In 2009 dozens of patients undergoing CT head examinations were accidentally overexposed leading to hair epilation and concerns for cancer induction. These events were an eye-opener for the radiology industry, as up to this point no other significant diagnostic radiology incident had occurred. This drove the need for far more attention on how to manage radiation exposure for patients, not necessarily from a clinical image quality perspective, but from a patient safety perspective. What the industry quickly realized is that within the current healthcare framework there is no clear owner of managing cumulative radiation dose to patients and how this information should be used throughout their care. The goal of this whitepaper is to drive this conversation and offers the Philips perspective on how we use the data available from radiation dose tracking solutions to contribute to patient care.
What is dose tracking and why is it important?

In February 2018 the EU is slated to also codify new laws through a European Union Council Directive laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation” that will implement the directive and improving patient exposure. These new rules are even more explicit that in the 2015 Joint Commission standards.

In the US there is a new law being enacted referred as to “MACRA” short for Medicare Access and CHIP Reauthorization Act, which went into effect April 2015. This is a bold move for Medicare that shifts reimbursement from a pay-per-service model to a “value-based” care system.

Value-based care will be measured by metrics that are driven by the healthcare provider’s ability to manage costs, quality, and patient outcomes. While the scope of MACRA is massive, buried in the metrics are patient-level radiation dose exposures which dose tracking software can help manage.

Framework of existing hospital process

Radiation is ubiquitous in today’s worldwide healthcare environment. X-ray machines are standard tools employed by clinicians in diagnosis and in treating people, and radioactive materials are used in diagnosing symptoms, in treating cancers, and in sterilizing blood. The hazards associated with radiation require that the sources of radiation be tightly regulated and controlled.

Hospitals are required to have the administrative resources to manage the acquisition and disposal of radiation sources including policies, programs and procedures. They also must have the facilities and personnel needed to implement these policies, programs and procedures. The standard model is to have a Hospital Radiation Safety Committee (RSC) that essentially oversees the implementation of programs, and ensure that all activities are performed in compliance with applicable regulations.

The RSC is required in the United States per Federal Code 10 CFR 35.24 (and local Agreement State regulations) to:

- Provide technical advice to the hospital’s Radiation Safety Officer (RSO) to ensure that the hospital’s Radiation Safety Program is a great challenge to implement.
- Work with the data from dose tracking software into one place allowing hospitals to segment, analyze and track dose to individual patients. It also allows hospitals to discover trends in their data across their imaging suite of machines, allowing protocol adjustments and normalizing exam exposure.

DRL/Achievable dose targets

The National Commission on Radiation Protection Report 172 established levels for general types of procedures that most institutions perform using X-rays for the purposes of providing patient care. Radiation providers can apply these values for a variety of procedures from all modalities for comparison allowing institutions to generate average values of their own, and if they are higher than the published values, then they should take steps to possibly manage radiation exposures to patients to bring it within a “reasonable” range.

The NCRP report 172 also provided more challenging lower levels that institutions should try to attain, referred to as Achievable Doses (AIDs). The intention is that when the institution is hovering at or below the DRL, there should a lower target to aim for. The AIDs are typically between 10 and 25% of the published values, allowing the institution to strive even further while maintaining adequate image quality.

Certain countries in Europe, such as France’s ASN Guide No. 11, have also established local DRLs that healthcare institutions are required by law to comply with. For example, the UK PM77 Guidance refers to Diagnostic Reference Levels (DRLs). These DRLs are typically the 50th percentile of the dose distribution for radiation over a period of time. In the US, the terms “authorized users” and “byproduct material” may be foreign to most people.

- Authorized users are hospital staff with specialty academic and practical training in radiation dosimetry, protection, radiology, mathematics, medical use and research use of radioactive materials.
- Byproduct materials are radioactive materials that are not clear reactor products. These are usually “byproducts” of nuclear fuel such as uranium and thorium that are recovered to make medical radioisotopes. The production of 99m-99m, 99-99, 99-99 is a great example of these materials.

The key to medical radiation exposure is optimizing and continuing. In the US, the focus has been on patient radiation dose delivered by CT scanners, and second from the fluoroscope used for interventional procedures.

Working with the data from dose tracking software integrating patient radiation safety related data into the institutional Radiation Safety Program is a great change for many. The primary focus has been on patient radiation dose delivered by CT scanners, and second from the fluoroscope used for interventional procedures.

The reason why these modes of radiation exposure were chosen over the others is because they are performed on a larger proportion of the worldwide population as compared to the other modalities, and the exposure to each patient can be a significant amount of radiation compared to other radiation modalities such as digital radiography and mammography.

