico and during normal business hours. Any overtime charges or other special expenses shall be additional charges to the prices shown.

12.3 Trade Unions. In the event that a trade union, or unions, or other local labor conditions prevent Seller from performing the above work with its own employees or contractors, then Purchaser shall either make all required arrangements with the trade union, or unions, to permit Seller's completion of said work or shall provide the personnel, at Purchaser's sole cost and expense. Moreover, any additional cost incurred by Seller and related to such labor disputes shall be paid by the Purchaser and Seller's obligations under such circumstances will be limited to providing engineering supervision of installation and connection of Seller equipment to existing wiring.

12.4 Purchaser's Obligations. Purchaser shall, at its expense, provide all proper and necessary labor and materials for plumbing service, carpentry work, conduit wiring, and other preparations required for such installation and connection. All such labor and materials shall be completed and available at the time of delivery of the Products by Seller. Additionally, the Purchaser shall provide free access to the premises of installation and, if necessary, safe and secure space thereon for storage of Products and equipment prior to installation by Seller. Purchaser shall be responsible, at its sole cost and expense, for obtaining all permits, licenses and approvals required by any federal, sate or local authorities in connection with the installation and operation of the Products, including but not limited to any certificate of need and zoning variances. Purchaser shall provide a suitable environment for the Products and shall ensure, at its sole cost and expense, that its premises are free of asbestos, hazardous conditions and any concealed, unknown or dangerous conditions and that all site requirements are met. Seller shall delay its work until Purchaser has completed the removal of the asbestos or other hazardous materials or has taken any other precautions and completed any other work required by applicable regulations. Purchaser shall reimburse Seller for any increased costs and expenses incurred by Seller that are the result of or are caused by any such delay. In the event that Seller is requested to supervise the installation of the Products, it remains the Purchaser's responsibility to comply with local regulations. Seller is not an architect and all drawings furnished by Seller are not construction drawings.

12.5 Regulatory Reporting. In the event that any regulatory activity is performed by other than Seller authorized personnel, Purchaser shall be responsible for fulfilling any and all reporting requirements.

12.6 Completion of Installation. Installation shall be complete upon the conclusion of final calibration and checkout under Seller's standard procedures to verify that the Products meet applicable written performance specifications. Notwithstanding the foregoing, first use of the Products by Purchaser, its agents or employees for any purpose after delivery shall constitute completion of installation.

13. PATENT, TRADEMARK AND OTHER INFRINGEMENT CLAIMS

13.1 Infringement by Seller. Seller warrants that the Products manufactured by Seller and sold hereunder do not infringe any U.S. patent or copyright. If Purchaser receives a claim that any such Product, or parts thereof, infringe upon the rights of others under any U.S. patent or copyright, Purchaser shall notify Seller immediately in writing. As to all infringement claims relating to Products or parts manufactured by Seller or one of its affiliates:

(a) Purchaser shall give Seller information, assistance and exclusive authority to evaluate, defend and settle such claims.

(b) Seller shall then, at its own expense, defend or settle such claims, procure for the Purchaser the right to use the Products, or remove or modify them to avoid infringement. If none of these alternatives is available on terms reasonable to Seller, then Purchaser shall return the Products to Seller and Seller shall refund to Purchaser the purchase price paid by the Purchaser less reasonable depreciation for Purchaser's use of the Products. The foregoing states Seller's entire obligation and liability, and the Purchaser's sole remedy, for claims of infringement.

13.2 Infringement by Purchaser. If some or all of the Products sold hereunder are made by Seller pursuant to drawings or specifications furnished by the Purchaser, or if Purchaser modifies or combines, operates or uses the Products other than as specified by Seller or with any product, data, software, apparatus or program not provided or approved by Seller, then the indemnity obligation of Seller under Section 13.1 shall be null and void and should a claim be made that such Products infringe the rights of any third party under patent, trademark or otherwise, then Purchaser shall indemnify and hold Seller

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harmless against any liability or expense, including reasonable attorneys' fees, incurred by Seller in connection therewith.

14. DESIGNS AND TRADE SECRETS; LICENSE; CONFIDENTIALITY
14.1 Any drawings, data, designs, software programs or other technical information supplied by Seller to Purchaser in connection with the sale of the Products are not included in the sale of the Products to Purchaser, shall remain Seller's property and shall at all times be held in confidence by Purchaser. Such information shall not be reproduced or disclosed to others without Seller's prior written consent.
14.2 For all goods purchased hereunder which utilize software for their operation, such "Applications Software" shall be licensed to Purchaser under the terms of Seller's Software License Schedule as attached hereto.
14.3 Diagnostic/Maintenance Software is not included under 14.2 above, is available only as a special option under a separate Diagnostic Materials License Agreement and may be subject to a separate licensing fee.
14.4 Seller and Purchaser shall maintain the confidentiality of any information provided or disclosed to the other party relating to the business, customers and/or patients of the disclosing party, as well as this Agreement and its terms (including the pricing and other financial terms under which the Purchaser will be purchasing the Products hereunder). Each party shall use reasonable care to protect the confidentiality of the information disclosed, but no less than the degree of care it would use to protect its own confidential information, and shall only disclose the other party's confidential information to its employees and agents having a need to know this information. The obligations of confidentiality set forth herein shall not apply to any information in the public domain at the time of disclosure or that is required to be disclosed by court order or by law.

15. ENGINEERING CHANGES
15.1 Seller makes no representation that engineering changes which may be announced in the future will be suitable for use on, or in connection with, the Products.

16. ASSIGNMENT
16.1 Neither party may assign any rights or obligations under this Agreement without the written consent of the other and any attempt to do so shall be void, except that Seller may assign this Agreement without consent to any subsidiary or affiliated company, and may delegate to authorized subcontractors or service suppliers any work to be performed under this Agreement so long as Seller remains liable for the performance of its obligations under this Agreement. This Agreement shall inure to and be binding upon the parties and their respective successors, permitted assigns and legal representatives. Seller shall have no obligations under this Agreement to any assignee of Purchaser that is not approved by Seller in advance.

17. DAMAGES, COSTS AND FEES
17.1 In the event that any dispute or difference is brought arising from or relating to this Agreement or the breach, termination or validity thereof, the prevailing party shall NOT be entitled to recover from the other party any punitive damages. The prevailing party shall be entitled to recover from the other party all reasonable attorneys' fees incurred, together with such other expenses, costs and disbursements as may be allowed by law.

18. MODIFICATION
18.1 This Agreement may not be changed, modified or amended except in writing signed by duly authorized representatives of the parties.

19. GOVERNING LAW; WAIVER OF JURY TRIAL
19.1 This Agreement shall be governed by the laws of the Commonwealth of Pennsylvania.
19.2 EACH OF THE PARTIES EXPRESSLY WAIVES ALL RIGHTS TO A JURY TRIAL IN CONNECTION WITH ANY DISPUTE UNDER THIS AGREEMENT.

20. COST REPORTING
20.1 Purchaser agrees that it will fully and accurately account for and report in all cost reports and otherwise fully and accurately disclose to federal and state health care program payors and fully and accurately reflect where and as appropriate to the applicable reimbursement methodology, all services and other items, including any and all discounts, received from Seller under this Agreement, in compliance with all applicable laws, rules and regulations, including but not limited to the Social Security Act and implementing regulations relating to Medicare, Medicaid and other federal and state health care reimbursement programs

21. INTEGRATION
21.1 These terms and conditions, including any attachments or other documents incorporated by reference herein, constitute the entire agreement and the complete and exclusive statement of agreement with respect to the subject matter hereof, and supersede any and all prior agreements, understandings and communications between the parties with respect to the Products.

22. SEVERABILITY; HEADINGS
22.1 No provision of this Agreement which may be deemed unenforceable will in any way invalidate any other portion or provision of this Agreement. Section headings are for convenience only and will have no substantive effect.

23. WAIVER
23.1 No failure and no delay in exercising, on the part of any party, any right under this Agreement will operate as a waiver thereof, nor will any single or partial exercise of any right preclude the further exercise of any other right.

24. NOTICES
24.1 Any notice or other communication under this Agreement shall be deemed properly given if given in writing and delivered in person or mailed, properly addressed and stamped with the required postage, to the intended recipient at its address specified on the face hereof. Either party may from time to time change such address by giving the other party notice of such change in accordance with this section.

