Disclosures

• Nothing to Disclose
Learning Objectives

– To understand the purpose and implementation of dose index registries
– To recognize the challenges and limitations
– To learn to interpret the comparisons from registries with an understanding of potential inaccuracies
Outline

• Motivation
• Description of ACR Dose Index Registry
• Sources for inaccuracies and solutions
• How to interpret registry reports for quality improvement
• Future direction for the registry
Guiding principle behind registries

Cyclic Quality Improvement Process

- Transmit data to NRDR
- Receive semi-annual national benchmarking report
- Develop and implement improvement plan
- Analyze results
Motivation: What is the national average level of radiation administered by imaging facilities for a CT of the head?
What is the ACR Dose Index Registry?

• A tool for quality improvement so facilities can review dose indices and optimize protocols
  – Collects and compares dose index information across facilities
  – Fully automated; uses standard methods of data collection and processing
  – Will help to develop size-specific reference levels
• Meets Joint Commission requirements for radiation dose monitoring
• CT DIR launched in May 2011
What the ACR Dose Index Registry is Not

• It does **not** collect individual patient doses; only dose indices
  – CTDI\_vol
  – DLP
  – SSDE (although getting closer with SSDE, still not there yet)

• It does **not** collect patient identifiable information
  – HIPAA (Health Insurance Portability and Accountability Act of 1996) privacy concerns
  – Participation agreement

• It is **not** a mechanism to track individual patient dose
How does the Dose Index Registry work?

- **Scanner** → **DICOM SR** → **TRIAD Site Server** → Anonymized **DICOM SR** → **DIR Database** → **NRDR** → **Feedback Reports**
Data Collection

- Data sources vary across facilities. Data submission may be:
  - Directly from scanners,
  - From PACS, or
  - Through third-party dose monitoring tools
- Data format may be DICOM radiation dose structured reports (RDSRs) or dose screens
- ACR software to collect, anonymize, and transmit data may be installed on any computer at the facility, and works as a service in the background
Data Collection and Reporting

• What is collected
  – Data on dose indices for each exam, and each irradiation event
  – Characteristics of the exam to enable comparisons
  – Localizer image to measure patient width

• What is reported on
  – Average, 25\textsuperscript{th}/50\textsuperscript{th}/75\textsuperscript{th} percentile dose indices for facility and registry, for each protocol
  – Dose indices per scan, to help optimize protocols
  – Dose indices per exam, to assess performance across all scans per exam
Reports

• Semi-annual and Quarterly Feedback Report
  – PDF and Excel reports uploaded to registry website every six months
  – Excel reports only at the end of the first and third quarters
  – Available to all facility users

• Facility’s own data available at all times
  – Web-based reports
  – Displays exam details and comparisons of scanners
# Executive Summary: Facility 999999

**CTDvol Per Scan (mGy)**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CT ABD</td>
<td>(14/18/21)</td>
<td>(13/17/24)</td>
<td>(12/16/21)</td>
<td>(12/17/22)</td>
<td>(13/17/22)</td>
</tr>
<tr>
<td>CT ABD PELVIS KIDNEY CALC</td>
<td>(10/14/18)</td>
<td>(9/13/19)</td>
<td>(10/14/18)</td>
<td>(11/15/19)</td>
<td>(10/14/20)</td>
</tr>
<tr>
<td>CT ABD PELVIS W IVCON</td>
<td>(10/15/21)</td>
<td>(11/16/22)</td>
<td>(11/16/22)</td>
<td>(11/16/22)</td>
<td>(11/16/22)</td>
</tr>
<tr>
<td>CT ABD PELVIS WO &amp; W IVCO</td>
<td>(11/17/28)</td>
<td>(13/19/25)</td>
<td>(14/19/26)</td>
<td>(14/20/27)</td>
<td>(13/20/26)</td>
</tr>
<tr>
<td>CT ABD PELVIS WO IVCON</td>
<td>(10/15/23)</td>
<td>(10/16/22)</td>
<td>(10/15/21)</td>
<td>(11/17/23)</td>
<td>(11/16/23)</td>
</tr>
<tr>
<td>CT C SPINE WO IVCON</td>
<td>(26/40/69)</td>
<td>(20/30/49)</td>
<td>(21/31/49)</td>
<td>(22/34/52)</td>
<td>(20/31/56)</td>
</tr>
<tr>
<td>CT CHST</td>
<td>(13/16/24)</td>
<td>(8/12/16)</td>
<td>(8/11/15)</td>
<td>(9/12/16)</td>
<td>(9/12/17)</td>
</tr>
<tr>
<td>CT CHST ABD PELVIS W IVCO</td>
<td>(12/17/24)</td>
<td>(12/16/22)</td>
<td>(12/15/22)</td>
<td>(13/17/24)</td>
<td>(11/16/22)</td>
</tr>
<tr>
<td>CT CHST ANGIO W IVCON</td>
<td>(13/14/18)</td>
<td>(13/18/27)</td>
<td>(13/17/23)</td>
<td>(13/16/24)</td>
<td>(13/17/26)</td>
</tr>
<tr>
<td>CT CHST PULM ARTS EMBO W</td>
<td>(17/25/36)</td>
<td>(13/21/33)</td>
<td>(14/22/33)</td>
<td>(14/23/36)</td>
<td>(13/22/35)</td>
</tr>
<tr>
<td>CT CHST W IVCON</td>
<td>(9/14/17)</td>
<td>(9/13/20)</td>
<td>(8/13/19)</td>
<td>(9/13/18)</td>
<td>(10/14/20)</td>
</tr>
<tr>
<td>CT HEAD SINUSES WO IVCON</td>
<td>(13/26/47)</td>
<td>(13/20/36)</td>
<td>(14/20/33)</td>
<td>(19/33/44)</td>
<td>(14/19/28)</td>
</tr>
<tr>
<td>CT L SPINE WO IVCON</td>
<td>(17/29/47)</td>
<td>(20/31/45)</td>
<td>(18/27/43)</td>
<td>(22/34/51)</td>
<td>(20/29/43)</td>
</tr>
<tr>
<td>CT NECK W IVCON</td>
<td>(14/19/48)</td>
<td>(14/20/36)</td>
<td>(14/21/41)</td>
<td>(13/22/48)</td>
<td>(14/19/33)</td>
</tr>
</tbody>
</table>
For Each Exam, Facility Data are Compared to that of Similar Facilities
Reports color coded based on performance relative to registry

