Patient perspectives on digital technology and experiences of computerized history taking for chest pain management in the emergency department: The CLEOS-CPDS prospective cohort study

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Submitted to: Journal of Medical Internet Research
on: August 19, 2024

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Abstract

Background: Automated, self-reported medical history taking has the potential for improving the physician - patient dialogue and for delivering patient - reported information across a wide range of clinical issues. Medical history data was entered by patients on a tablet in an emergency department in the CLEOS?Chest Pain Danderyd Study (CLEOS-CPDS). Since successful implementation of this technology depends on understanding patients' views and willingness to use such technology, we have studied this after their entry into the CLEOS study.

Objective: To develop a questionnaire to investigate patients' attitudes, perceptions and skills when using digital technology in health care in general and their experience of using the CLEOS program at an emergency department, which they visited for care of chest pain.

Methods: The study design included the development of a questionnaire, followed by a cross-sectional study. Questionnaire design and the Technology Acceptance Model underpinned the development of the questionnaire. The think-aloud method was used to test the questionnaire. Adults who participated in the CLEOS-CPDS were invited consecutively to respond to the questionnaire. Descriptive and correlational analyses were performed.

Results: The refinement of the questionnaire included language revision, removal of similar items and replacement of some response formats. The final questionnaire consisted of 16 items and one free text comment that assessed attitudes, perceptions, and skills related to the use of digital technology in health care in general and the specific experience of using the self-reported history taking by CLEOS. The mean age of the participants was 56 years. A clear majority of the 129 patients who answered the questionnaire found it easy to use digital technology in general. Most believed that digital technology has a role when seeking health care; and two thirds believed that patient-reported symptoms are helpful in making a diagnosis. Most felt confident in answering the CLEOS-CPDS questions on a tablet. However, one third were concerned that the interaction between patient and physician would be disrupted when using digital technology in health care. Correlation analyses showed that older age was associated with less ease (p?0.001), confidence (p?0.001), and trust (p=0.002) when using digital technology. Moreover, older

age was associated with worry that the patient-doctor personal contact would be disrupted when using digital technology in health care (p=0.001)

Conclusions: This study indicates strong approval of usefulness and trust of digital technology in health care but the concern for lack of personal contact should be acknowledged. The CLEOS program performed well for end users but would benefit from some adjustments for future studies. The questionnaire obtained new insights on perceived usability of digital technology for health care delivery and appears relevant for future evaluations in other contexts. Clinical Trial: ClinicalTrials.gov NCT03439449

(JMIR Preprints 19/08/2024:65568)
DOI: https://doi.org/10.2196/preprints.65568

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Patient perspectives on digital technology and experiences of computerized history taking for chest pain management in the emergency department: The CLEOS-CPDS prospective cohort study

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ABSTRACT

Background: Automated, self-reported medical history taking has the potential for improving the physician - patient dialogue and for delivering patient - reported information across a wide range of clinical issues. Medical history data was entered by patients on a tablet in an emergency department in the CLEOS-Chest Pain Danderyd Study (CLEOS-CPDS). Since successful implementation of this technology depends on understanding patients' views and willingness to use such technology, we have studied this after their entry into the CLEOS study.

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Conclusion: This study indicates strong approval of usefulness and trust of digital technology in health care but the concern for lack of personal contact should be acknowledged. The CLEOS program performed well for end users but would benefit from some adjustments for future studies. The questionnaire obtained new insights on perceived usability of digital technology for health care delivery and appears relevant for future evaluations in other contexts.

Trial Registration: ClinicalTrials.gov NCT03439449

Keywords: Acceptance, Chest pain, Computerized medical history taking, Digital Technology, Emergency department, Health informatics, Medical history taking, Self report

INTRODUCTION

Automated, self-reported medical history-taking can become a key technology for maximizing outcomes for patients, for improving the physician - patient dialogue and for delivering patient - reported information to the point of care across a wide range of clinical issues [1,2]. Programs for computerized medical history taking (CHT) that interact directly with patients in clinical settings collect more complete and accurate data, as compared to physician entries in patients' medical records [3,4]. For example, the CHT program Clinical Expert Operating System (CLEOS) provided sufficient data for risk stratification for a major adverse cardiac event using the well-established HEART score in approximately 77% of 1000 emergency department (ED) patients with chest pain [5]. In contrast, risk stratification was only feasible for 31% of the patients when relying on data from the electronic health record [6]. CLEOS collects self-reported medical history data entered by patients on a tablet during hospital waiting times before or after seeing a physician [7]. The program emulates clinical thinking continuously through its automated interpretation of all prior answers as data is collected.