25. RIGHTS CUMULATIVE
25.1 The rights and remedies afforded to Seller under this Agreement are in addition to, and do not in anyway limit, any other rights or remedies afforded to Seller by any other agreement, by law or otherwise.

26. END USER CERTIFICATION
26.1 Purchaser represents, warrants and covenants that it is acquiring the Products for its own end use and not for reselling, leasing or transferring to a third party (except for lease-back financings).

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Software License Schedule to the Siemens Medical Solutions USA, Inc. General Terms and Conditions

1. DEFINITIONS: The following definitions apply to this Schedule:
"Agreement" shall mean the attached (i) Quotation for Products and/or Services including the Terms and Conditions of Sale and applicable schedules; and/or (ii) Software License Agreement describing the software licensed herein and the specific system for which the license is issued.
"Licensor" shall mean Siemens Medical Solutions USA, Inc.
"Licensee" shall mean the end-user to whom Licensor provides Software or Documentation for its internal use under the Agreement.
"Software" shall mean the software described in the attached Agreement, including the following as contained therein: (i) software programs consisting of a series of statements or instructions to be used directly or indirectly in a programmable controller or computer to bring about a certain result and (ii) databases consisting of systemized collections of data to be used or referenced directly or indirectly by a programmed controller or computer. Notwithstanding the foregoing, "Software" does not include "firmware" as such term is conventionally understood. Diagnostic/Maintenance Software also is not included within the scope of the Software licensed under this Schedule, and is available only as a special option under a separate Diagnostic Materials License Agreement and may be subject to a separate licensing fee.
"Documentation" shall mean the documents and other supporting materials which are intended to support the use of an associated product, including (but not limited to) instructions, descriptions, flow charts, logic diagrams and listings of the Software, in text or graphic form, on machine readable or printed media.
"Designated Unit" shall mean a single control unit or computer identified on the first page of the Agreement, on which Software licensed hereunder may be used by Licensee.
2. SCOPE: The following terms and conditions shall apply to all Software and Documentation provided by Licensor to Licensee under the Agreement (whether included with other products listed in the Agreement or listed separately in the Agreement), together with any updates or revisions thereto which Licensor may provide to Licensee, and all copies thereof, except any Software and/or Documentation licensed directly by Licensor's supplier under a separate end-user license agreement accompanying the Software or the Documentation, in which case Licensee agrees to be bound by that license agreement as a condition to using the Software and/or Documentation. Except as expressly provided herein, and provided that in no event shall the warranties or other obligations of Licensor with respect to such Software or Documentation exceed those set forth in this Schedule, this Schedule shall be subject to the liability limitations and exclusions and other terms and conditions set forth in the Agreement. **ANY USE OF THE SOFTWARE, INCLUDING BUT NOT LIMITED TO USE ON THE DESIGNATED UNIT, WILL CONSTITUTE LICENSEE'S AGREEMENT TO THIS SOFTWARE LICENSE SCHEDULE (OR RATIFICATION OF ANY PREVIOUS CONSENT).**
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MI Warranty Information

Product	Period of Warranty[1]	Coverage	
(New Systems and "Proven Excellence" Refurbished Systems Only)			
MI-SPECT System or MI-PET System (not including radioactive sources and consumables)	12 month	Full Warranty (parts & labor including ALL CT tubes)	
Post-Warranty (after expiration of system warranty) – Replacement parts only:			
Straton CT tubes	Prorated to a maximum of 160,000 scan-seconds or 12 months whichever occurs first	Prorated credit given to customer against replacement cost	credit percentage = (160,000 – scan-seconds used) / 160,000*100
Dura Akron Q CT tubes	Prorated to a maximum of 120,000 scan-seconds or 12 months whichever occurs first	Prorated credit given to customer against replacement cost	credit percentage = (120,000 – scan-seconds used) / 120,000*100
All other Dura CT tubes	Prorated to a maximum of 130,000 scan-seconds or 12 months whichever occurs first	Prorated credit given to customer against replacement cost	credit percentage = (130,000 – scan-seconds used) / 130,000*100
Spare Parts	6 month	Parts only	
Radioactive Sources	Not covered		
Consumables	Not covered		

Note: Optional extended warranty coverage can be obtained by purchase of a service agreement.

[1] Period of warranty commences from the date of first use or completion of installation, whichever occurs first. In the event the completion of installation is delayed for reasons beyond Siemens' control, the stated Warranty period shall commence 60 days after delivery of equipment.

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Detailed Technical Specifications

Biograph mCT S/X

Part No. / Product	Description
10248473 **Biograph mCT-S(40)**	The Biograph mCT•S is a whole-body PET•CT tomograph designed for the purposes of oncological, neurological and cardiac imaging and diagnosis. With a single noninvasive procedure, the Biograph produces remarkable CT and PET•CT images that reveal highly-detailed anatomy and biological processes at the molecular level. The Biograph mCT provides: - high performance spiral computed tomography (CT) imaging and applications. - high-resolution, high-count rate, positron emission tomography (PET) imaging of metabolic and physiologic processes. - highest quality anatomic and metabolic image registration for optimal lesion detection and identification within the body. - highest quality attenuation correction and scatter correction for PET imaging. Scope of Delivery: Scanning Unit (Integrated PET•CT Gantry) The fully integrated PET•CT gantry incorporates CT and PET detector assemblies and electronics in an efficient, compact design that reduces data transmission noise and increases system reliability. The large gantry opening, continuous patient port and short tunnel length provide ease of positioning for all patient types and help to minimize patient claustrophobia. Quad operator controls on gantry for positioning from either side of patient from either the front or rear. Dual gantry displays (front and rear) for system status. CT System The CT imaging capability of the Biograph mCT consists of a 40-slice CT featuring a full range of SPIRAL CT clinical applications with highest performance. Gantry: Aperture: 78 cm; power supplied via low-voltage slipring. Rotational speed of the gantry: 182 rpm with a rotation time of 330 ms. Scanning system: Adaptive Array Detector (AAD) system based on UFC™ (ultrafast ceramics) with up to 14.720 elements depending on configuration, and 1472 measuring channels per slice (the measuring system can contain replacement components). STRATON tube high-performance X-ray system: The STRATON tube provides direct oil cooling of the anode with the ball bearings located outside the vacuum. The direct anode cooling and the small and compact design of the anode eliminates the need for heat storage capacity (0 MHU) and enables an unprecedented cooling rate of 7.3 MHU/min. Therefore cooling delays between multiple long range scans are eliminated, even for large patients. Tube current range: 20-666 mA. Focal spot size according to IEC 60336: 0.7 x 0.7mm/7°, 0.9 x 1.1mm/7°. Computer controlled monitoring of anode temperature, multifan principle with flying focal spot. Z-Sharp technology: The unique STRATON X-ray tube utilizes an electron beam that is accurately and rapidly deflected, creating two precise focal spots alternating 4,608 times per second. This doubles the X-ray projections reaching each detector element. The two overlapping projections result in an oversampling in z-direction, known as Double z-Sampling. The resulting measurements interleave half a detector slice width, doubling the scan information without a corresponding increase in dose. Siemens' proprietary, high-speed Ultra Fast Ceramic (UFC) detector enables a virtually simultaneous readout of two projections for each detector element - 2 x 20 slices for every viewing angle - resulting in a full 40-slice acquisition. 80 kW X-ray generator: Microprocessor-controlled, low-noise high-frequency generator with integrated, automatic self-testing system for

