



The CT Image Library of the Lung Screening Study (LSS) of the National Lung Screening Trial (NLST)

KW Clark¹, DS Gierada¹, G. Marquez², SM Moore¹, DR Maffitt¹, JD Moulton¹, MA Wolfsberger¹, P Koppel¹, SR Phillips¹, FW Prior¹

¹ Dept. of Radiology, Washington University; in Saint Louis ² Early Detection Research Group, National Cancer Institute

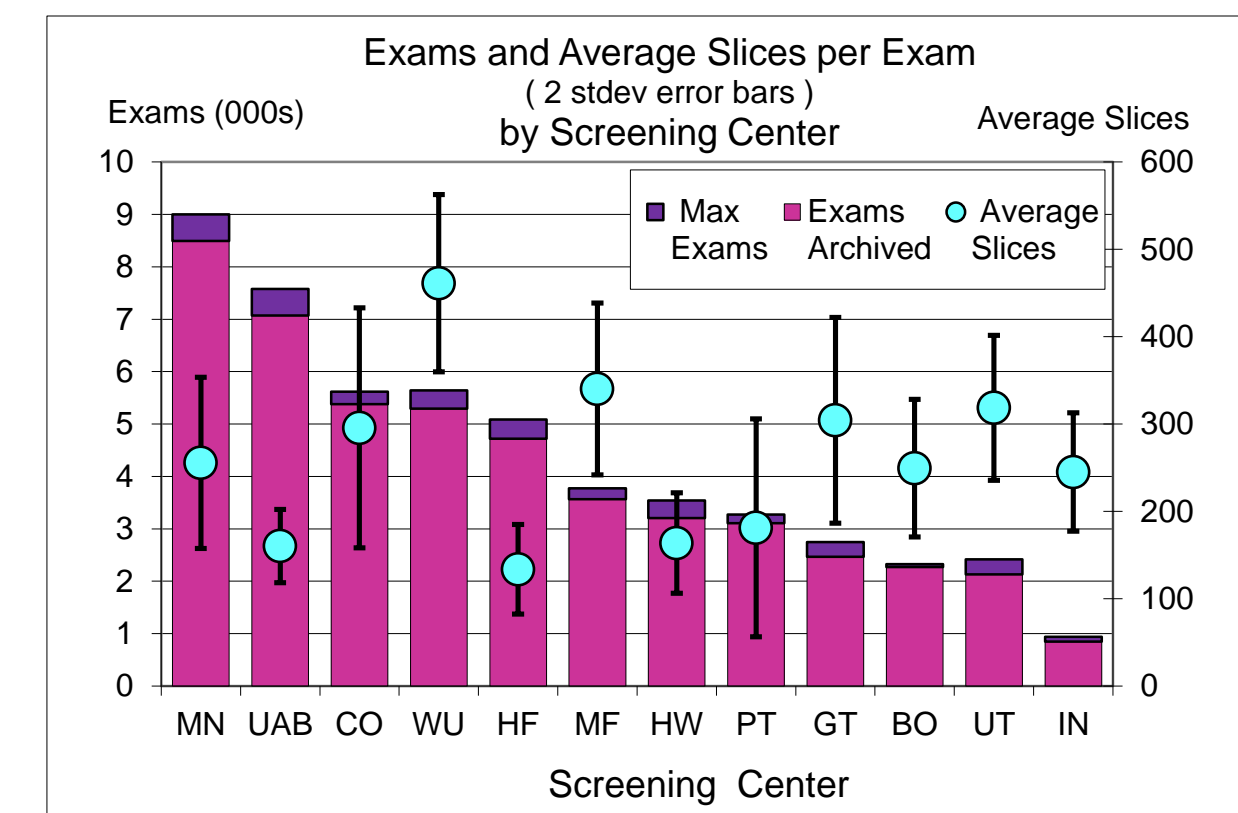


BACKGROUND

From 2002-2004, the Lung Screening Study (LSS) of the National Lung Screening Trial (NLST) enrolled 34,614 participants, aged 55-74 years, at risk for lung cancer due to heavy cigarette smoking. Participants were randomized to chest X-ray (CXR) or computed tomography (CT) arms through 12 screening centers and received up to 3 imaging screens at annual intervals. Available CT exams (48,547) were de-identified of protected health information and delivered to a CT Image Library (CTIL) at Washington University where stringent quality assurance measures (automated checks of DICOM headers and visual inspection of images) were applied before images were archived. Associated baseline medical histories, medical updates at screening, and radiologist interpretations of images are maintained at Westat, an independent research firm contracted to manage the LSS. The CT exams are now available, on a restricted basis, to clinical-research and imaging-science investigators. Summarized here are the CT data available from the CTIL, as well as guidelines by which investigators may gain access to the images.

