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Cost-Consequences Analysis (CCA) of Artificially Intelligent (AI) Clinician-Friendly Interpretable Computer-Aided Diagnosis (ICADX) Tool for Coronary Artery Disease (CAD) Developed at HosmartAI (HORIZON 2020 FUNDED)

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Background

- Coronary artery disease (CAD) has been regarded as one of the most dangerous and life-threatening chronic diseases.
- The clinical recommendations followed use contrast enhanced Coronary Computed Tomography Angiography (CCTA) as a first-line diagnostic option in obstructive CAD Data-driven decision-making.
- The use of AI algorithms has been increasingly common in the CAD field by providing improved diagnostic accuracy and automated, standardized interpretation and inference processes.
- CADXpert-CARDIO uses clinically validated models that can efficiently predict the Pre-test probability of stable CAD (Stenosis>50%) and does not require additional diagnostic testing.

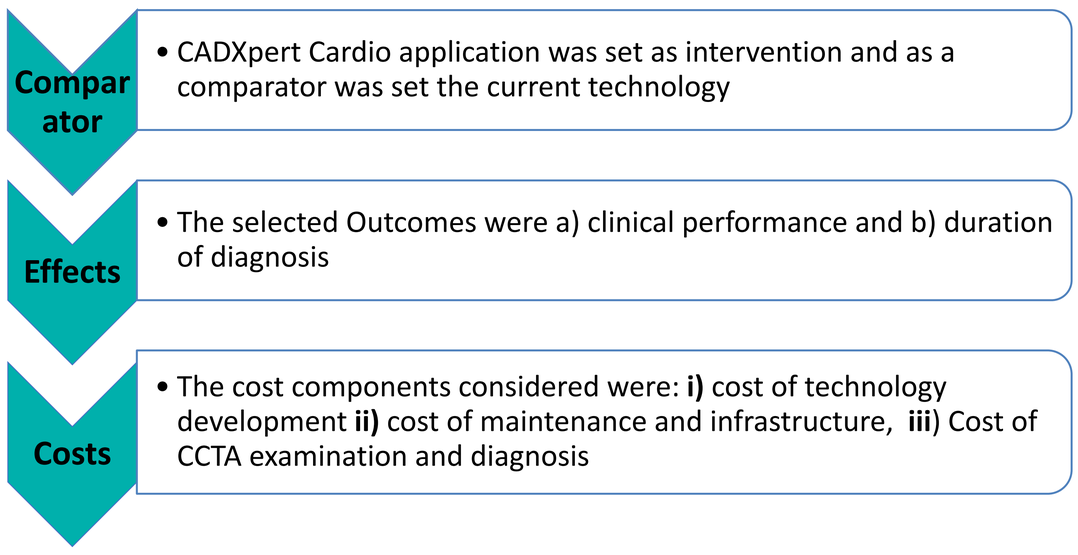
Objective

The study aims to analyze the economic and clinical performance of the CCTA tool on the accurate detection of CAD emerging from an automatic AI-based tool.

Methods

- 234 patients participated in the study at AHEPA General Hospital of Thessaloniki with the following inclusion criteria:
  - Symptoms of chest pain that underwent CCTA to exclude obstructive CAD
  - Age >18 years old
- A micro-costing analysis was performed, based on the perspective of the Greek healthcare system, to identify the following cost elements:
  - costs of development of the new AI technology,
  - cost of maintenance of the technology
  - cost of CCTA examination and diagnosis
- The selected Key Performance Indicators (KPIs) to capture the effectiveness of the new technology were a) clinical performance, b) user satisfaction, c) duration of diagnosis.
- The comparison with the current technology was performed incrementally (both costs and effects) to enable the cost-consequence analysis of the CADXpert CCTA application.
- The chosen methodology was cost-consequence analysis (CCA) since it enables the presentation of various impacts of an intervention individually, rather than combining them into a single metric, This approach enables a more holistic understanding of the effects, while leaving it to the decision maker to determine the relative significance of each aspect (Figure 1).

Figure 1. Components of costs and consequences in cost consequence analysis



- The model prediction variables were collected based on medical team recommendations. The variables used consisted of epidemiological and clinical parameters e.g., Age, smoking, Diabetes Mellitus, Arterial Hypertension, family history of premature CAD. The characteristics of the sample which were also used as model prediction variables are presented in Table 1.
- To prevent over-fitting, we assessed the prediction accuracy of all models under consideration using 10-fold stratified cross-validation and area under the receiver operating characteristic curve (ROC-AUC).
- In each cross-validation fold, a training sample (consisting of 70% of participants) was used to create all machine learning (ML) models, followed by a held-out sample (consisting of 30% of participants) for performance evaluation. The final model that was chosen for this clinical decision support task, is a Voting ensemble of the Logistic Regression and Xgboost. This model is embedded in the CADxpert application to provide the stenosis prediction.
- The application provided the prediction along with the explanation for each prediction. Then, the participants' care was provided according to standard clinical practice, independent of CADxperts results. The medical team was then provided with the final results from each case and collected them with the results from the CADxpert. These results were then used to evaluate the application.