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Part No. / Product	Description
(Continued) **10248473** **Biograph mCT-S(40)**	continuous monitoring of operation. Settings: High-voltage range 80,100, 120 and 140 kV; power max. 80 kW, adjustable in fine steps. PET System The PET imaging capability of the Biograph mCT consists of the multi-LSO-detector ring system with 3D acquisition and reconstruction and 81 image planes with a 16.2 cm axial field of view. - High spatial slice resolution in trans-axial and axial dimensions. - Slice spacing (2 mm) optimized for speed and resolution. - Pico-3D ultra fast electronics for decreased deadtime and high signal-to-noise. - ACS III acquisition computer system for high countrate capability. - PRS reconstruction system for fast reconstruction of PET data. - Three-dimensional display of organs with a large axial view. - Excellent volume sensitivity. - Fast acquisition and reconstruction of 128 x 128 and 200 x 200 matrices. - Unique block detector technology provides excellent temporal and energy resolution response. - Simultaneous data acquisition and image reconstruction for high patient throughput. - Static, whole body, and list mode acquisition capability. - 842 mm detector ring diameter. - 78 cm gantry aperture. - 70 cm transverse field of view - 16.2 cm axial field of view. - Unique, accurate Patient Handling System. - TrueC advanced scatter correction technique Patient Handling System The Biograph mCT patient handling system (PHS) has a unique reinforced cantilever design that ensures reliable patient support with the highest weight capacity and minimal pallet deflection. - Reinforced cantilever design for maximum patient support and absolute positioning between PET and CT scan. - Integrated patient table design for easy patient positioning. - Low attenuation carbon fiber pallet. - 43 cm vertical motion range. - Maximum 190 cm PETCT co-scan range. - Low attenuation head holder, table extensions, head-arm support, knee-leg support. - Maximum patient weight of 227 kg (500 lbs.). Control and evaluation unit: CT control box with intercom system with user-programmable patient instruction system. Dual monitors (19 inch (48 cm) LCD flat panel displays), keyboard and mouse for *syngo* Acquisition Workplace. Computer system: The computer system of the Biograph mCT consists of four components. - *syngo* Acquisition Workplace console for the planning and execution of the CT examination, including evaluation and management of the CT images - Reconstruction computer for the preprocessing and reconstruction of the CT data - PET acquisition system (ACS III) - PET data reconstruction system (PRS) The *syngo* Acquisition Workplace console consists of a high-performance Celsius Windows XP based computer with 1x Core2 Quad Q9400 2.66 Ghz processors, 8 GB RAM, 146 GB storage capacity for 260,000 images, CD-R 700 MB for 1,100 images. DVD DICOM with 4.7 GB media for 8,400 images. External USB 2.0 devices for data storage are supported (recommended: Iomega 160 GB External Hard Drive Hi-Speed USB 2.0; Maxtor One Touch 160 GB External Hard Drive). The CT reconstruction computer contains a cluster of 2.2 GHz dual kernel high-performance processors performing the preprocessing and reconstruction of the CT data at 40 images/sec (512x512). Raw data memory is 450 GB. The PET acquisition system (ACS III) provides high performance acquisition and sorting of 3D coincidence events. Supports 3D static and 3D whole body acquisition modes. Contains dual Xeon 2.33 GHz processors with a total of

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Part No. / Product	Description
(Continued) **10248473** **Biograph mCT-S(40)**	32 GB RAM. Disk storage of 1.0 TB for PET raw data is provided. The PET reconstruction system (PRS) provides fast 3D image reconstruction of the PET raw data. Iterative and backprojection are supported. Contains dual Xeon 2.83 GHz QuadCore processors, GX280 GPU, 20 GB RAM. Disk storage of 1.0 TB for PET raw data. syngo User Software: syngo features an intuitive and thus easy-to-learn user interface. syngo visualizes the examination in individual process steps on so-called task cards, such as patient registration or examination card. A Large number of functions and input parameters as well as the language used can be selected according to individual requirements. Frequently repeated processes can be automated and saved. Patient registration - The system can accept patient data in different ways. These include entering the data via keyboard or transfer of a worklist via network. DICOM Worklist: Software module for accepting lists of patient data and exam requirements from a Radiology Information Systems (RIS) via DICOM Get Worklist functionality. The program enables very efficient working and ensures consistent patient data. Examination card - The scanner is supplied with a large number of predefined CT and fully integrated PET•CT examination protocols, making examination planning a very fast and efficient procedure. Viewing card - On the viewing card it is possible to move interactively with the mouse through the image volume of the ongoing examination. The images of different examinations can be displayed in parallel for comparison. A large number of functions are available for evaluation, documentation and archiving. Filming card - A virtual film sheet shows a 1:1 display of the film sheets to be printed out, thus permitting an effective preview of the filming job and re-windowing the images, as well as providing a large number of evaluation functions. Layout changes are possible interactively with up to 64 images. The printout parameters for the ongoing auto-filming running parallel to acquisition or reconstruction are also defined with the filming card. 3D card - The 3D task card contains the User Interface for the operation of the MIP (Maximum Intensity Projection), SSD (Surface Shaded Display), MPR (Multi-planar Reconstruction) three-dimensional post-processing. 3D VRT - Advanced 3D functionality as an extension to the basic 3D viewer, containing volume rendering technique (VRT) and advanced editing functions. Advanced 3D application package for the optimal display and differentiation of different organs through independent control of color, opacity, and shading in up to 4 tissue classes. CT Angio: Software for the reconstruction of angular projections from the images of a spiral data record for the display and diagnosis e.g. of aneurysms, plaques, stenoses, vascular anomalies or vascular origins. MIP: Maximum Intensity Projection, MinIP: Minimum Intensity Projection and Thin MIP available. Interfering or irrelevant parts of the image can be eliminated with the integrated volume editor. The angular projections are reconstructed around a definable axis, whereby the maximum CT values in this direction are selected for each angular projection. The resulting images can be viewed with the CINE function as a series of images with a 3D image effect. Workstream – Planning and reconstruction of diagnostic CT coronal, sagittal, oblique and MIP images can take place directly after scanning. DynEva card: Software for dynamic evaluation of the contrast enhancement in organs and types of tissues, enabling the reconstruction of - Time-density curves (up to 5 ROIs) - Peak-enhancement images - Time-to-peak images. Video Capture and Editing Tool: Software contains integrated solution for imaging and visualization of 4D information, allowing the generation and editing of video files for improved diagnoses, recording and teaching. A wide range of multimedia formats is supported, e.g. AVI, Flash (SWF), GIF, QuickTime (MOV), streaming video. AC Plus - Extended Field of View - option which allows visualization of objects with a CT FOV up to 78 cm., for improved PET attenuation correction. TrueD Basic: Single-mode, single timepoint layout for displaying the PET and CT either fused or side-by-side comparison with viewer formats and color map tables. Support for 3D spherical regions-of-interest with units of Bq/ml or Standard Uptake Value (SUV). Allows re-registration of PET to CT data for correction of misregistration as a result of patient motion.

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Part No. / Product	Description
(Continued) **10248473** **Biograph mCT-S(40)**	Media Viewer: Provides basic viewing capabilities in a portable Windows-based application that can be burned to media (CD, DVD) along with patient images. Not intended for diagnostic use. - Review volume datasets from CT and PET - Supports viewing single-modality or fused images - View linked axial, coronal, and sagittal views - Navigate in three dimensions - View MIP images correlated to axial, coronal, and sagittal views - Blend fused images - Quantify Hounsfield units, SUV CARE Solutions: UFC Detector: Up to 30% dose reduction compared to conventional CT detectors. High efficiency for low mAs requirements enable best possible image quality with low patient dose. CARE Filter: Specially designed X-ray exposure filter installed at the tube collimator. Up to 25% dose reduction with increased image quality. Pediatric Protocols: Special examination protocols with 80 kV and a large range of adjustable mAs values for optimum adaptation of the radiation exposure to the age and weight of the child to be examined. CARE Topo: Real-time topogram, Manual interruption possible once desired anatomy has been imaged. CARE Bolus: Operating mode for CM-enhancement triggered data acquisition. The objective is optimum utilization of the contrast medium bolus in its "plateau" phase in the target organ. This option has been especially adapted to the increased speed and timing requirements resulting from the multirow capability and faster rotation. The CM enhancement is observed via monitoring scans in a user-defined ROI with a trigger threshold. As soon as the enhancement reaches its predefined threshold, the spiral scan is triggered as quickly as possible. License for software use on one modality. CARE Dose4D: This software feature provides automatic, real-time x-ray dose management for all scan modes. The minimal x-ray dose level needed to obtain optimal image quality is determined from extensive computer analysis of the Topogram image and also from the data collected during every slice scanned, on a real time basis. This automatic approach ensures optimal image quality at the lowest possible x-ray dose. CARE Dose4D uses at first a automated adjustment of the dose level depending on patient size based on the attenuation values obtained from the standard topogram along the patient axis. In addition CARE Dose4D uses a real-time adaptation of the tube current during the scan based on the actual attenuation of the X-ray beam measured around the patient. Up to 2,320 projections are evaluated per second to optimize the mA level instantaneously. In combination with the extreme adjustment speed of the tube current, CARE Dose4D ensures consistent high quality images in every anatomical position. And that's at anytime with the minimal possible X-ray dose. Several clinical benefits are achieved with CARE Dose4D: - Significant x-ray dose reduction (up to 68 %) possible for all body regions scanned compared with standard sequence or spiral scanning; - Consistent, optimal image quality with the x-ray dose level unique for every patient and for every anatomical region; - Thinner axial slices and/or longer scan ranges possible because of reduced tube loading; - Ultra-low dose examinations for pediatric patients. Adaptive Dose Shield eliminates clinically irrelevant radiation in every spiral scan, adding to the lowest possible dose that CARE Solutions provide. Examination and Evaluation Functions: Topogram: Scanning perspectives: a.p., p.a., lat.; length of scan field: 128 - 1974mm, width of scan field: 512 mm, 1.5 - 20s. The topogram can be switched off manually when the desired examination length is reached. Tomogram: Scan field size: 50 cm. Standard scan times: 0.33, 0.5 and 1 seconds. Slice thickness in sequence: 0.6, 0.75,1, 1.2, 1.5, 2.0, 2.4, 3, 4.0, 4.8, 5, 6, 7, 7.2, 8, 9, 10, 12, 14.4, 15, 20 mm Slice thickness in spiral: 0.4*, 0.5*(*optional with z-UHR), 0.6, 0.75, 1.0, 1.5, 2, 3, 4, 5, 6, 7, 8, 10 mm Real-time image display. Immediate image reconstruction and display without time delay simultaneously to data acquisition in 512 x 512 matrix size. Spiral: Scanning technique for continuous volume scans with continuous table feed in multirotation mode. Max.