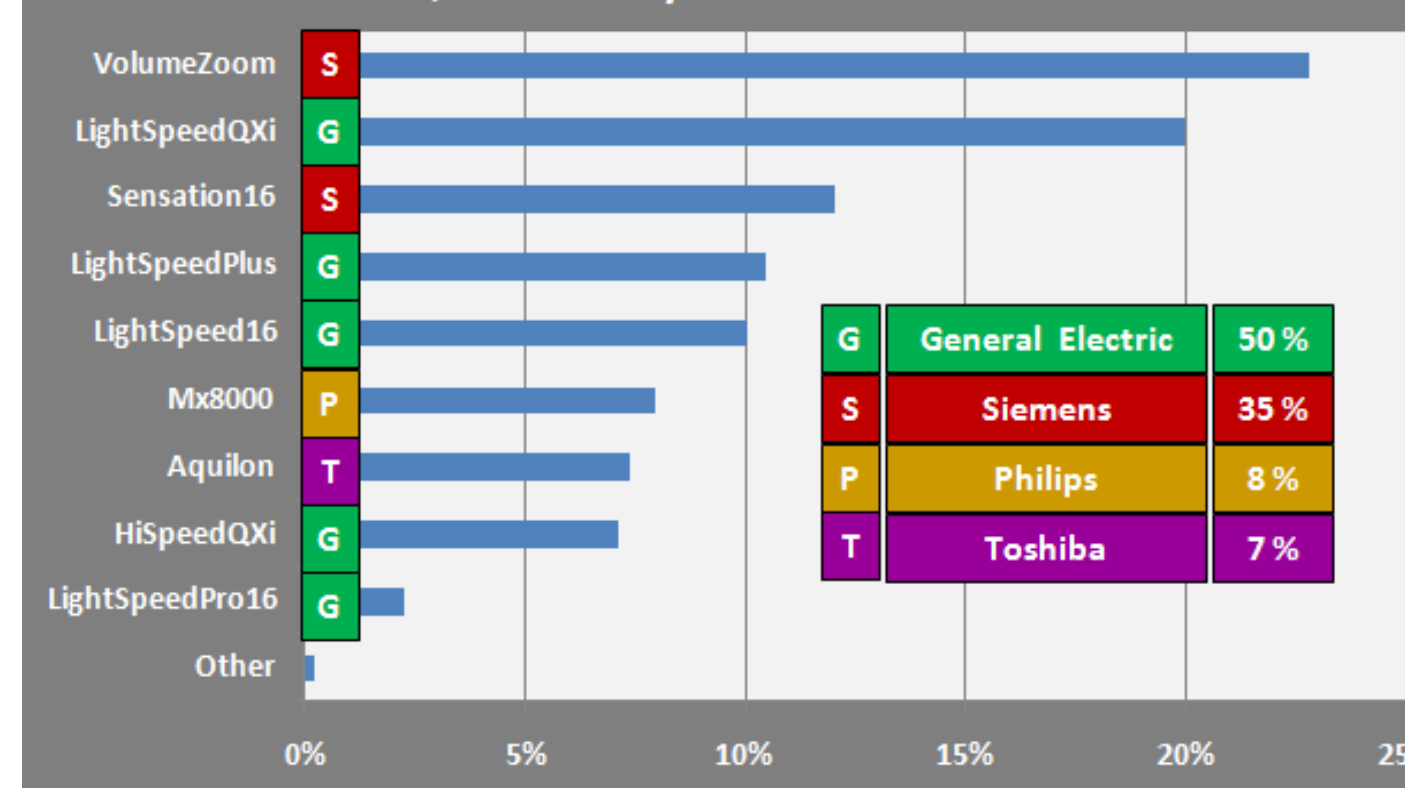
DE-IDENTIFICATION and QUALITY ASSURANCE

Screening centers stored their participants' screening CT exams in varying ways; most used their medical centers' PACS, while some created a separate electronic archive. Before submitting copies of their CT exams to the CTIL, all centers retrieved and de-identified copies of the exams on laptop computers provided by the CTIL, using custom de-identification software. De-identification involved the removal of protected health information (PHI) from image DICOM headers, substituting an "NLST PID" (screening-center number + participant number) for the participant's local ID. Exams were shipped to the CTIL on external hard drives (94.0%) or DVDs (5.9%), or they were transmitted over a secure Internet connection (0.1%). Exams were checked-into the CTIL as they passed both automated and visual quality assurance tests. In the library, a screening center-independent "CTIL PID" replaces the screening center-dependent NLST PID. Multiple screens from the same participant are distinguished by CTIL-assigned accession numbers. A web-based management graphical user interface and database were used to monitor and direct CTIL workflow.



The number of slices/exam varied among screening centers, primarily due to the number of image series reconstructed and minor differences in slice thickness.

CT Exams, Percent by Vendor & Scanner Model



SCANNER & EXAM DATA

Available to Investigators

Attribute	DICOM Tag
Manufacturer	0008 0070
Model Name	0008 1090
Software Version	0018 1020
Kvp	0018 0060
mAs	0018 1152
Exposure Time	0018 1150
Xray Tube Current	0018 1151
Table Feed per Rotation	0018 9310
Slice Thickness	0018 0050
Slice Spacing	0028 0030