Effective implementation of CHT programs in health care requires that we understand patients' concerns and attitudes about such programs and their willingness to use them. Studies of patients' perceptions within this field are scarce; but early work suggests that CHT software is well-accepted by patients [8,9]. The introduction of technology in health care can both facilitate and constrain individuals from providing health related information and interacting with health care professionals [10]. When developing health technology solutions, it is important to consider patients' digital health literacy – the ability to understand and communicate basic health information and to express health concerns to health care professionals in the context of technology. A review concluded that digital tools in healthcare can empower patients and facilitate personalized communication with the healthcare system. They also can pose a barrier for communicating relevant information due to patients' poor digital and health literacy as well as their concerns for the privacy of their medical data [11].

We previously performed an interview study of patients seeking ED care for chest pain as part of our ongoing studies of patient-experience with the use of CLEOS [12]. Generally, CLEOS was well accepted by the patients and could be managed despite their experience of a busy ED. The interviews yielded insight into the influence of context, clinical content, and technology on the program's usability. The program was perceived sometimes, for example, as too extensive. We did not address previously, however, patients' perceptions of the ease of use of the program and its possible impact

on the value of health care they would receive. These are two determinants identified in the Technology Acceptance Model (TAM) for acceptance of computer technology by its potential users [13]. Obviously, effective development of patient-directed health care technology depends on detailed understanding of patient perceptions of the technology. Detailed study of patient perceptions of this technology, based on real-time use by patients with significant medical issues, will provide insights for developers of such programs and health care managers on important factors that influence an individual's intention to use digital technology effectively as they seek health care. Accordingly, this study aimed to develop a questionnaire to investigate patients' attitudes, perceptions, and skills related to using digital technology in health care in general, and specifically their experiences with the CLEOS program in an ED setting.

METHODS

Design

The study design included i) the development of a questionnaire and ii) a cross-sectional study investigating the outcomes of the questionnaire in a study population attending the ED with chest pain. This study is part of the CLEOS-Chest Pain Danderyd Study (CPDS) presented in detail elsewhere [7]. It has been approved by the Swedish Ethical Review Authority (reference number 2015/1955-1) and is registered at https://www.clinicaltrials.gov (NCT03439449).

Questionnaire development

The questionnaire development was guided by questionnaire design [14,15] and by results from our interview study investigating patients interacting with CLEOS in an ED [12]. The construction of items in the questionnaire was inspired by the System Usability Scale (SUS) [16]. The SUS is a standardized questionnaire for the assessment of perceived usability. It does not cover all areas of significance for the research questions we address here. Therefore, we used the TAM model [13] to give further structure to the development of questions. The TAM determines an individual's evaluative judgment of the target behavior in some dimension (attitudes). For example, it includes the perception that using an IT system will be free of effort (perceived ease of use) and will enhance performance (perceived usefulness). Another determinant in the TAM model is the specific behavior when interacting with the technology of the CHT program (use). The Swedish functional health literacy scale [17] was employed to develop questions to evaluate an individual's digital health literacy (skills). All areas of interest (attitudes, perceptions, use and skills) were entered into a template guiding the construction of the questionnaire (Appendix 1). Two scaling methods were

chosen initially for capturing patients' responses in the questionnaire. These were the Likert method (strongly agree, agree, undecided, disagree, strongly disagree), and a frequency scale with fixed choice responses (never, seldom, sometimes, often, always).

Face validity test of questionnaire

During January 2022, 14 patients visiting the cardiology ED at Danderyd University Hospital with acute chest pain and taking part in the CLEOS-CPDS prospective cohort study were asked to participate in the development of the questionnaire. The selected patients represented a variation in age and gender. If they agreed to participate, an information letter and a questionnaire was sent to their home by post and a few days later a researcher (KS or KF) contacted them by phone. We used the think-aloud (TA) method [18] to test the face validity of the questionnaire. During the phone call, the respondents were asked to fill in the questionnaire, encouraged to think out loud and to verbalize any thoughts while doing so. This provided an opportunity for listening to their understanding of each item as they worked through the questionnaire. In addition, probing questions were asked when the session leader needed further clarification. At the end of the TA session, all participants were asked if they had any additional comments that had not been addressed during the session. The content of the sessions was recorded in a spreadsheet to facilitate the evaluation and revision of the questionnaire.