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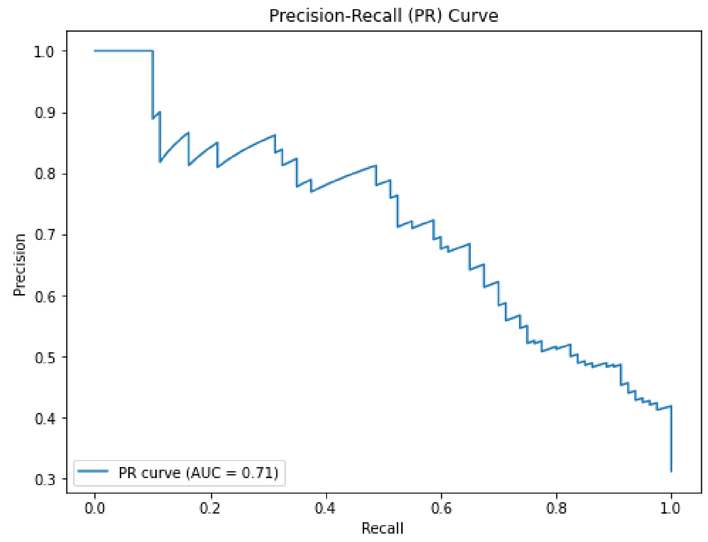
Table 1. Characteristics of the sample & Variables used at the Prediction Accuracy Model

Variable	Mean (Std. Dev)	Variable	Mean (Std. Dev)
Age (years)	58.02 ± 14.58	**Total cholesterol (mg/dl)**	206.28 ± 47.95
Gender	54% / 47% (Male vs Female)	**Total triglycerides (mg/dl)**	180.15 ± 64.26
Diabetes Mellitus	135 (52%)	**HDL (mg/dl)**	46.9 ± 10.8
Dyslipidaemia	131 (51.17%)	**LDL (mg/dl)**	123.34 ± 46.46
Smoking	133 (62.5%)	**Neutrophil to lymphocyte ratio (N/l=)**	1 (256) 100%
Family history of premature CAD	109 (43%) (yes, current smoker), 147 (57%) (no & never in the past)	**QRS duration (msec)**	89.52 ± 9.54
Peripheral Arterial Disease	130 (51%)	**ST segment abnormalities**	3 (1.17%)
Autoimmune Disease	10 (3.9%)	**LVEF (%)**	61.46 ± 8.16
Chronic Kidney Disease	12 (4.7%)	**LV diastolic dysfunction**	5 (2%) (Yes) 251 (98%) (No)
COPD	0	**Symptoms - angina**	73 (28%) (Asymptomatic), 78 (30%) (typical- angina), 61 (24%) (atypical-chest pain), 44 (16%)(dyspnoea)
BMI	6 (2.3%)	**Coronary Artery Calcium Score (Agatston Units)**	492.13 ± 734.37
Creatinine	32 ± 7	**Epicardial Fat Volume (cm3)**	224.4 ± 93.02

Results

- The Model's performance was rigorously evaluated reflecting its predictive capabilities in a real-world clinical setting. The PR curse indicates a moderate trade-off between precision and recall. The area under the curve (AUC) of 0.71 suggests a fair level of performance, especially in scenarios where the positive class is rare. Figure 2.

Figure 2. Model Precision Recall (PR) Curve



In table 2 the results of the cost consequences analysis are presented. Based on the cost analysis, the examination with the new HosmartAI technology is cost saving option, since the annual cost for all patients (n=239) has been estimated at €41.860 versus the €67.210 of the currently used system. The budget impact savings of the new AI CCTA examination have been estimated at €25.350 annually.

Table 2. Cost Consequence Analysis of CCTA Scenario

COST-CONSEQUENCES ANALYSIS PILOT 1 - CCTA SCENARIO			
Cost/Outcomes Categories	HOSMARTAI Intervention (Annual Cost)	Current Practice (annual cost)	Difference
Cost of AI Technology (personnel)	5.000 €	0 €	5.000 €
Cost of Maintenance	6.972 €	0 €	6.972 €
Cost of AI Infrastructure	170 €	0 €	170 €
CCTA Examination	127 €	286 €	-159 €
CCTA Examination (n=239 patients annually)	29.718 €	66.924 €	-37.206 €
Total Cost per year	41.860 €	67.210 €	-25.350 €
Consequences Categories	HOSMARTAI Intervention	Current Practice	Difference
Clinical Performance	84.00	77.00	7.00
Duration of diagnosis (Duration for Experienced Physician>2years)	3 examinations	2 examinations	1
Duration of diagnosis (Duration for Experienced Physician<2years)	3 examinations	2 examinations	1

Conclusions

CADXpert Cardio application, is a very promising technology in comparison to standard practice and seems to be a value for money option.

References

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