Reconstruction Kernel	0018 1210
CT Pitch Factor	(from DICOM private group)
Screening Year	(in DICOM Comment)
Scanner ID	(Assigned from a cross-reference table built from attributes Institution, Station Name, Manufacturer, Model Name, and Software Version)

SUPPORT

National Cancer Institute Contract NO1-CN-25516; and Mallinckrodt Institute of Radiology, Washington University School of Medicine

CT IMAGE LIBRARY -- BY THE NUMBERS

CT Participants – 17,309
 Max # CT Exams – 51,927
 # CT Exams Performed – 48,723
 # CT Exams Archived – 48,547 (99.7%)
 # CT Exams Unavailable – 176 (0.3%)
 (lost, corrupt, compressed)
 CTIL Size – 12,466,488 images (6.2 TBytes)

ACCESSING CT IMAGE LIBRARY EXAMS

CTIL images are not yet publicly available, nor are blinded participant medical data and screening results. These restrictions remain in effect until after the NLST follow-up period completes in 2009. However, images may still be requested by investigators on a limited basis. The provisioning of CTIL images is 2-step process:

- (1) An investigator submits a proposal to Westat, specifying the kinds and numbers of images, as well as research summary-plan. Westat has the ability to match medical history, medical follow-up data, and screening results with CTIL exams. If the images are available, the research plan must be approved by NCI; if unavailable, Westat asks the investigator to recast the request. Images available and approvals in hand, Westat notifies the CTIL which CT exams to prepare for the investigator.
- (2) CTIL personnel then pull the requested exams from the library and deliver them to the investigator. The exams may be transmitted over a secure Internet connection or shipped on media provided by the investigator.