<table>
<thead>
<tr>
<th>CTDIvol per scan (mGy)</th>
<th>DIR Standing</th>
<th>1: Site 999999</th>
<th>2: All DIR sites</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>25th %'ile</td>
<td>Median</td>
</tr>
<tr>
<td>CT ABDOMEN</td>
<td>25th-75th %'ile</td>
<td>2587</td>
<td>13</td>
</tr>
<tr>
<td>CT ABDOMEN ANGIO W IVCON</td>
<td>25th-75th %'ile</td>
<td>94</td>
<td>9</td>
</tr>
<tr>
<td>CT ABDOMEN ANGIO WO THEN W IVCON</td>
<td>Above 75th %'ile</td>
<td>21</td>
<td>16</td>
</tr>
<tr>
<td>CT ABDOMEN BIOPSY KIDNEY GUIDANCE</td>
<td>25th-75th %'ile</td>
<td>58</td>
<td>8</td>
</tr>
<tr>
<td>CT ABDOMEN BIOPSY LIVER GUIDANCE</td>
<td>Below 25th %'ile</td>
<td>36</td>
<td>10</td>
</tr>
<tr>
<td>CT ABDOMEN BIOPSY RETROPERITONEUM GUIDANCE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CT ABDOMEN KIDNEY ANGIO</td>
<td>25th-75th %'ile</td>
<td>30</td>
<td>13</td>
</tr>
<tr>
<td>CT ABDOMEN KIDNEY WO THEN W IVCON</td>
<td>25th-75th %'ile</td>
<td>11</td>
<td>16</td>
</tr>
<tr>
<td>CT ABDOMEN LIVER MULTIPHASE WO THEN W IVCON</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CT ABDOMEN PELVIS ANGIO</td>
<td>25th-75th %'ile</td>
<td>24</td>
<td>8</td>
</tr>
<tr>
<td>CT ABDOMEN PELVIS ANGIO WO THEN W IVCON</td>
<td>25th-75th %'ile</td>
<td>49</td>
<td>9</td>
</tr>
<tr>
<td>CT ABDOMEN PELVIS COLONOGRAPHY W IVCON</td>
<td>25th-75th %'ile</td>
<td>28</td>
<td>15</td>
</tr>
<tr>
<td>CT ABDOMEN PELVIS COLONOGRAPHY WO IVCON</td>
<td>25th-75th %'ile</td>
<td>160</td>
<td>20</td>
</tr>
<tr>
<td>CT ABDOMEN PELVIS ENTERO W IVCON</td>
<td>25th-75th %'ile</td>
<td>349</td>
<td>11</td>
</tr>
<tr>
<td>CT ABDOMEN PELVIS KIDNEY CALC W IVCON</td>
<td>25th-75th %'ile</td>
<td>58</td>
<td>2</td>
</tr>
<tr>
<td>CT ABDOMEN PELVIS LE ANGIO</td>
<td>25th-75th %'ile</td>
<td>2</td>
<td>34</td>
</tr>
<tr>
<td>CT ABDOMEN PELVIS LE ANGIO W IVCON</td>
<td>25th-75th %'ile</td>
<td>66</td>
<td>9</td>
</tr>
<tr>
<td>CT ABDOMEN PELVIS LE ANGIO W IVCON</td>
<td>25th-75th %'ile</td>
<td>4895</td>
<td>10</td>
</tr>
<tr>
<td>CT ABDOMEN PELVIS LE ANGIO W IVCON</td>
<td>25th-75th %'ile</td>
<td>76</td>
<td>17</td>
</tr>
<tr>
<td>CT ABDOMEN PELVIS LE ANGIO WO THEN W IVCON</td>
<td>Above 75th %'ile</td>
<td>1</td>
<td>17</td>
</tr>
</tbody>
</table>
Online reports

