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Cost-Consequences Analysis (CCA) of Small Bowel Video Capsule Endoscopy (VCE) Digital Artificial Intelligence (AI) Monitoring Application Developed at HosmartAI (HORIZON 2020 FUNDED)

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Background

- VCE is an examination for diagnosing abnormalities of the gastrointestinal (GI) tract and, especially, the small bowel (SB).
- A camera-equipped device of pill shape and size is swallowed by the patient and records more than 50,000 images as it passes through the GI tract. At the end of the procedure, the images produced are examined by a gastroenterologist in the form of a video.
- The review time of a typical VCE video is approximately 2 to 4 hours, depending on the experience of the gastroenterologist.
- There is a clear unmet need for a new technology to reduce the time needed to evaluate the the capsule endoscopy (CE) videos.

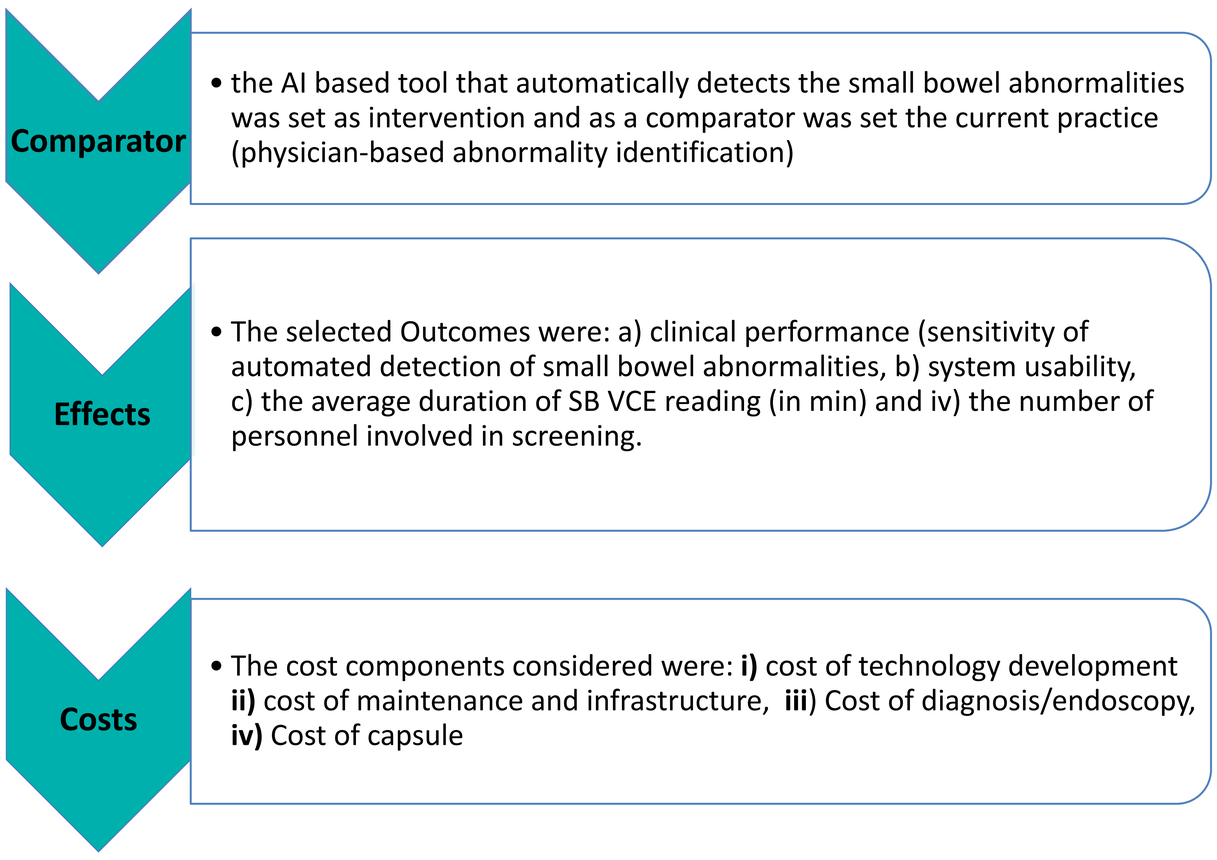
Objective

The study aims to analyze the economic and clinical performance of the automatic detection AI-based tool in detecting and classified the potential abnormalities by lowering the experience requirements and reducing the time for CE video examination.