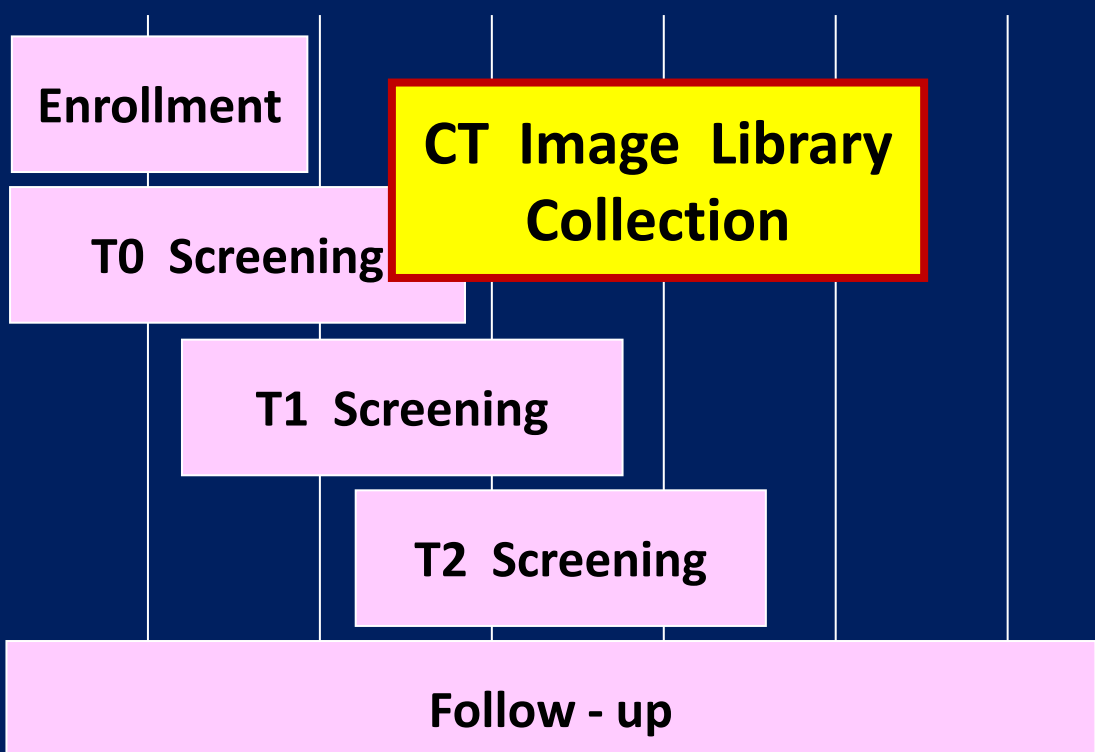
EXAMPLE INVESTIGATIONS USING CTIL IMAGES

- Radiologist reader variability study.
- Computer aided detection (CAD).
- Comparison of emphysema in different groups of NLST participants.