- Corresponds to semi-annual report measures
- Includes SSDE, CTDIvol and DLP
- Reports by RPID, Study Description, and Scanner
Online reports

Horizontal line on chart = Registry median

<table>
<thead>
<tr>
<th>By Scanning</th>
<th>#1</th>
<th>#2</th>
<th>#3</th>
<th>#4</th>
<th>#5</th>
<th>#6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max</td>
<td>27.63</td>
<td>20.77</td>
<td>19.21</td>
<td>18.92</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min</td>
<td>3.87</td>
<td>2.86</td>
<td>2.82</td>
<td>2.16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median</td>
<td>4.97</td>
<td>6.22</td>
<td>3.97</td>
<td>6.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>9.23</td>
<td>8.12</td>
<td>6.22</td>
<td>8.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>177</td>
<td>6</td>
<td>28</td>
<td>17</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Standardization for Comparison: Challenges and Solutions

1. Capture of standard data from all participants
2. Patient size adjustment
3. Normalizing for phantom size
4. Monitoring runs
5. Procedure name standardization
1. DICOM Standard: Radiation Dose Structured Report

### TID 10012
CT ACCUMULATED DOSE DATA

<table>
<thead>
<tr>
<th>Concept Name</th>
<th>Value Set Constraint</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 CT Accumulated Dose Data</td>
<td></td>
</tr>
<tr>
<td>2 Total Number of Irradiation Events</td>
<td>Units = events, Total Number of CT irradiation events</td>
</tr>
<tr>
<td>3 CT Dose Length Product Total</td>
<td>Units =mGycm, The Dose Length Product (DLP) is calculated for every Product Total is the sum of the DLP values. The calculate each irradiation event.</td>
</tr>
<tr>
<td>4 CT Effective</td>
<td>Units =mSv, Effective dose (E, in units of mSv) evaluated as a total</td>
</tr>
</tbody>
</table>

### TID 10013
CT IRRADIATION EVENT DATA

<table>
<thead>
<tr>
<th>Concept Name</th>
<th>Value Set Constraint</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 CT Acquisition</td>
<td>User-defined type of clinical acquisition protocol for creating images or image-derived measurements. May be taken from Protocol Name (0018.1030) or from Performed Procedure Step Description (0040.0254).</td>
</tr>
<tr>
<td>2 Acquisition Protocol</td>
<td>CT and MR Anatomy Imaged, The target region is the anatomy exposed.</td>
</tr>
<tr>
<td>3 Target Region</td>
<td>CT Acquisition Types, Description of the method used during acquisition of this CT irradiation event, may be derived from Acquisition Type (0018.9302).</td>
</tr>
<tr>
<td>4 Procedure Context</td>
<td>Contrast Imaging Technique, The acquisition was performed with or without contrast medium application.</td>
</tr>
<tr>
<td>5 Irradiation Event UID</td>
<td></td>
</tr>
<tr>
<td>7 CT Acquisition Parameters</td>
<td></td>
</tr>
</tbody>
</table>
1. Data Capture: Variety of scanners/models

*New and old, all major manufacturers*

- DIR accepts DICOM radiation dose structured reports (RDSRs) from new scanners with the capability to generate them.
- Older scanners provide dose screens that are processed and converted to DICOM RDSRs.
- Manufacturers of scanners currently sending data to DIR:
  - GE
  - Siemens
  - Philips
  - Toshiba
  - Neurologica
1. Data capture challenges

• Despite use of industry standards and automation
  • Non-RDSR dose screens not always uniform for scanners from the same manufacturer

• Even scanners producing RDSRs do not adhere comprehensively to standard
  • Meet required criteria but not optional, and we find that facilities need the optional fields to fully characterize their data
  • Example: ProtocolName
2. Patient Size Adjustment

