

## **Deep Learning to Predict 10-year Cardiovascular Risk from Chest Radiographs**

### **PURPOSE**

Current guidelines recommend estimating 10-year risk of major adverse cardiovascular events (MACE) to establish statin candidacy for the primary prevention of atherosclerotic cardiovascular disease (ASCVD). The current ASCVD risk score requires age, sex, race, systolic blood pressure, hypertension treatment, smoking, type 2 diabetes and a lipid panel. As these variables are often not available in the electronic record, other approaches for population-based screening are desirable. Here, we developed a deep learning model (CXR-CVD risk), to estimate 10-year cardiovascular risk from a routine chest radiograph (CXR).

### **METHODS AND MATERIALS**

The CXR-CVD risk model was developed using 147,497 CXRs of 40,643 participants from the PLCO cancer screening trial. The model was trained to predict cardiovascular mortality from a single CXR image. Independent testing was performed in a second separate cohort of 11,430 outpatients potentially eligible for primary prevention (low-density lipoprotein cholesterol 70-190 mg/dl, no prevalent diabetes and no prior MACE). Statin eligibility was defined as a 10-year MACE risk  $\geq 7.5\%$ . The prognostic value of CXRCVD risk was compared to the established ASCVD risk score in the subset of 2,401 (21%) where the variables necessary to calculate ASCVD risk were available. The primary outcome was observed 10-year incident MACE (stroke and myocardial infarction). Hazard ratios and c-statistics for MACE were estimated using Cox proportional hazards regression.

### **RESULTS**

In the independent testing dataset of 11,430 patients (mean age  $60.1 \pm 6.7$  years; 42.9% male), 1096 (9.6%) MACE occurred over median follow-up of 10.3 years. There was a significant association of CXR-CVD risk and MACE in statin eligible patients (HR: 2.03 [1.81-2.30];  $p < 0.001$ ), which remained significant after adjustment for cardiovascular risk factors (adjusted HR: 1.63 [1.43-1.86];  $p < 0.001$ ). In the subgroup where all variables necessary to calculate ASCVD risk were available, the performance of CXR-CVD risk was similar (c-statistic 0.64 vs. 0.65;  $p = 0.48$ ) to and additive to the ASCVD risk score (adjusted HR: 1.58 [1.20-2.09];  $p = 0.001$ ).

### **CONCLUSIONS**

Based on a single routine CXR image, our deep learning model predicts 10-year incident MACE with similar performance and incremental to the established clinical standard. As CXR images are commonly available, our approach may help identify individuals at high risk for cardiovascular disease, prompting risk factor assessment and targeted prevention.

### **CLINICAL RELEVANCE/APPLICATIONS**

Deep learning can estimate cardiovascular risk from a routine CXR image similar to the current clinical standard. This enables opportunistic screening to identify high-risk patients who would benefit from prevention with statins.