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Part No. / Product	Description
(Continued) **10248473** **Biograph mCT-S(40)**	scan time 120 seconds with full low-contrast resolution. Volume length 1940 mm with full low-contrast resolution. Selection of the pitch factor between 0.3 and 1.5 depending on scan mode. Selection of up to 33 separately parameterizable examination ranges in a patient protocol. In addition individual anatomic sections can be successively combined and then scanned automatically. Storage of up to 10,000 examination protocols. Rotation times/cycle: 0.33 sec, 0.5 sec and 1 sec. Dynamic: Program for functional dynamic examinations. Serial scanning technique in one slice position with variable scan cycle times. Serio sequential examination without table feed: Up to 100 scans in uninterrupted, continuous sequence without table feed. Scan cycle time: 0.75 - 60 seconds. Multiscan spiral examination without table feed: Continuous multirotational data acquisition in one slice position. Quantitative evaluation and graphical display of time-density curves. WorkStream4D with Asynchronous Recon: 4D workflow with direct generation of axial, sagittal, coronal, or double-oblique images from standard scanning protocols. Elimination of manual reconstruction steps. Asynchronous Recon allows for multiple image reconstructions and reformats, parallel to scanning. With this feature, up to eight reconstruction job requests can be loaded into a scan protocol. Immediately upon completion of the scan acquisition, these reconstruction jobs are automatically executed in the background without delaying the start of next patient examination. Image reconstruction and storage: Image reconstruction in full resolution (512 x 512 matrix) takes place during the examination with up to 40 images per second, with full cone beam reconstruction, z-Sharp Technology and full image quality. Reconstruction fields of 5 cm to 50 cm through raw data zoom with the possibility of freely selecting the image center either prospectively before each scan or retrospectively. Reconstructions of different slice thicknesses from a single raw data record, e.g. lung soft tissue and lung high-contrast with CombiScan, with simultaneous suppression of partial volume artifacts. Up to 8 reconstructions per scan range can be predefined with the examination protocol. Patient-related storage of the image and raw data. Image display: 1024 x 1024 display matrix; screen splitting configurable up to 64 image segments; CT value scale from -1024 to +3071 HU. For very dense objects, the CT value scale can be extended from -10240 to +30710 HU (extended CT scale) e.g. for suppressing metal artifacts. Image evaluation: Complete software-controlled image evaluation program for all diagnostic requirements. CINE Display: Dynamic display technique for the visualization of time or volume series. A series of up to 1024 images can be displayed at a frame rate of at least 30 f/s. Automatic or interactive mouse-operated control. Multitasking functions: Simultaneous processing during operation of the scanner. Real-time Display: Image reconstruction in pace with the examination in full image quality (512 x 512 matrix) with up to 40 images/second (with full cone beam reconstruction and z-Sharp Technology). Metro Display: Simultaneous display, processing and evaluation of images from other patients while the current patient is being scanned. Metro Documentation: Simultaneous documentation of images from any previously examined patient while the current patient is being scanned. Metro Copy: Automatic transfer of image data to the syngo CT Workplace (optional) or a DICOM network node. Networking and Documentation For the connection to a local Ethernet (10, 100 Mbit or 1-Gigabit) in order to communicate with networked printers, diagnostic and therapy workstations, RIS or HIS systems and teleradiology routers. Scope of functions: - Configurable network stations. - Unlimited selection of stations. - DICOM Standard (Digital Imaging and Communications in Medicine) for the transfer of information between DICOM-compatible units from different manufacturers. The scope of functions is described in detail in the DICOM Conformance Statement, and the standard version comprises the functions Send/Receive, Query/Retrieve and BasicPrint, Worklist, Storage Commitment, MPPS (Modality Performed Procedure Step). System Documentation (1 set)

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Part No. / Product	Description
(Continued) **10248473** **Biograph mCT-S(40)**	Siemens Remote Service: Siemens Remote Service (SRS) offers a wide range of medical equipment-related remote services resulting in increased system availability and efficiency. SRS employs sophisticated authentication and authorization procedures, state-of-the-art encryption technologies and logging routines together with strictly enforced organizational measures that provide optimal patient data security and access protection. The following SRS services are included for all service agreement customers and during warranty period: Remote Diagnosis & Repair: In case of an unforeseen system malfunction, Siemens competent experts may directly connect with the CT system in order to identify the problem quickly. Moreover the remote repair function enables Siemens to often correct software errors immediately. Should an engineer on site be required, Remote Diagnosis & Repair allows Siemens to identify defective parts efficiently and accelerate their delivery, thereby keeping repair times to a minimum. Event Monitoring: Event Monitoring screens the performance of the system. If a parameter deviates from a predefined value, a status message is automatically sent to the Siemens UPTIME Service Center. Service Engineers may evaluate the status message at periodic intervals and may initiate appropriate action within the scope of the service agreement.
10249462 **TrueV PET - mCT**	The Biograph TrueV option provides additional PET axial coverage (21.6 cm/109 image planes) providing improved system sensitivity and count rate performance for enhanced patient throughput and/or improved image quality. The extended axial field-of-view reduces the number of bed positions needed for whole body imaging relative to the standard coverage mCT systems, while providing greater coverage for single bed static and listmode (gated or dynamic) acquisitions.
10249560 **Biograph Ge-68 Sources**	Sources consist of the following: 2 LS-ART Set-up rod sources (Max. 46.25 MBq per rod source) 1 CS-27 Low Activity Uniform Phantom (Max. 92.5 MBq) Disposal of sources is not included in sale price.
10249566 **HD-PET # mCT (AWP)**	HD•PET Package provides unprecedented PET image quality with clearer, more defined PET images from edge-to-edge of the field of view. The world's only clinical PET technology with near uniform resolution throughout the entire field of view, HD·PET is the first to deliver razor sharp, distortion-free image quality from edge to edge. Allowing you to precisely visualize lesions with exceptional contrast and clarity. HD•PET Package contains TrueX, an innovative image processing technique, as well as HI-REZ, and 3D iterative reconstruction. TrueX is an innovative image processing technology that is the final key to achieving HD•PET performance levels. Conventional PET technology ultimately causes loss of resolution and contrast in the final image, especially farther from the center of the field of view. TrueX technology utilizes millions of accurately measured point spread functions in the iterative reconstruction of the image, and produce High Definition PET images with improved uniformity, high resolution, and enhanced contrast. HI-REZ provides optimized image processing for maximum reconstructed image resolution for the most demanding clinical and research applications. Provides 81 (109) image planes across the 162 (216) mm axial field-of-view (2.0 mm slice spacing). Supported reconstruction matrix; 128 x 128, 200 x 200, 256 x 256, 400 x 400, 512 x 512. Maximum reconstructed image resolution is 4.4 mm FWHM at center. 3D Iterative reconstruction (OSEM) provides improved image quality in the most demanding low statistics acquisitions.
14415389 **CT IRIS #AWP**	Dose reduction with CT has been limited by the currently used filtered back projection (FBP) reconstruction algorithm. When using this conventional reconstruction of acquired raw data into image data, a trade-off between spatial resolution and image noise has to be considered. Higher spatial resolution increases the ability to see the smallest detail; however, it is directly correlated with increased image noise in standard filtered back projection reconstructions as they are used in CT scanners today. Iterative reconstruction approaches allow decoupling of spatial resolution and image noise. In an Iterative Reconstruction in Image Space (IRIS), a correction loop is introduced into the image generation process. To avoid long reconstruction times the new Iterative Reconstruction in Image Space first applies a raw data reconstruction