*Size-Specific Dose Estimate (SSDE)*

- Patient sizes may vary widely and require different dose indices to obtain comparably diagnostic images across patients.
  - Same dose index results in different doses for patients of different sizes.
- Size-Specific Dose Estimate measures developed by American Association of Physicists in Medicine (AAPM)
  - Empirical measure based on calculating radiation doses using four different methods, and a variety of scanners
- DIR uses normalized dose conversion factor from AAPM TG204 report to convert CTDIvol to SSDE
2. Patient Size Adjustment

Size-Specific Dose Estimate (SSDE)

- DIR allows sites to submit localizer images along with Dose Report to measure patient thickness

3. Normalization for Phantom size

- CTDIvol is measures using different phantoms based on protocol.
  - Adult body – 32cm phantom
  - Adult and pediatric head – 16 cm phantom
  - Pediatric body – some manufacturers use 16cm and some use 32cm
    - DIR normalizes all body exams to 32 cm phantom
- Empirical conversion factor of 2.3 based on measurements from a variety of scanners
  - divide by 2.3 to convert CTDIvol and DLP from 16cm to 32cm phantom
  - multiply by 2.3 to convert CTDIvol and DLP from 32cm to 16 cm phantom
4. Timing/Monitoring runs

- Some exams have monitoring runs that do not really represent dose to patient and must be excluded from dose estimates
  - Exclude exams that have CTDIvol > DLP
  - Use Acquisition Protocol to identify timing runs for exclusion, but field is not always populated
5. Procedure Name Standardization

• Exam names mapped to Radlex Playbook
  – http://playbook.radlex.org

• ACR used external vendor, RadMapps, to map all exam names in the registry at a point in time.
  – ~21,000 unique exam names

• After that, facilities map their own exam names using a mapping tool on website. Suggested tags are provided if an exam name is already in the database.
5. Mapping Exam Names

*Procedure Name Standardization*

- Exam names mapped to Radlex Playbook (playbook.radlex.org)
- Online tool to map procedure names to standard terminology.

Suggested tags are provided if an exam name is already in the database.
August 2014
1035 facilities/650 fully active; 11.3 million exams/19.4 million scans
Participation from a Variety of Practice Types Across the US

Some facilities outside of the US
January – June 2014

- 585 facilities received feedback reports on adult exams, and 564 on pediatric
- Reports on over 2 million adult CT exams and 194,000 pediatric CT exams with standardized names
- Results reported on Size-Specific Dose Estimate (SSDE), CTDIvol, and DLP
Additional Benefits of DIR

- Meets the recent Joint Commission requirements for CT radiation dose monitoring
- Meets reporting requirements
  - Certified as PQI (Practice Quality Improvement) project for ABR MOC (Maintenance of Certification)
  - Supports CMS’s PQRS (Practice Quality Reporting System) requirements for 2014
- Free webinars led by ACR DIR staff and committee to answer questions related to radiation dose monitoring
How accurate are the data?

• There are several sources of inaccuracies
  – Errors in data processing, for example, inaccurate parsing, misidentification of timing runs
  – Incomplete data submission, particularly on localizers
  – Vendor issues in parsing dose screen
  – Ability to standardize procedure names
Data accuracy – mitigation and issues

• Over the past two years, facilities have helped us identify errors and correct them. As a result, data quality improves with use of the registry.
• As more scanners generate RDSRs, errors in the data decrease.
• There are persistent issues with some vendors in processing dose screens and we continue to identify and correct these.
Data accuracy – mitigation and issues

• Over the past two years, facilities have helped us identify errors and correct them. As a result, data quality improves with use of the registry.

• As more scanners generate RDSRs, errors in the data decrease.

• There are persistent issues with some vendors in processing dose screens and we continue to identify and correct these.
Data accuracy – mitigation and issues

• Exam name standardization has improved greatly as facilities have become more comfortable with the process and helped us adapt our processes.

• Persistent issues related to procedure names
  – The scanner fields that are available to us sometimes contain truncated names of procedures
  – Protocol names with more complete information are not always available
  – Hand entered procedure names continually introduce new names that may be unmapped
  – Actual procedure may change after protocol was picked and may not be reflected anywhere in the procedure name
Future plans

• Establish Diagnostic Reference Levels for high-volume CT exams

• Include additional modalities in the registry in the near future
  – Interventional fluoroscopy: in design stages for combining data from scanners and RIS to support appropriate exam name standardization
  – Computed and digital radiography: in pilot but waiting for scanner manufacturers to make some DICOM modifications to generate compliant radiation dose structured reports
  – Nuclear medicine: proposed
Contact ACR DIR

nrdr@acr.org
X3535

Mythreyi Chatfield, PhD
Debapriya Sengupta, MBBS, MPH
Lu Meyer, MS
Victoria O’Brien, BS