Investigating outcomes of the questionnaire

Sample and setting

Adult patients (≥18 year) with acute chest pain, presenting to the ED at Danderyd University Hospital and participating in the CLEOS-CPDS from May until November 2022 (n=288, mean age 55 years, 41 % women) were invited to answer the questionnaire. Before discharge from the ED, patients were invited consecutively by a study nurse to participate. Those who agreed were given study information and a paper copy of the questionnaire, along with a pre-paid return envelope. Of the 130 questionnaires returned, one was blank, leaving 129 participants.

Analysis

The items in the questionnaire were analyzed using descriptive statistics, including frequencies and percentages. Spearman's *rho* was used to explore the correlations between age and attitudes of using digital technology rated as "yes", "often", "sometimes", "seldom", or "no". The interpretation of the results depended on whether the questions were posed in a negative or positive way. Conventional content analysis was applied for the free text comments [19]. The comments were entered into a document and coded by highlighting similar texts in the same color, followed by categorizing into

color-coded clusters. To determine the frequency of similar comments, a response frequency chart was used.

RESULTS

Development of the questionnaire

The initial version of the questionnaire contained a total of 19 items and an additional 4 sociodemographic questions. The items concerned experience of use of digital technology in general, the use of digital technology in health care, and the use of the CLEOS program.

Twelve individual TA sessions were held, involving 6 women and 6 men, with mean age 72 (min 37 – max 82) years. A majority had postgraduate/university (n=7) as the highest level of education, followed by senior high school (n=2), junior compulsory (n=3), and a majority were retired (n=8.

Based on the results of the TA sessions, the wording of two questionnaire items was revised. For item 5 the word “lean on” was changed to “depend on” and for item 7 the word “relation” was changed to “personal contact”. Three items were removed because they were similar to other items and did not contribute to the evaluation of CLEOS. Moreover, the response format “strongly agree” to “strongly disagree”, which was used in seven items, was perceived as difficult to understand. It was replaced with the response format “yes”. “often”, “sometimes”, “seldom” or “no” which was consistent with the allowed response alternatives for all other items. The revised questionnaire had 16 items and one free text comment (Appendix 2). The first set of questions assessed attitudes, perceptions, and skills related to the use of digital technology in health care (Table 1). The second set evaluated the specific experience using self-reported history taking by CLEOS (Table 2). The questionnaire included a combination of positively and negatively phrased items, response alternatives such as (yes/no/uncertain), Likert scales (strongly agree - strongly disagree), and frequency scales (yes/often/ sometimes/seldom/no).

Table 1. Attitudes, perceptions and skills related to the use of digital technology in health care

	Yes	No	Uncertain			n
Have encountered digital technology previously in contact with health care	63 (50)	59 (46)	5 (4)			127
Digital technology has a role when visiting health care	115 (91)	2 (1)	10 (8)			127
	Yes	Often	Sometimes	Seldom	No	
Find it easy to use digital technology	104 (80)	14 (11)	9 (7)	1 (1)	1 (1)	129
Feel confident to use digital technology	105 (81)	13 (10)	7 (5)	3 (2)	1 (1)	129

Trust the digital technology to function as intended when visiting health care	84 (66)	31 (24)	10 (8)	0	2 (2)	127
Worry that information regarding own health collected by digital technology will be disclosed to unauthorized persons	4 (3)	1 (1)	18 (14)	31 (24)	73 (58)	127
Worry that the patient doctor personal contact is disturbed when digital technology is used in health care	11 (9)	3 (2)	34 (27)	22 (17)	58 (45)	128
Believe that patient reported symptoms using digital technology are helpful for the physician when making a diagnosis	60 (47)	23 (18)	35 (28)	6 (5)	3 (2)	127
Believe that patient contribution is valuable when developing digital technology in health care	100 (78)	17 (14)	8 (6)	3 (2)	0	128

Data are presented by numbers and (%) from the total sample (N=129)