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Part No. / Product	Description
(Continued) 14415389 CT IRIS #AWP	only once. During this initial raw data reconstruction, a so-called and newly developed master image is generated that contains the full amount of raw data information, but at the expense of significant image noise. During the following iterative corrections the image noise is removed without degrading image sharpness. In addition, the noise texture of the images is comparable to standard well-established convolution kernels. The new technique results in noise reduction, increased image sharpness, or dose savings of up to 60 % for a wide range of clinical applications.
MI_PET_PM MI PET Project Management	A Siemens Project Manager (PM) will be the single point of contact for the implementation of your Siemen's equipment. The assigned PM will work with the customer's facilities management, architect or building contractor to assist you in ensuring that your site is ready for installation. Your PM will provide initial and final drawings and will coordinate the scheduling of the equipment, installation, and rigging, as well as the initiation of on-site clinical education.
MI_PET_INITIAL_32 Initial onsite training 32 hrs	Up to (32) hours of on-site clinical education training, scheduled consecutively (Monday – Friday) during standard business hours for a maximum of (4) imaging professionals. Training will cover agenda items on the ASRT approved checklist. Uptime Clinical Education phone support is provided during the warranty period for specified posted hours. **This educational offering must be completed (12) months from install end date. If training is not completed within the applicable time period, Siemens obligation to provide the training will expire without refund.**
MI_PET_FLWUP_32 Follow-up training 32 hrs	Up to (32) hours of follow-up on-site clinical education training, scheduled consecutively (Monday – Friday) during standard business hours for a maximum of (4) imaging professionals. Uptime Clinical Education phone support is provided during the warranty period for specified posted hours. **This educational offering must be completed (12) months from install end date. If training is not completed within the applicable time period, Siemens obligation to provide the training will expire without refund.**
MI_PET_BCLS Basic Biograph Class	Tuition for (1) imaging professional to attend a Siemens Classroom Course at Siemens Training Center. The objectives of this class are to introduce the user interface of the common *syngo* platform and instructions on building protocols, demonstration of software functions, and hands-on sessions. This class includes lunch, economy airfare, and lodging for (1) imaging professional. All arrangements must be arranged through Siemens designated travel agency. **This educational offering must be completed (12) months from install end date. If training is not completed within the applicable time period, Siemens obligation to provide the training will expire without refund.**
MI_PET_CTCRSTR CT Cross Trainer	CT Cross Trainer printed self study materials for (1) imaging professional. These materials will provide the user with basic CT knowledge by testing the participant periodically. Successful completion of the self study program will provide the participant with CE credits. CT Cross Trainer printed self study materials for (1) imaging professional. These materials will provide the user with basic CT knowledge by testing the participant periodically. Successful completion of the self study program will provide the participant with CE credits. This educational offering must be completed (12) months from install end date. If training is not completed within the applicable time period, Siemens obligation to provide the training will expire without refund.
MI_PET_ADD_16 Additional onsite training 16 hours	Up to (16) hours of on-site clinical education training, scheduled consecutively (Monday – Friday) during standard business hours for a maximum of (4) imaging professionals. Training will cover agenda items on the ASRT approved checklist if applicable. **This educational offering must be completed (12) months from install end date. If training is not completed within the applicable time period, Siemens obligation to provide the training will expire without refund.**
MI_PET_ADD_CLS Additional Training Class	Tuition for (1) attendee for a customer classroom course of choice at one of the Siemens training centers. Includes economy airfare and lodging for (1) attendee. All arrangements must be arranged through Siemens designated travel agency. This educational offering must be completed (12) months from install end date. If training is not completed within the applicable time period, Siemens obligation to provide the training will expire without refund.
M2SCT211PET Stellant D PET/CT Injector (stand) (Optional)	Stellant D Dual Head Injector – pedestal mounted. The Stellant D PET/CT Injector is a dual syringe injection system that enables clinicians to perform the most critical CT contrast exams, including cardiac CT and coronary CTA. - Real-time display of injection pressure in graph form. - Snap-on / twist-off syringe design.

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Part No. / Product	Description
(Continued) **M2SCT211PET** **Stellant D PET/CT Injector (stand) (Optional)**	- Automatic plunger advance and retract when attaching and detaching syringes. - Automatic filling and priming with the touch of a button. - Stores and recalls up to 32 protocols. - Multi-phase programming (and patented Hold/Pause feature) - Programmable pressure limit Installation, applications and one year warranty provided by Medrad. This product has been tested and verified for compatibility with the following Siemens' products: Biograph and mCT. Compatibility with other products cannot be guaranteed and used w/any other products may void service contracts and/or system warranties. Additional Options Available: M2SCTXDS700P - MEDRAD XDS™ extravasation detector – Pedestal M2SCTUFKP3TC - MEDRAD P3T Cardiac

Attachment O

Financial Attachments I & II

Lawrence & Memorial Hospital

11. C (i). Please provide one year of actual results and three years of projections of **Total Facility** revenue, expense and volume statistics without, incremental to and with the CON proposal in the following reporting format:

Total Facility: Description	FY 2010 Actual Results	FY 2011 Projected W/out CON	FY 2011 Projected Incremental	FY 2011 Projected With CON	FY 2012 Projected W/out CON	FY 2012 Projected Incremental	FY 2012 Projected With CON	FY 2013 Projected W/out CON	FY 2013 Projected Incremental	FY 2013 Projected With CON
NET PATIENT REVENUE										
Non-Government	$165,372,627	$165,372,627	$0	$165,372,627	$165,372,627	$54,780	$165,427,407	$165,372,627	$210,888	$165,583,515
Medicare	$97,994,557	$97,994,557	$0	$97,994,557	$97,994,557	$35,400	$98,029,957	$97,994,557	$108,174	$98,102,731
Medicaid and Other Medical Assistance	$30,160,421	$30,160,421	$0	$30,160,421	$30,160,421	$4,205	$30,164,626	$30,160,421	$9,425	$30,169,846
Other Government	$13,035,372	$13,035,372	$0	$13,035,372	$13,035,372	$11,515	$13,046,887	$13,035,372	$34,633	$13,070,005
Total Net Patient Patient Revenue	$306,562,977	$306,562,977	$0	$306,562,977	$306,562,977	$105,900	$306,668,877	$306,562,977	$363,120	$306,926,097
Other Operating Revenue	$14,292,897	$14,292,897		$14,292,897	$14,292,897		$14,292,897	$14,292,897		$14,292,897
Revenue from Operations	$320,855,874	$320,855,874	$0	$320,855,874	$320,855,874	$105,900	$320,961,774	$320,855,874	$363,120	$321,218,994
OPERATING EXPENSES										
Salaries and Fringe Benefits	$174,502,282	$174,502,282		$174,502,282	$174,502,282	$70,538	$174,572,820	$174,502,282	$141,075	$174,643,357
Professional / Contracted Services	$20,028,640	$20,028,640		$20,028,640	$20,028,640	($269,137)	$19,759,503	$20,028,640	($352,709)	$19,675,931
Supplies and Drugs	$33,399,993	$33,399,993	$0	$33,399,993	$33,399,993	$2,894	$33,402,887	$33,399,993	$46,043	$33,446,036
Bad Debts	$14,381,176	$14,381,176		$14,381,176	$14,381,176		$14,381,176	$14,381,176		$14,381,176
Other Operating Expense	$35,065,186	$35,065,186	$0	$35,065,186	$35,065,186	$0	$35,065,186	$35,065,186	$0	$35,065,186
Subtotal	$277,377,277	$277,377,277	$0	$277,377,277	$277,377,277	($195,705)	$277,181,572	$277,377,277	($165,591)	$277,211,686
Depreciation/Amortization	$16,728,407	$16,728,407		$16,728,407	$16,728,407	$282,592	$17,010,999	$16,728,407	$565,183	$17,293,590
Interest Expense	$2,332,245	$2,332,245		$2,332,245	$2,332,245	($88,721)	$2,243,524	$2,332,245	($177,442)	$2,154,803
Lease Expense	$2,798,067	$2,798,067		$2,798,067	$2,798,067		$2,798,067	$2,798,067		$2,798,067
Total Operating Expense	$299,235,996	$299,235,996	$0	$299,235,996	$299,235,996	($1,834)	$299,234,162	$299,235,996	$222,150	$299,458,146
Gain/(Loss) from Operations	$21,619,878	$21,619,878	$0	$21,619,878	$21,619,878	$107,734	$21,727,612	$21,619,878	$140,970	$21,760,848
Plus: Non-Operating Revenue				$0			$0			$0
Revenue Over/(Under) Expense	$21,619,878	$21,619,878	$0	$21,619,878	$21,619,878	$107,734	$21,727,612	$21,619,878	$140,970	$21,760,848
FTEs	1892.85	1892.85	0	1892.85	1892.85	0.6	1893.45	1892.85	1.2	1894.05
*Volume Statistics:	30,700	30,700	0	30,700	30,700	177	30,877	30,700	423	31,123