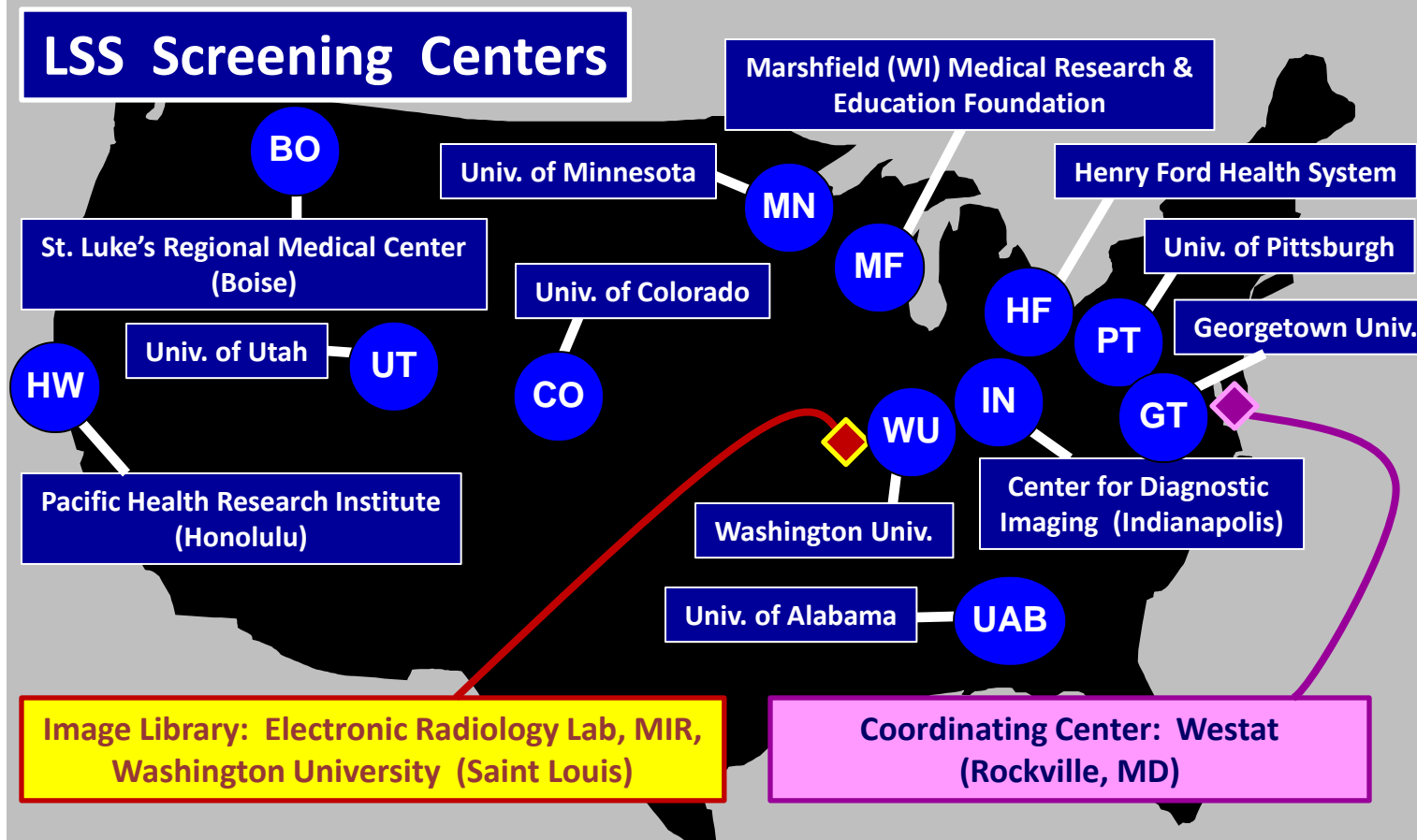
REFERENCE

KW Clark, DS Gierada, G. Marquez, SM Moore, DR Maffitt, JD Moulton, MA Wolfsberger, P Koppel, SR Phillips, FW Prior. "Collecting 48,000 CT Exams for the Lung Screening Study of the National Lung Screening Trial", J. Digital Imaging (accepted for publication, August, 2008), DOI: 10.1007/s10278-008-9145-9.

2002 2003 2004 2005 2006 2007 2008 2009



2002 2003 2004 2005 2006 2007 2008 2009



Quality Assurance Checks

Automated Inspection of DICOM Headers

-
- NLST – PID Valid ?
- Image Counts Reasonable ?
- Protocol – Valid Reconstruction Kernel ?
- Proper Image – Slice Spacing ?
- Proper Image – Slice Thickness ?
- DICOM Headers Free of PHI ?

Visual Inspection of All Images

-
- Images Free of PHI ?
- Images of Good Quality ?
- Lung Coverage Complete ?
- Missing Images ?
- Extra Images ?