Methods

- The selected Key Performance Indicators (KPIs) to capture the effectiveness of the new technology were a) clinical performance (sensitivity of automated detection of SB abnormalities), b) system usability, c) the average duration for completion of SB VCE reading (in min) and iv) the number of personnel involved in screening.
- The performance of the AI pipeline was evaluated using Receiver Operating Characteristic (ROC) analysis and calculating the area under the ROC curve (AUROC). The varying threshold for the ROC analysis was applied to the output of the last stage of the AI pipeline, i.e., a RetinaNet neural network. Next, based on the ROC analysis, the sensitivity and specificity of the optimal AI pipeline were resulted. The optimal AI pipeline was the one for which the threshold for detecting suspicious findings is calculated as the geometric mean between sensitivity and specificity.
- 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 endoscopy and cost of capsule.
- The comparison with the current technology was performed incrementally (both costs and effects) to enable the cost-consequence analysis of the AI based tool that automatically detects the small bowel abnormalities.
- The chosen economic evaluation 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.[1] 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).
- Usability was assessed with System Usability Scale (SUS).

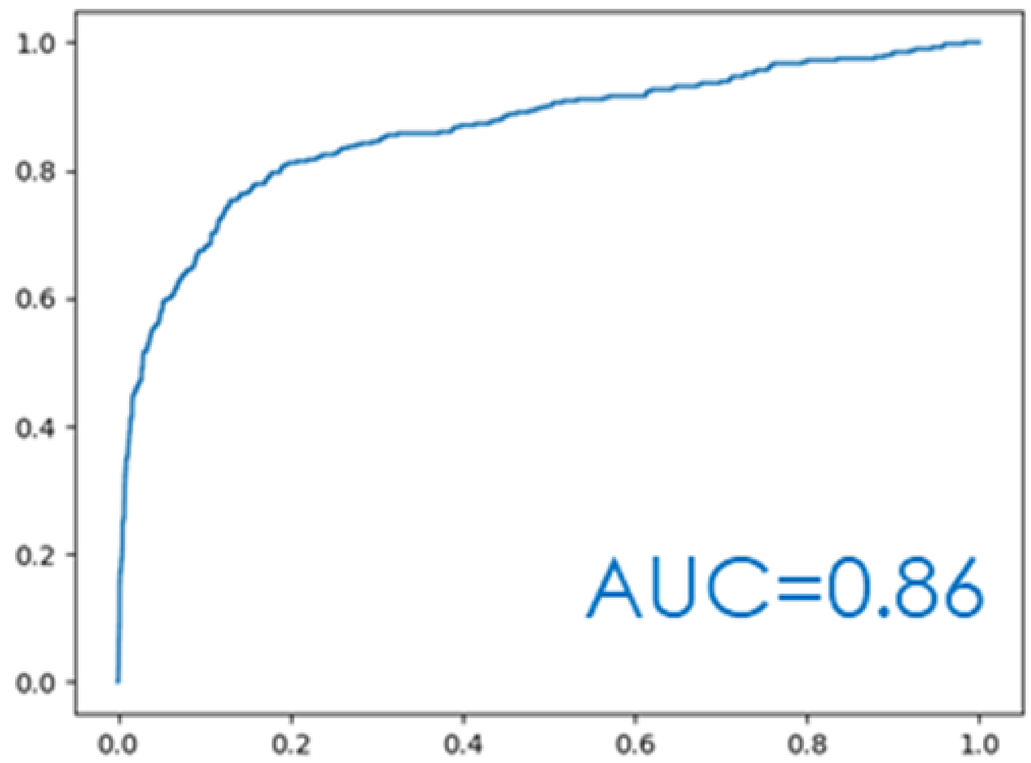
Figure 1. Components of costs and consequences in cost consequence analysis