Provide projected inpatient and/or outpatient statistics for any new services and provide actual and projected inpatient and/or outpatient statistics for any existing services which will change due to the proposal.

11. C (i). Please provide one y
without, incremental

Total Facility:	FY 2014 Projected	FY 2014 Projected	FY 2014 Projected	FY 2015 Projected	FY 2015 Projected	FY 2015 Projected
Description	W/out CON	Incremental	With CON	W/out CON	Incremental	With CON
NET PATIENT REVENUE						
Non-Government	$165,372,627	$312,126	$165,684,753	$165,372,627	$340,474	$165,713,101
Medicare	$97,994,557	$145,688	$98,140,245	$97,994,557	$156,998	$98,151,555
Medicaid and Other Medical Assistance	$30,160,421	$10,585	$30,171,006	$30,160,421	$11,020	$30,171,441
Other Government	$13,035,372	$44,219	$13,079,591	$13,035,372	$47,056	$13,082,428
Total Net Patient Patient Revenue	$306,562,977	$512,618	$307,075,595	$306,562,977	$555,548	$307,118,525
Other Operating Revenue	$14,292,897		$14,292,897	$14,292,897		$14,292,897
Revenue from Operations	$320,855,874	$512,618	$321,368,492	$320,855,874	$555,548	$321,411,422
OPERATING EXPENSES						
Salaries and Fringe Benefits	$174,502,282	$141,075	$174,643,357	$174,502,282	$141,075	$174,643,357
Professional / Contracted Services	$20,028,640	($352,709)	$19,675,931	$20,028,640	($352,709)	$19,675,931
Supplies and Drugs	$33,399,993	$52,205	$33,452,198	$33,399,993	$54,383	$33,454,376
Bad Debts	$14,381,176		$14,381,176	$14,381,176		$14,381,176
Other Operating Expense	$35,065,186	$0	$35,065,186	$35,065,186	$0	$35,065,186
Subtotal	$277,377,277	($159,429)	$277,217,848	$277,377,277	($157,251)	$277,220,026
Depreciation/Amortization	$16,728,407	$565,183	$17,293,590	$16,728,407	$565,183	$17,293,590
Interest Expense	$2,332,245	($177,442)	$2,154,803	$2,332,245	($177,442)	$2,154,803
Lease Expense	$2,798,067		$2,798,067	$2,798,067		$2,798,067
Total Operating Expense	$299,235,996	$228,312	$299,464,308	$299,235,996	$230,490	$299,466,486
Gain/(Loss) from Operations	$21,619,878	$284,306	$21,904,184	$21,619,878	$325,058	$21,944,936
Plus: Non-Operating Revenue			$0			$0
Revenue Over/(Under) Expense	$21,619,878	$284,306	$21,904,184	$21,619,878	$325,058	$21,944,936
FTEs	1892.85	1.2	1894.05	1892.85	1.2	1894.05
*Volume Statistics: Provide projected inpatient and/or outpa	30,700	493	31,193	30,700	519	31,219

	Lawrence & Memorial Hospital									
Please provide **three** years of projections of incremental revenue, expense and volume statistics **attributable to the proposal** in the following reporting format:										
Type of Service Description	CT/PET									
Type of Unit Description:	Scans									
# of Months in Operation	6									
FY 2012	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
FY Projected Incremental	**177**	Rate	Units	Gross	Allowances/	Charity	Bad	Net	Operating	Gain/(Loss)
Total Incremental Expenses:	**($1,834)**			Revenue	Deductions	Care	Debt	Revenue	Expenses	from Operations
				Col. 2 * Col. 3				Col.4 - Col.5	Col. 1 Total *	Col. 8 - Col. 9
Total Facility by								-Col.6 - Col.7	Col. 4 / Col. 4 Total	
Payer Category:										
Medicare		$1,747	59	$103,073	$67,673			$35,400	($611)	$36,011
Medicaid		$1,747	29	$50,663	$46,458			$4,205	($300)	$4,505
CHAMPUS/TriCare		$1,747	12	$20,964	$9,449			$11,515	($124)	$11,639
Total Governmental			100	$174,700	$123,580	$0	$0	$51,120	($1,036)	$52,156
Commericial Insurers		$1,747	71	$124,037	$69,257		$0	$54,780	($736)	$55,516
Uninsured		$1,747	6	$10,482		$10,482		$0	($62)	$62
Total NonGovernment		$1,747	77	$134,519	$69,257	$10,482	$0	$54,780	($798)	$55,578
Total All Payers		$1,747	177	$309,219	$192,837	$10,482	$0	$105,900	($1,834)	$107,734

	Lawrence & Memorial Hospital									
Please provide **three** years of projections of incremental revenue, expense and volume statistics **attributable to the proposal** in the following reporting format:										
Type of Service Description	CT/PET									
Type of Unit Description:	Scans									
# of Months in Operation	12									
FY 2013_____	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
FY Projected Incremental	**423**	Rate	Units	Gross	Allowances/	Charity	Bad	Net	Operating	Gain/(Loss)
Total Incremental Expenses:	**$222,150**			Revenue	Deductions	Care	Debt	Revenue	Expenses	from Operations
				Col. 2 * Col. 3				Col.4 - Col.5	Col. 1 Total *	Col. 8 - Col. 9
Total Facility by								-Col.6 - Col.7	Col. 4 / Col. 4 Total	
Payer Category:										
Medicare		$2,425	149	$361,325	$253,151			$108,174	$78,251	$29,923
Medicaid		$2,425	65	$157,625	$148,200			$9,425	$34,137	($24,712)
CHAMPUS/TriCare		$2,425	26	$63,050	$28,417			$34,633	$13,655	$20,979
Total Governmental			240	$582,000	$429,768	$0	$0	$152,232	$126,043	$26,190
Commericial Insurers		$2,425	171	$414,675	$203,787		$0	$210,888	$89,805	$121,082
Uninsured		$2,425	12	$29,100		$29,100		$0	$6,302	($6,302)
Total NonGovernment		$2,425	183	$443,775	$203,787	$29,100	$0	$210,888	$96,107	$114,780
Total All Payers		$2,425	423	$1,025,775	$633,555	$29,100	$0	$363,120	$222,150	$140,970