Radiation dose tracking software brings all patient exposures into one place allowing hospitals to segment, analyze and track dose to individual patients. It also allows hospitals to discover trends in their data across their imaging suite of machines, allowing protocol adjustments and normalizing exam exposure.

In the US, the focus has been on patient radiation dose delivered by CT scanners, and second from the fluoroscope used for interventional procedures.

The reason why these modes of radiation exposure were chosen over the others is because they are performed on a larger proportion of the worldwide population as compared to the other modalities, and the exposure to each patient can be a significant amount of radiation compared to other radiation modalities such as digital radiography and mammography.

Radiation dose tracking software brings all patient exposures into one place allowing hospitals to segment, analyze and track dose to individual patients. It also allows hospitals to discover trends in their data across their imaging suite of machines, allowing protocol adjustments and normalizing exam exposure.

Report 172 also provided more challenging lower levels that institutions should try to attain, referred to as Achievable Doses (AIDs). The intention is that when the institution is hovering at or below the DRL, there should a lower target to aim for. The AIDs are typically between 10 and 25% of the published values, allowing the institution to strive even further while maintaining adequate image quality.

Certificated in countries such as Europe, France’s ASN Guide No. 11, have also established local DRLs that healthcare institutions are required by law to comply with. For example, the UK PM77 Guidance refers to Diagnostic Reference Levels (DRLs). These DRLs are typically the 50th percentile of the dose distribution for radiation over a period of time.
Methods of analyzing data
The RSC is responsible for ensuring that the use of radiation for diagnostic purposes in the hospital is purchased, used and disposed of according to applicable regulations, and that the safety of workers, the public, and now patients are appropriately managed. The collected data is used for two purposes. The first are as quality measures – to ensure that the programs and procedures are being performed as intended and that the outcomes are consistent with the respective design goals. The second is to identify outliers, i.e., those instances where things did not go as expected.

Dose monitoring and tracking is extremely useful for both purposes. For example, the patient-specific radiation dose metric for CT scans (i.e., Dose Length Product, volumetric Computed Tomography Dose Index or Size Specific Dose Estimate) can be aggregated by protocol type (e.g., head scan, abdomen scan, etc.) and described and compared through statistics. Comparing actual values to appropriate benchmarks can reveal whether the institution is comparable to other institutions performing the same types of scans on the same types of patients. The data can also be used to identify outliers. Dose metrics used on the individual level can be used to identify those patients that received far more radiation than the protocol or other controlling factors can explain. This can help Medical Physicists to identify areas of improvement, or unknown operational practices, that could help manage equipment use and normalize dose per exam across the patient population.

Because DRLs and Achievable Dose work within the concept of “percentile” of the dose distribution, the statistical boxplot graph is a very effective method of analyzing the data. A boxplot indicated the distribution of data with a min/max/median while also identifying the 75th percentile and also the 25th percentile. If you participate in the American College of Radiology’s Dose Index Registry (DIR) then you are probably familiar with this type of graph, as this is what they use to distribute data to participants. See Figure 1 below for an example of a box plot.

Goals/Review of progress
Healthcare institutions are expected to manage patient exposure having probably never done it before, so where do you start?

The concept of dose management is one that entails patient safety, risk, regulatory compliance and now facility accreditation. As such, it is important that hospital executives “buy-in” to this philosophy to ensure that staffing, funding and other adequate resources are available with accountability established. A robust hospital infrastructure builds the foundation for success. This is where the concept of the CDOT, as mentioned above, comes into play. The CDOT should serve as the central owner of patient dose that reports into the Radiation Safety Committee for that institution. Vendors and manufacturers are keen on the needs of users and can also help provide training, content and support for developing your patient radiation safety program. Education of stakeholders is key after programs are established and infrastructure is complete. Of course all relevant staff should be educated on the processes and teams established to monitor dose, but patients should also be included. Patients have never been as educated on dose as they are today. The reality is that the internet is full of content that may be either too technical, or misleading based on the source, for patients to educate themselves. A proactive and transparent patient education campaign with factual data is a good path to follow.

The first step to managing patient dose is data. Using a commercial dose tracking software, or data mining from your PACS or RIS, allows you to benchmark yourself with retrospective data. Set goals to understand your current dose results against DRL values and make modest targets to improve aggregate dose. Reviewing the data will also identify unknown practices, such as variation among Technologists, and help standardize ways of working in an environment with equipment from multiple vendors and with different levels of technology due to age.

The path forward for patient dose management will take some time, but small steps with some organizational support will begin to yield successful results. This is the expectation from organizations such as Joint Commission as well as Individual States as they promulgate more regulation in this area.