Table 2. Correlations between age and attitudes of using digital technology

Attitudes	**Correlation Coefficient**	***P*-value**
Find it easy to use digital technology	.342**	<. 001
Feel confident to use digital technology	.410**	<. 001
Trust the digital technology to function as intended when visiting health care	.278**	.002
Worry that information regarding own health collected by digital technology will be disclosed to unauthorized persons	-.078	.394
Worry that the patient doctor personal contact is disrupted when digital technology is used in health care	-.283**	.001
Believe patient reported symptoms using digital technology are helpful for the physician when making a diagnosis	-.020	.826
Believe that patient contribution is valuable when developing digital technology in health care	.129	.155

Results for 127-129 participants. Tested by Spearman´s rho. The items were rated as “yes”, “often”, “sometimes”, “seldom”, and “no”. A significant positive correlation means a strong relationship between older age and “no” and, a significant negative correlation means a strong relationship between older age and “yes”.

Outcomes of the questionnaire

The mean age of the 129 patients who answered the questionnaire was 56 years (18-89). There were more men (62%) than women (Table 3).

Table 3. Socio demographic characteristics for participants answering the questionnaire

Age, mean (min-max)	56	(18–89)
Sex		
Women	49	(38)
Men	79	(61)
Missing	1	(<1)
Education level,		
Junior compulsory	7	(5)
Senior high school	47	(37)
Postgraduate/university	74	(58)
Missing	1	(<1)
Occupation		
Working/student	87	(67)
Retired	40	(31)
Unemployed/sick leave	2	(2)

Data are presented by numbers and (%) from the total sample (N=129), if not otherwise stated.

Attitudes, perceptions, and skills

Most participants found it easy or often easy (91%) and felt confident or often confident (91%) using digital technology. Most (91%) believed that digital technology has a role when visiting health care. Half (50%) had not previously encountered or were not sure if they had encountered digital technology in interactions with health care. Almost all (90%) trusted the digital technology to operate as intended during health care visits. One fifth (18%) was concerned or sometimes concerned that information regarding their own health collected by digital technology would be disclosed to unauthorized persons. Furthermore, one third (38%) was concerned or sometimes concerned that the interaction between patient and physician would be disrupted when using digital technology in health care. Two thirds (65%) believed that patient reported symptoms using digital technology are helpful for the physician in making a diagnosis. A clear majority (78%) believed that patient contribution is valuable when developing digital technology in health care (Table 1).

Correlations between age and attitudes of using digital technology

Significant positive correlations were found between age and the items “I find it easy to use digital technology” (p=<.001), “I feel confident to use digital technology in general” (p=<.001), and “I trust the digital technology to function as intended when visiting health care “(p=.002). The items were rated as “yes”, “often”, “sometimes”, “seldom”, and “no” indicating that older age is associated with less ease, confidence, and trust in using digital technology. A significant negative correlation was

found between “I worry that the patient-doctor personal contact is disturbed when digital technology is used in health care” (p=.001), rated as “yes”, “often”, “sometimes”, “seldom”, and “no”, indicating that higher age is associated with greater concern (Table 2).

Experience of using CLEOS

Most respondents (90%) were confident or often confident to answer the questions on a tablet in the CLEOS-CPDS study. Almost all (97%) could make use of the content in the text. Most participants (86%) reported a high level of understanding of the terminology used in the CLEOS program, and a majority (69%) did not or seldom find that the questions were difficult to answer. A majority of respondents (72%) found that the questions in the CLEOS program were relevant. Slightly more (79%) thought it had been easy or often easy to find relevant response alternatives (Table 4).

Table 4. Experience of answering questions regarding own health using CLEOS on a tablet

	Yes	Often	Sometimes	Seldom	No	n
I was confident answering the questions	90 (70)	25 (20)	11 (9)	1 (1)	1 (1)	128
I could make use of the content in the text	92 (71)	33 (26)	3 (2)	0	1 (1)	129
It took long time for me to read the text	5 (4)	5 (4)	23 (18)	21 (16)	75 (58)	
There were words that I did not understand	6 (5)	1 (<1)	11 (9)	26 (20)	85 (66)	129
It was difficult to answer the questions	2 (2)	4 (3)	34 (26)	36 (28)	53 (41)	129
The questions were relevant	46 (36)	47 (36)	32 (25)	4 (3)	0	129
It was easy to find relevant response alternatives	34 (26)	68 (53)	26 (20)	0	1 (1)	129

Data are presented by numbers and (%) from the total sample (N=129)

Free text comments

The last item in the questionnaire allowed for patients’ own comments regarding the experience of performing the CLEOS interview on the tablet (Table 5). Forty percent of the patients left comments concerning: Time aspects regarding the CLEOS interview (n=11); perceptions regarding the interview questions included in CLEOS (n=13); perceptions regarding the response alternatives (n=13); perceptions of technical performance (n=6); perceptions of layout (n=9); difficult to

understand words (n=6); not confident in using (n=2).