	Lawrence & Memorial Hospital									
Please provide **three** years of projections of incremental revenue, expense and volume statistics **attributable to the proposal** in the following reporting format:										
Type of Service Description	CT/PET									
Type of Unit Description:	Scans									
# of Months in Operation	12									
FY 2014_____	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
FY Projected Incremental	**493**	Rate	Units	Gross	Allowances/	Charity	Bad	Net	Operating	Gain/(Loss)
Total Incremental Expenses:	**$228,312**			Revenue	Deductions	Care	Debt	Revenue	Expenses	from Operations
				Col. 2 * Col. 3				Col.4 - Col.5	Col. 1 Total *	Col. 8 - Col. 9
Total Facility by								-Col.6 - Col.7	Col. 4 / Col. 4 Total	
Payer Category:										
Medicare		$2,875	180	$517,500	$371,812			$145,688	$83,359	$62,329
Medicaid		$2,875	73	$209,875	$199,290			$10,585	$33,807	($23,222)
CHAMPUS/TriCare		$2,875	28	$80,500	$36,281			$44,219	$12,967	$31,252
Total Governmental			281	$807,875	$607,383	$0	$0	$200,492	$130,133	$70,359
Commericial Insurers		$2,875	199	$572,125	$259,999		$0	$312,126	$92,158	$219,967
Uninsured		$2,875	13	$37,375		$37,375		$0	$6,020	($6,020)
Total NonGovernment		$2,875	212	$609,500	$259,999	$37,375	$0	$312,126	$98,179	$213,947
Total All Payers		$2,875	493	$1,417,375	$867,382	$37,375	$0	$512,618	$228,312	$284,306

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Lawrence & Memorial Hospital

Please provide **three** years of projections of incremental revenue, expense and volume statistics **attributable to the proposal** in the following reporting format:

Type of Service Description	CT/PET									
Type of Unit Description:	Scans									
# of Months in Operation	12									
FY 2015	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
FY Projected Incremental	**519**	Rate	Units	Gross	Allowances/	Charity	Bad	Net	Operating	Gain/(Loss)
Total Incremental Expenses:	**$230,490**			Revenue	Deductions	Care	Debt	Revenue	Expenses	from Operations
				Col. 2 * Col. 3				Col.4 - Col.5	Col. 1 Total *	Col. 8 - Col. 9
Total Facility by								-Col.6 - Col.7	Col. 4 / Col. 4 Total	
Payer Category:										
Medicare		$2,954	191	$564,214	$407,216			$156,998	$84,824	$72,174
Medicaid		$2,954	76	$224,504	$213,484			$11,020	$33,752	($22,732)
CHAMPUS/TriCare		$2,954	29	$85,666	$38,610			$47,056	$12,879	$34,177
Total Governmental			296	$874,384	$659,309	$0	$0	$215,075	$131,455	$83,620
Commericial Insurers		$2,954	209	$617,386	$276,912		$0	$340,474	$92,818	$247,656
Uninsured		$2,954	14	$41,356		$41,356		$0	$6,217	($6,217)
Total NonGovernment		$2,954	223	$658,742	$276,912	$41,356	$0	$340,474	$99,035	$241,438
Total All Payers		$2,954	519	$1,533,126	$936,222	$41,356	$0	$555,548	$230,490	$325,058

Attachment P

Assumptions for Financial Attachments I & II

Lawrence & Memorial Hospital
Project: CT/PET
Forecasted Profit and Loss Statement
Assumptions

	1st YEAR	1st YEAR Prorated	2nd YEAR	3rd YEAR	4TH YEAR
	2012	**2012**	**2013**	**2014**	**2015**
VOLUME					
Scans CT	**353**	**177**	**363**	**374**	**385**
Scans PET	-	-	**60**	**119**	**134**
Total	**353**	**177**	**423**	**493**	**519**
REVENUES					
CT	$211,800	$105,900	$217,800	$224,400	$231,000
PET	$0	$0	$145,320	$288,218	$324,548
Net Revenues	$211,800	$105,900	$363,120	$512,618	$555,548
OPERATING EXPENSES					
Direct Expenses					
Salaries & Wages	111,083	55,542	111,083	111,083	111,083
Nonsalary	(709,927)	(354,964)	(484,109)	(477,947)	(475,769)
Total Direct Expenses	(598,844)	(299,422)	(373,025)	(366,864)	(364,686)
Depreciation	282,592	282,592	565,183	565,183	565,183
Indirect Expenses					
Fringe Benefits	29,992	14,996	29,992	29,992	29,992
Other indirect	-	-	-	-	-
Total Indirect Expense	29,992	14,996	29,992	29,992	29,992
Total Operating Expenses	(286,260)	(1,834)	222,150	228,312	230,490
OPERATING INCOME(LOSS)	498,060	107,734	140,970	284,306	325,058
CUMULATIVE INCOME(LOSS)	498,060	107,734	248,704	533,011	858,069

	Rate Per Procedure
	$600.00
	$2,422.00

27.00% percent of total salaries Historical Average

0.00% percent of total expenses Historical Average

Breakeven per year

	2012	2013	2014	2015
PET-CT	(3)	259	220	215

	1st YEAR	1st YEAR Prorated	2nd YEAR	3rd YEAR	4TH YEAR		Rate Per						relief	
Salary Detail:								FTE's	FTE's	FTE's	FTE's	FTE's		W/Diff.
MRI/CT Technician	111,083	55,542	111,083	111,083	111,083	80,495	per FTE	1.2	1.2	1.2	1.2	1.2	Y*	
Clerical	0	0	0	0	0	41,600	per FTE	0.00	0.00	0.00	0.00	0.00	Y*	
								1.2	1.2	1.2	1.2	1.2		
							Includes	15.00%	15.00%	15.00%	15.00%	15.00%	relief	
	111,083	55,542	111,083	111,083	111,083									
Non Salary Detail:														
Contrast Costs CT	2,909	1,454	2,991	3,082	3,172	8.24	per scan							
Contrast Costs PET	0	0	0	5,500	7,375	125.00	per scan							
Contrast Costs Cardiac			39,600	39,600	39,600	3,300.00	per month							
Med./Surg.Supplies	2,880	1,440	3,452	4,023	4,235	8.16	per scan							
Lease	(177,442)	(88,721)	(177,442)	(177,442)	(177,442)		Operating Lease of older scanner							
Purchased outside service	(538,274)	(269,137)	(538,274)	(538,274)	(538,274)		Purchased service of mobile Pet Scanner							
Maintence Contract	0	0	185,565	185,565	185,565									
* Denotes Start\Up Costs														
	(709,927)	(354,964)	(484,109)	(477,947)	(475,769)									
Depreciation:							Years of Service							
Building renovations	20,000	20,000	40,000	40,000	40,000	600,000	15							
Movable Equipment	262,592	262,592	525,183	525,183	525,183	2,625,915	5							
Total	282,592	282,592	565,183	565,183	565,183	3,225,915								

Lawrence & Memorial Hospital
Project: PET/CT
Forecasted Profit and Loss Statement
Depreciation Schedule

	1st YEAR	2nd YEAR	3rd YEAR	Purchase								
	2012	2013	2014	Price								
Depreciation:					Years of Service							
Building renovations	20,000	40,000	40,000	600,000	15							
Movable Equipment	262,592	525,183	525,183	2,625,915	5							
Total	282,592	565,183	565,183	3,225,915								

Attachment Q

Rate Schedule

Lawrence & Memorial Hospital

CHARGE MASTER DETAIL BY DEPARTMENT - PET/CT

01.6630 LMH NUCLEAR MED As of

Mnemonic	Description	CHG
1403014	PET FOLLOW CORONARY ANGIO SING	$2,476.00
1403016	PET FOLLOW CORONARY ANGIO MULT	$2,476.00
1403018	PET FOLLOW MYOCARD PERF SINGLE	$2,476.00
1403020	PET FOLLOW MYOCARDIA PERF MULT	$2,476.00
1403022	PET FOLLOW STRESS ECHO SINGLE	$2,476.00
1403024	PET FOLLOW STRESS ECHO MULTIPL	$2,476.00
1403026	PET FOLLOW VENTRICULOGRAM SING	$2,476.00
1403028	PET FOLLOW VENTRICULOGRAM MULT	$2,476.00
1403030	PET FOLLOW REST ECG SINGLE	$2,476.00
1403032	PET FOLLOW REST ECG MULTIPLE	$2,476.00
1403034	PET FOLLOW STREE ECG SINGLE	$2,476.00
1403036	PET FOLLOW STRESS ECG MULTIPLE	$2,476.00
1403038	PET IMAGE PULMONARY NODULE	$5,288.00
1403040	PET WHOLE BODY LUNG	$5,288.00
1403042	PET INITIAL LUNG	$5,288.00