Results

- The performance of the AI pipeline that detects and classifies abnormalities in CE videos is evaluated via ROC analysis measuring the area under ROC curve (AUROC).
- The varying threshold for the ROC analysis is applied to the output of the last stage of the AI pipeline, i.e., a RetinaNet neural network.
- The performance of the AI pipeline as presented by the ROC curve is shown in Figure 2. area under the ROC curve (AUROC) is 0.86.
- The sensitivity and specificity achieved by the optimal AI pipeline is 0.893 and 0.801, respectively.

Figure 2. ROC Curve of AI pipeline



- Regarding the usability assessment, the overall average SUS score is 76.4 (±7.2) %, so the usability of the platform can be characterized as "Good" and "Acceptable"[2]. The average SUS per experience group is 75.8 (±4.1) % and 76.7 (±8.4) % for Highly Experienced (HE) and Low Experienced (LE) physicians, respectively.
- To assess the time efficiency of the new approach, several gastroenterologists examined 20 VCE videos with and without the help of the AI tool. This was achieved via a dedicated web platform, developed in-house, that hosts and displays the VCE videos and records the reading time (in min) of each video[4]. The average duration of the physician-based assessment without the help of AI (current practice) was 240 min. while the one with the AI technology enabled was 60 min.
- In table 2 the results of the cost consequences analysis are presented. The annual cost of the new AI capsule endoscopy technology costs slightly more than current practice (€68.300 vs. €61.674) leading to extra annual cost of €6.626 which is attributed to the introduction of the new AI technology and infrastructure. Although in productivity terms, the new technology is time-saving due to shorter duration and human resources for the review, still the time difference was not enough to counterbalance the extra – low- cost difference from current practice. In terms of effectiveness, the new technology, seems very promising since it is as sensitive as current practice (0.89 vs 0.90), but needs only 1 physician to review the analysis, in comparison to 2 physicians currently. In terms of productivity, it takes 60 minutes for the review with the AI technology vs. 240 minutes currently. As far as user satisfaction is concerned, the new AI technology presents high level of user satisfaction reaching 76,4%.

Table 2. Cost-Consequences Analysis of AI Video Capsule Endoscopy

COST-CONSEQUENCES ANALYSIS PILOT 1 - VIDEO CAPSULE ENDOSCOPY 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	3.000 €	0 €	3.000 €
Cost of Capsule	60.000 €	60.000 €	0 €
Small bowel capsule endoscopy review	0 €	1.674 €	-1.674 €
Cost of infrastructure	300 €	0 €	300 €
Total Cost per year	68.300 €	61.674 €	6.626 €
Consequences Categories	**HOSMARTAI Intervention**	**Current Practice**	**Difference**
System Usability (SUS)	76,40%	70%	6%
Sensitivity of automated detection of small bowel abnormalities	0.89	0.90	-0.01
Average time for completion of small bowel VCE reading (in min)	60.00	240	-180.00
Number of Personnel involved in screening/examination	1 senior doctor	1 resident doctor & 1 senior doctor	resident doctor - 1

Conclusions

- The new AI technology can play the role of the pre-assessment procedure by reducing the time of the assessment/reading spent by the physician, presenting high accuracy and acceptance levels. Additionally, it seems to be a good value for money option with high potential.

References

1. NICE. Evidence standards framework for digital health technologies. Cost consequences and budget impact analyses and data sources. In: National Institute for Health and Care Excellence London, UK; 2019.
2. Bangor, A., Kortum, P. T., & Miller, J. T. (2008). An empirical evaluation of the system usability scale. Intl. Journal of Human–Computer Interaction, 24(6), 574-594.
3. https://www.hosmartai.eu/
4. Apostolidis, G., Kakouri, A., Dimaridis, I., Vasileiou, E., Gerasimou, I., Charisis, V., ... & Hadjileontiadis, L. (2024). A web-based platform for studying the impact of artificial intelligence in video capsule endoscopy. Health Informatics Journal, 30(4)

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