Table 5. Examples of comments in the questionnaire

Time aspects regarding the CLEOS interview (n=11)
It was too extensive and time consuming, it was tiresome to answer all the questions and hard to stay focused, not enough time to answer all questions.
Perceptions regarding the questions (n=13)
Lacking questions (ie a question about other diseases), questions that were grammatically wrong, not translated from German or English, questions about a topic that never ended or unrecognizable scenarios becoming increasingly irrelevant, questions that were incomplete and lacking an illustration (image), irrelevant follow-up question (i.e requested to answer “what kind of surgery” after having said no to “had any surgery”).
Perceptions regarding the response alternatives (n=13
Lacking an appropriate alternative, wanting more alternatives or “I don’t know”, having to answer “how often” after answering no to a symptom occurrence, not finding a prescribed medication in the list of medicines.
Perceptions of technical performance (n=6)
A slow interface, technical or internet problems.
Perceptions of layout (n=9)
The size of the text was too small, unclear transition to the next page, not clear when the questions had ended, an inert maneuvering.
Difficult to understand words (n=6)
Connotation of wording i.e that some words needed explanation, that medical terms were difficult, some test was strangely worded.
Not confident in using (n=2)
Feeling uncertain about using the technique, “talking” to a doctor on a screen feels impersonal.

DISCUSSION

Principal results

This study included a developing process of a questionnaire and a cross-sectional study that evaluated patients’ attitudes towards digital technology in health care and experiences of interacting with a CHT program while attending an ED setting for chest pain. The questionnaire development process required only minor changes for the final version. Overall, the findings from the evaluation of using the CLEOS program showed a high acceptance of digital technology when incorporated in health care as well as user confidence and high digital literacy among the participants.

Comparison with prior work

In general, there was a favorable attitude towards digital technology, with many participants expressing their faith in its potential to help physicians in making accurate diagnoses. Although not all had previous experience using digital technology in health care encounters, a clear majority in this study had a positive attitude about the role of such technology when visiting health care. Moreover, most were confident to use CLEOS. This is in line with the results by Arora et al. [8] who were early

to use a CHT program in the waiting area of an ED. In that study, the overall impressions among the patients were that they would like to fill out a digital questionnaire again in the future. In a more recent pilot study assessing digital patient self-anamnesis in the waiting area of an ED, 63% agreed to filling out a digital questionnaire again [20]. In another study evaluating medical history taking via an app in general practice, the usability score (evaluated by SUS) was in favor of acknowledging a recurrent use of the app [21]. The app described in that study is similar to a CHT program that emulates clinical thinking, but the app uses a branching logic that is adaptive to patient responses instead of automated interpretation of prior answers. While a clear majority expressed a trust in the technique when used in health care interactions, there were some concerns about data security and privacy in the present study. The high level of trust in digital technology to function well was somewhat surprising in our present results, given that only just over half of the respondents had previously encountered digital technology when in contact with health care. Altogether, the data so far supports a high level of patient acceptance of health care technology when visiting health care facilities, including EDs.

There was a modest but noteworthy concern about disrupted patient-physician interaction when using digital technology in health care. This concern was more pronounced in older patients. As there are no other CHT programs like CLEOS and very few other comparable systems, it is hard to conclude what these results mean. A related area in healthcare, however, is patients' opinions on the patient-doctor relationship and communication with physicians using electronic medical records (EMR). Perceptions of such computer use during the health care visit were compiled in a systematic review. The authors concluded that it did not substantially affect the quality of communication with their physician [22]. In a survey examining perceived benefits and risks of using artificial intelligence (AI) applications in health care, communication barriers emerged as the most significant predictors of perceived risks [23]. The authors discussed that the loss of face-to-face cues and lack of interaction with physicians would give the patient a more passive position. On the other hand, their results showed that if users believe that AI-based devices can improve diagnostics and patient management systems, they become more prone to use them. A review showed that digital tools in health care can be facilitators for factors such as empowerment, and personalized communication with health care [11]. Reciprocally, patient empowerment contributed to patient uptake of digital health tools. The study concluded too that digital tools could facilitate a shift from paternalistic health care models to those in which relationships between clinicians and patients are more collaborative. Based on those findings, we agree that patient-physician communication through

modern technology could be perceived as positive by patients. Nevertheless, our results also tell us that patients' trust, especially with rising age, needs to be ensured and further investigated before CHT programs are integrated into standard clinical practice.