Mnemonic	Description	CHG
1403044	PET RESTAGING LUNG	$5,288.00
1403046	PET WHOLE BODY COLORECTAL	$5,288.00
1403048	PET INITIAL COLORECTAL	$5,288.00
1403050	PET RESTAGING	$5,288.00
1403052	PET WHOLE BODY MELANOMA	$5,318.00
1403054	PET INITIAL WHOLEBODY MELANOMA	$5,318.00
1403056	PET RESTAGING WB MELANOMA	$5,318.00
1403058	PET WHOLE BODY LYMPHOMA	$5,288.00
1403060	PET INITIAL LYMPHOMA	$5,288.00
1403062	PET RESTAGING LYMPHOMA	$5,288.00
1403064	PET RESTAGING DEX HEAD	$5,288.00
1403066	PET RESTAGING INITIAL HEAD	$5,288.00
1403068	PET RESTAGING HEAD/NECK	$5,288.00
1403070	PET WHOLE BODY ESOPHAGEAL	$5,288.00
1403072	PET IMG INIT ESOPHAGUS	$5,288.00

CHARGE MASTER DETAIL BY DEPARTMENT-CT

01.6640 LMH C.T. SCANNER

Mnemonic	Description	CHG
3601002	CT HEAD W/O CONTRAST	$1,043.00
3601004	CT HEAD WO/W CONTRAST	$1,447.00
3601006	CT HEAD W/CONT	$1,300.00
3601010	CT ORB SEL P FOSSA N-CON	$1,314.00
3601010A	3D CT ORB SEL P FOS N-CONT (P)	$0.00
3601012	CT ORB SEL P FOSSA W/CONTRAST	$1,470.00
3601012A	3D CT ORB SEL P FOS W/CON (P)	$0.00
3601014	CT ORB SEL P FOSA WO/W CONT	$1,735.00
3601014A	3D CT ORB SEL P FOS WO/W C (P)	$0.00
3601016	CT SOFT TISSUE NECK WO CONT	$946.00
3601018	CT SOFT TISSUE NECK W/CONT	$1,162.00
3601020	CT SOFT TIS NECK WO/W CONT	$1,279.00
3601025	CT MAX FACIAL W/O CONTRAST	$1,268.00
3601025A	3D CT MAX FACIAL W/O CONT (P)	$0.00
3601026	CT MAX FACIAL	$1,544.00
3601026A	3D CT MAX FACIAL W/CONT (P)	$0.00
3601027	CT MAX FACIAL WO/W CONTRAST	$1,688.00
3601027A	3D CT MAX FACIAL WO/W CONT (P)	$0.00
3601028	CT FACIAL IMAG W/O CONT NO CHG	$0.00
3701005	CT FINE NEEDLE BIOPSY	$367.00
3701006	CT GUIDED STEROTACTIC LOCAL	$576.00
3701007	CT GUIDANCE TISSUE ABLATION	$533.00
3701022	CT PELVIS W/O CONTRAST	$1,567.00
3701024	CT PELVIS W/CONTRAST	$1,425.00
3701026	CT PELVIS WO/W CONTRAST	$1,740.00
3701028	CT CERV SPINE W/O CONTRAST	$1,385.00
3701029	CT CERV SPINE	$1,636.00
3701030	CT THORACIC SPINE W/O CONTRAST	$1,266.00
3701031	CT THORACIC SPINE W/CONTRAST	$1,617.00
3701032	CT LUMBAR SPINE W/O CONTRAST	$1,554.00
3701032A	3D CT LUMB SPINE W/O CONT (P)	$0.00
3701033	CT LUMBAR SPINE W/CONTRAST	$1,673.00

Mnemonic	Description	CHG
3701033A	3D CT LUMBAR SPINE W/CONT (P)	$0.00
3701034	CT UPPER EXT W/O CONTRAST	$1,320.00
3701036	CT UPPER EXT W/CONTRAST	$1,411.00
3701038	CT UPPER EXT WO/W CONTRAST	$1,576.00
3701040	CT LOWER EXT W/O CONTRAST	$997.00
3701042	CT LOWER EXT	$1,140.00
3701044	CT LOWER EXT WO/W CONTRAST	$1,602.00
3701046	CT ABD W/O CONTRAST	$1,366.00
3701048	CT ABD W/CONTRAST	$1,398.00
3701050	CT ABD WO/W CONTRAST	$1,540.00
3701052	CT CHEST W/O CONTRAST	$1,174.00
3701054	CT CHEST W/CONTRAST	$1,419.00
3701055	CT CHEST W/CONTRAST PE	$1,500.00
3701055A	3D CHEST W/CONTRAST PE (P)	$0.00
3701056	CT CHEST WO/W CONTRAST	$1,421.00
3701058	CT ANGIO HEAD WO/W CONTRAST	$1,262.00
3701060	CT ANGIO NECK WO/W CONTRAST	$1,369.00
3701062	CT ANGIO CHEST WO/W CONTRAST	$1,294.00
3701064	CT ANGIO PELVIS WO/W CONTRAST	$1,186.00
3701066	CT ANGIO UP EXT WO/W CONTRAST	$1,090.00
3701068	CT ANGIO LOW EXT WO/W CONTRAST	$817.00
3701070	CT ANGIO ABD WO/W CONTRAST	$1,316.00
3701072	CT ANGIO ABD AORTA WO/W CONT	$1,355.00
3701080	CS SAME MD>= 5 YRS 1ST 30 MIN	$289.00
3701080A	CONSCIOUS SEDATION ADDT'L 15	$38.00
3701082	RADIOL GUIDANCE	$1,523.00
3701084	RADIO GUIDANCE SAC JT	$454.00
3701085A	CT CHEST/ABD/PELV W/O CONT (P)	$0.00
3701086	CT GUIDANCE PLACEMT RAD THERAP	$397.00
3701087B	CT CHEST/ABD/PEL W/CONT (P)	$0.00
3701087C	CT 3D CHEST/ABD/PELV W/CON (P)	$0.00
3701088	CHEST/ABD W/O CONTRAST (P)	$0.00
3701089	CHEST/ABD W/ CONTRAST (P)	$0.00
3701089A	3D CHEST/ABD W/CONT (P)	$0.00
3701091B	CT ABD/PELV WO & W/CONT	$3,280.00
3701091C	CT 3D ABD/PELV WO/W CONT (P)	$0.00

Mnemonic	Description	CHG
3701092B	CT ABD/PELV W/O CONTRAST	$2,933.00
3701093B	CT ABD/PELV W/CONTRAST	$2,823.00
3701093C	CT 3D ABD/PELVIS W/CONT (P)	$0.00
3701094	CHEST W/ & ABD W/O&W/CONT (P)	$0.00
3701095	CHEST W/O & ABDOMEN W/CONT (P)	$0.00
3701096A	CT CHEST W/ABD W/WO& PEL W (P)	$0.00
3701097	CT HEART W/O CONT IM+QT EV CC	$413.00
3701098	CT HEART W/CON CARD STRU+MORPH	$1,322.00
3701099	CTA HRT W/CON W/O QT EVAL CC	$1,322.00
3701100	CTA HRT W/CON W/QT EVAL OF CC	$1,322.00
3701101	CTA HRT W/CONT BYPS GFT W/O CC	$1,594.00
3701102	CTA HRT W/CONT BYPS GFT W/CC	$1,594.00
3701103	CT HEART W/CON CAR STR MOR CHD	$1,328.00
3701104	CT HEART W/CON FUNCT EVAL	$1,328.00
3701105	3-D POSTPROC NOT REQ IND WRKST	$509.00
3701106	3-D POSTPROC REQ IND WRKST	$520.00
3701107	NO CHARGE CT SCAN (STAT)	$0.00
3701108A	CT RENAL ABLATION (P)	$0.00
3701109	CTA HEAD/NECK W/WO CONT (P)	$0.00
3701110	CT BONE MIN DENS HIP PELV SPIN	$344.00
3701111	CT BONE MIN DENS RAD HEEL WRIS	$320.00
3702109	ABLATION BONE TUMOR INCL CT	$4,231.00

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