Deep Learning Model for Cancer Risk from Low Dose Medical Imaging Radiation

Poster No.: ESI-10315
Congress: EuroSafe Imaging 2020
Type: EuroSafe Imaging
Authors: D. Koff¹, O. Boursalie², R. Samavi³, T. E. Doyle³; ¹McMaster University Hamilton/CA, ²McMaster University Hamilton/CA, ³Hamilton/CA

Keywords: Action 12 - Information for and communication with patients, Artificial Intelligence, eHealth, Management, CT, Digital radiography, PACS, Computer Applications-General, Dosimetry, Radiation safety, Cancer, Retrospective, Diagnostic or prognostic study, Multicentre study

DOI: 10.26044/esi2020/ESI-10315

Any information contained in this pdf file is automatically generated from digital material submitted to EPOS by third parties in the form of scientific presentations. References to any names, marks, products, or services of third parties or hypertext links to third-party sites or information are provided solely as a convenience to you and do not in any way constitute or imply ECR’s endorsement, sponsorship or recommendation of the third party, information, product or service. ECR is not responsible for the content of these pages and does not make any representations regarding the content or accuracy of material in this file.

As per copyright regulations, any unauthorised use of the material or parts thereof as well as commercial reproduction or multiple distribution by any traditional or electronically based reproduction/publication method is strictly prohibited.

You agree to defend, indemnify, and hold ECR harmless from and against any and all claims, damages, costs, and expenses, including attorneys’ fees, arising from or related to your use of these pages.

Please note: Links to movies, ppt slide shows and any other multimedia files are not available in the pdf version of presentations.
Background/introduction

Medical imaging is a powerful clinical tool that allows health professionals to diagnose their patients without subjecting them to invasive surgery. Although the benefits of medical imaging exams are significant, there are ionizing radiation risks associated with every imaging exam that needs to be considered. Existing cancer risk models such as the linear-no-threshold (LNT) model [1] extrapolate the risk from high radiation exposure to the low-dose radiation emitted by medical imaging (Fig. 1). However, the effect of radiation risk from high to low levels remains experimentally unchallenged. In addition, health professionals are uncertain about how to factor a patient's past radiation exposure when considering an imaging exam [3]. Therefore, there is a need for the development of an analysis platform for improved radiation benefit-risk-dialogue.

We are currently developing a decision support system using deep learning to provide real-time risk assessment of radiation exposure from medical imaging relative to a patient’s medical history. In this study, we provide an overview of our decision support system. Our system will allow patients, radiologists, and medical researchers to evaluate if the benefits of performing the imaging study outweigh the potential cancer risks [4] from low dose radiation, which has increased in terms of frequency and dose over the last decade [5]. Health professionals can then determine if the patient should proceed with conducting the imaging or resort to a lower-dose or non-ionizing modality. In addition, we propose an architecture to ensure the confidentiality and integrity of the sensitive health data being analyzed [6].
Fig. 1: Dose-response models to estimate the risk of low-dose radiation from medical imaging based on high-dose radiation exposure. Modified from [2].

Description of activity and work performed

Source Population: The training dataset used to develop our DSS has approximately 1.3 million diagnostic and 2.3 million imaging records from 340,525 patients over a ten-year period in four hospitals in Hamilton, Ontario, Canada.

Data Processing: Our first data processing step was to extract features from each patient's health (e.g., gender, ICD-10 diagnostic chapter codes) and imaging (e.g., modality and body part scanned) records over the ten-year study period. Next, we estimated the patient's effective dose exposure [7] from medical imaging using mean values from the literature [8]. Finally, we used aggregation [9] to sum the features across the patient's medical events over the ten-year period to construct the dataset used to train the deep learning model.

Deep Learning Risk Model: While existing models linearly extrapolate the cancer risks from high radiation exposure to the low-dose radiation emitted by medical imaging, our deep learning model directly assesses the cancer risk from low-dose radiation by analyzing medical and imaging records. Cancer patients were labeled as those with an ICD-10 diagnostic code for neoplasm (C-D48) at least one year after their first CT scan. The resulting training set was unbalanced with 90% non-cancer and 10% cancer patients. To balance our training set, we trained our deep learning model using 10-fold down-sampled cross-validation.

Data Aggregator: Existing machine learning systems have no trust mechanism for auditing the data's lifecycle (from collection to use, disclosure, and transformation) to ensure accountability. We designed a blockchain-based architecture [6] to facilitate trust management in a collaborative health environment. The proposed architecture has three layers (Fig. 2). First, the data layer generates date pointers that link to medical records and can be shared among actors. Next, the transaction layer is a mechanism to store and query data sharing transactions. Finally, the transparency layer generates an integrity proof of the data sharing transaction that all participants contribute to and maintain.

Preliminary Results: Our preliminary deep learning model classifies a patient's cancer risk with reasonable accuracy suggesting medical and imaging history can be an indicator of cancer risk. In addition, our proposed architecture supports the confidentiality and integrity of the model by allowing the flow of data in our system to be audited [6]. However, patients' total effective dose exposure was underestimated using mean doses from the literature which could impact the model's performance. There is a need to develop novel imputation approaches to estimate patient effective dose exposure from medical imaging.
Limitation: Our deep learning model removes the temporal aspect of medical data when evaluating a patient’s cancer risk from medical imaging.
Fig. 2: Architectural Layers [6].

Conclusion and recommendations

Deep learning is a promising tool for improved benefit-risk dialogue between health professionals and patients when considering an imaging scan. Further study is ongoing to validate our results by incorporating patient’s radiation exposure estimations from Digital Imaging and Communications in Medicine (DICOM) files into our model.
Personal/organisational information

D. Koff; Hamilton, ON/CA - nothing to disclose
O. Boursalie; Hamilton/CA - nothing to disclose
R. Samavi; Hamilton/CA - nothing to disclose
T. E. Doyle; Hamilton/CA - nothing to disclose
References