The ability to understand and make use of the content in the CLEOS program was overall very satisfactory. Low digital and health literacy have been described as barriers to implementation of digital tools [10,11]. Our results may be a consequence of a presumed high health literacy among the participants related to a relatively high educational level, known as a strong associated factor [24]. Higher age could be another barrier. The present results suggest that older people are more likely to experience less ease and confidence in using digital technology. This could explain why being 70 years or older was found to be a negative factor for completing the program in a previous study of the CLEOS-CPDS cohort [5]. Similarly, Albrink et al. [21] found that age was negatively associated with the usability SUS score when evaluating their app, suggesting that older people may face challenges in handling such an app.

Our study shows a strong support for including end users when designing new digital technology in health care. This confirms findings by others who recommend a participatory approach in the design of future digital health care [25-27]. The free text comments revealed aspects for improvement of the CLEOS program such as high time consumption, ambiguous questions, and slow technical performance. These results align well with those from our previous interview study [12], highlighting the need for further development of the program.

The challenge of developing questionnaires in research is to achieve high validity and reliability. Accordingly, the questionnaire development was guided by a robust process based on the results of our previous interview study and other recognized methods. Furthermore, the development process included the think-aloud method [18], which allowed the participants to speak freely while testing the questionnaire. This provided valuable information about the comprehensibility of the questionnaire. Presumably, all areas of interest were covered sufficiently. However, to be sure that the questionnaire measures what is intended, further evaluations in future studies are needed. The convenience sample of patients who responded to the questionnaire may not be representative of all patients seeking care at the cardiology ED. The selected sample may have had a positive attitude towards digital technology as they had consented to participate in the CLEOS-CPDS study. Other selection biases could be a slight overrepresentation of men in the sample and an uneven distribution of education level. Furthermore, we lack information about those who did not fulfil the criteria for inclusion e.g., fluency in Swedish, or declined participation both in CLEOS-CPDS and in the current

study.

Conclusion

This study indicates strong acceptability and trust of digital technology in health care. However, the concern for lack of patient and doctor personal contact should be acknowledged. Digital technology was seen as an important facilitator but not as a replacement of human interaction. The CHT program (CLEOS) studied performed well for end users but would benefit from some adjustments for future studies. The questionnaire responses yielded new insights on the use of digital technology for health care delivery. The questionnaire appears relevant and may be useful in other contexts in future evaluations of CHT.

Acknowledgements

All authors contributed to the conception and design of the study. KF and KS drafted the manuscript. All authors revised the manuscript for intellectual content and approved the final text. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

The authors would like to thank the patients who participated in this study. This study was funded by the Robert Bosch Stiftung (Stuttgart, Germany), grant number 11.5.1000.0258.0, Region Stockholm (ALF project; Stockholm, Sweden), grant number FoUI-954046 and FoUI-962663 and institutional funds from Department of Learning, informatics, management and ethics, Karolinska Institutet (Stockholm, Sweden).

Conflicts of Interest

DZ is the inventor on US patents for technology related to the CLEOS program. All patent rights and copyrights to technology, language, images and knowledge content are assigned without royalty rights by DZ to Karolinska Institutet, Stockholm, Sweden, which is a public university. Only Karolinska Institutet and its subsidiaries may be owners or receive royalties or other revenue from use of CLEOS technology, language, images, knowledge content or from clinical insights and/or computer algorithms generated from analysis of data acquired by the program.

Abbreviations

CHT: computerized history taking

CLEOS: clinical expert operating system

CLEOS-CPDS: CLEOS chest pain Danderyd study

ED: emergency department

HEART: history, electrocardiogram, age, risk factors and troponin

TAM: Technology Acceptance Model

SUS: System Usability Scale

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Supplementary Files