TITLE:
Prediction of Future Healthcare Expenses of Patients from Chest Radiograph Using Deep Learning

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HIGHLIGHTS:
This technical development study used 22,550 frontal chest radiographs from a single academic institution to train deep learning classification and regression models to predict 5-year total health care spending of individual patient. The model may be used to identify at-risk patients who may benefit from further intervention.

INTRODUCTION:
As healthcare reimbursement models change, hospitals and healthcare providers are taking on greater risk. In negotiating contracts with payers, healthcare entities need tools to estimate healthcare expenses that their populations will incur annually; the healthcare requirement of any population can vary substantially and 50% of the total population account for about 97% of total US healthcare expenditures. We hypothesize that the large amount of hidden information in chest radiographs can capture many general health indicators and thus may be utilized to predict future medical costs. In addition, the prediction harnessed from chest radiographs could be used for proactive preventive care for high-risk groups. To test this hypothesis, we trained two computer vision models based on chest radiographs in order to predict worth of medical treatment and identify top 50% spenders within 5 years after the chest radiographs were taken.

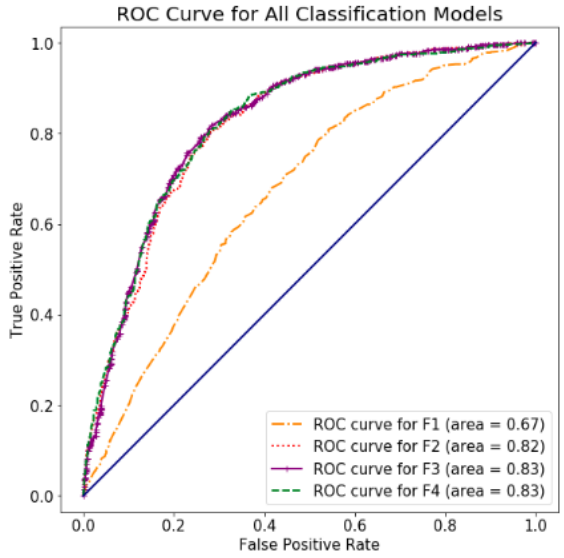
METHODS:
We used 22,550 frontal (AP or PA) chest radiographs from a single institution paired with the corresponding patient's total healthcare spending within the following 5 years. The training set was augmented by random adjustment of brightness, inversion, and rotation. For both classification and regression, a Resnet152 model, initialized with weights pretrained on ImageNet was used for feature extraction. For classification, cross-entropy loss function is used. For regression, two more affine layers were added before the mean squared loss (MSE). After hyperparameter tuning and training, the models were validated against a test set consisting of 1877 samples. Classification performance was measured by area under the receiver operating characteristic curve (ROC-AUC) and F1 score. Regression performance was measured by Pearson R, Spearman R and Mean Absolute Error (MAE).

RESULTS:
The best regression model was able to predict 5-year expenditures with Pearson R of 0.694 [95% CI, 0.669-0.718] and Spearman R of 0.691 [95% CI, 0.666-0.716] in log10-transformed data, both p-value < 0.01 and MAE of 63786 [95% CI, 55551-72107]. The best classification model was able to identify top-50% spenders with ROC-AUC of 0.825 [95% CI, 0.808-0.843] and F1 score of 0.721 [95% CI, 0.688-0.735].

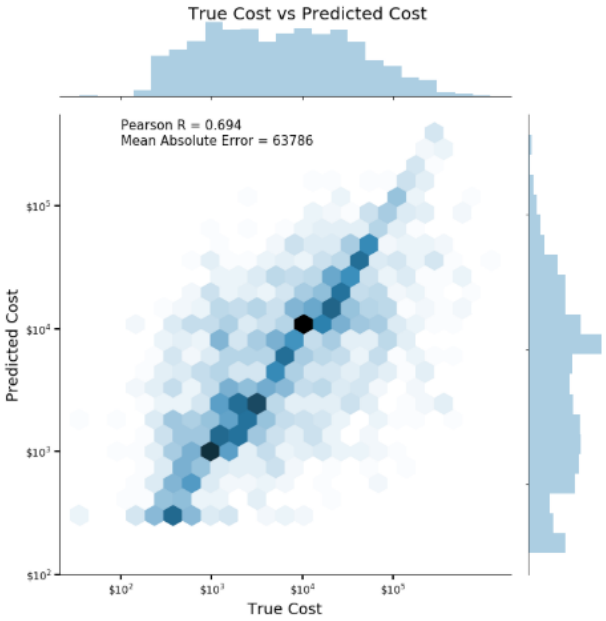
Conclusions and Relevance: Our deep learning model predicted an order-of-magnitude 5-year health care expenditure as well as identified top 50% healthcare spenders using frontal chest

radiograph. This suggests that our model is able to extract useful health cost associated indicators from the chest radiograph.

FIGURE



A. ROC Curve for all classification models



B. Joint distribution plot for the best performing regression model