International Journal of Medical Informatics 85 (2016) 61–67

Contents lists available at ScienceDirect

International Journal of Medical Informatics

journal homepage: www.ijmijournal.com

Criterion validity of a computer-assisted instrument of self-triage (ca-ISET) compared to the validity of regular triage in an ophthalmic emergency department

Eva S.V. Eijk[a,b,*], Marijke Wefers Bettink-Remeijer[c], Reinier Timman[b], Marion H.B. Heres[c], Jan J.V. Busschbach[b]

[a] Rotterdam Ophthalmic Institute, Schiedamse Vest 160D, 3011 BH Rotterdam, the Netherlands
[b] Department of Psychiatry, Section of Medical Psychology & Psychotherapy, Erasmus MC, 's-Gravendijkwal 230, 3015CE Rotterdam, the Netherlands
[c] Rotterdam Eye Hospital, Schiedamse Vest 180, 3011 BH Rotterdam, the Netherlands

ARTICLE INFO

Article history:
Received 9 September 2014
Received in revised form 14 October 2015
Accepted 15 October 2015

Keywords:
Sensitivity and specificity
Triage
Computer-assisted decision making
Validity
Equipment design
Emergency department

ABSTRACT

Objectives: The computer-assisted version of a self-triage tool (ca-ISET) for an ophthalmic emergency department (ED) was developed to increase the validity of the triage procedure when trained ED staff is absent.

Methods: We tested whether sensitivity, specificity, Negative Predictive Value (NPV) and Positive Predictive Value (PPV) of the ca-ISET deviated from regular triage. Patients ≥18 years visiting the ED of the Rotterdam Eye Hospital in the Netherlands were invited to participate in this prospective study. This ED focuses on eye-related problems. Patient recruitment was carried out during working hours. The ca-ISET is a touch operated software application and the algorithm of the triage is based in the Manchester triage system. For all participants three triage scores were determined by (1) the participant using the ca-ISET; (2) triage by a regular, trained triage assistant and (3) triage by one physician who was specially trained in ophthalmic triage. The diagnosis of the physician was chosen as the reference standard to define criterion validity. The order of triage administration was alternated per patient. Only cases with triage scores from the two triage systems and the reference standard were included. The outcome variables, four triage colours, were transformed into a binary score: high urgent and low urgent. The difference between the ca-ISET and regular triage in terms of sensitivity, specificity, NPV and PPV was tested by *Z*-scores.

Results: Of 247 eligible patients, data was elicited from 189 patients (average age 54 years, range 18–89). The sensitivity of the ca-ISET (0.89, CI: 0.75–0.96) did not differ from the sensitivity of the regular triage (0.69, CI: 0.53–0.82, $Z = 1.74$, $p = 0.08$). The ca-ISET was less specific (0.78, CI: 0.71–0.84) than the regular triage (0.92, CI = 0.86–0.95, $Z = 3.04$, $p = 0.00$). We found no significant difference between the ca-ISET and regular triage for PPV ($Z = 0.19$, $p = 0.85$) and NPV ($Z = 0.03$, $p = 0.98$).

Conclusions: The sensitivity, PPV and NPV of the ca-ISET does not differ from the sensitivity of the regular triage, while the ca-ISET retained a reasonable level of specificity. Therefore the ca-ISET can be recommended as a tool for ophthalmic emergency departments, and could be used when trained ED staff is absent.

1. Introduction

Emergency departments (ED's) are often overcrowded and need triage systems to categorize patients according to the urgency of their complaints [1,2]. In the Rotterdam Eye Hospital in the Netherlands, general triage systems do not apply due to the specialised character of the hospital. In response to a shortage of trained staff outside office hours, the authors of this paper previously developed a pen-and-paper instrument for patient self-triage

* Corresponding author at: Rotterdam Ophthalmic Institute, Schiedamse Vest 160D, 3011 BH Rotterdam, the Netherlands.
E-mail addresses: e.s.vaneijk@gmail.com (E.S.V. Eijk), m.wefers@oogziekenhuis.nl (M. Wefers Bettink-Remeijer), r.timman@erasmusmc.nl (R. Timman), m.heres@oogziekenhuis.nl (M.H.B. Heres), j.vanbusschbach@erasmusmc.nl (J.J.V. Busschbach).

http://dx.doi.org/10.1016/j.ijmedinf.2015.10.003
1386-5056/

(ISET) [3] for the ophthalmic emergency department. The ISET enables triage by patients themselves instead of triage by the triage-assistant by assessing the severity of the patient's condition. The pen-and paper ISET was validated by comparing ISET triage outcome to regular triage outcome based on the Manchester Triage System [4] and was presented as a sensitive and specific tool for the ophthalmic ED [3].

To implement the ISET in the ED of the Rotterdam Eye Hospital, a computer-assisted version of the ISET (ca-ISET) was developed [5]. The ca-ISET is a touch operated software application that presents one question at a time about the patient's ophthalmic complaints. After a maximum of 24 questions the ca-ISET assesses patient priority based on the flow charts of the Manchester Triage System.

Digitalization of procedures in the ED [6–9] or computer-assisted triage [10–12] is not new. The benefits of interviewing patients using a computer have been established before [13]. It has previously been shown to be feasible to use a self-administered computer-assisted history-taking device [14,15] for diagnostic support in emergency departments. However, self-administered computer-assisted triage for the prioritization of patients visiting the ED has not been previously reported.

Sensitivity and specificity of the pen-and-paper ISET were established using the judgments of the regular triage assistants as the reference standard [3]. In order to validate the ca-ISET in the current study, an even better reference standard criterion was chosen, i.e. the triage scoring by the physician. The physician could be seen as almost the best reference level. In that respect one could say that we test 'the criterion validity' of the ca- ISET. As we also registered the judgments of the regular triage assistant, were able to test could compare the criterion validity of the regular triage assistant as well.

2. Materials and methods

2.1. Setting

The research took place in the waiting room of the Rotterdam Eye Hospital emergency department, which is exclusively visited by patients with an ophthalmic complaint. The Rotterdam Eye Hospital is the only specialist eye hospital in The Netherlands and the ED is visited by approximately 25,000 unique patients annually.

2.2. Study design

The study was conducted on 14 test days between 9:00 am and 5:00 pm in the study period between 13th December 2011 and 03rd February 2012. The study was not conducted on national holidays such as Christmas and New Year's Day.

Consecutive patients ≥18 years old visiting the ED with ophthalmic complaints were invited by the researcher, ESVE, to participate in the study. Patients who had visited the ED previously with the same complaints were excluded, as well as unaccompanied patients who did not read or speak Dutch well enough to fill in the questionnaire.

Before they formally registered at the ED reception desk, participants were informed about the study by the researcher and they were asked to sign a form giving their consent. In order to obtain the required triage codes to validate the ca-ISET, the participants were allocated alternately to one of the two study routes: (1) first the ca-ISET, then the regular triage, followed by the physician's triage; or (2) first the regular triage, then the ca-ISET followed by the physician's triage. For all participants the three scores were determined consecutively with no pause in between. After the physician's triage, participants proceeded to the ED and waited in the waiting room for their consultation with the ophthalmologist. The order of triage administration was noted. At the end of each test day the triage scores were collected by the researcher from the ca-ISET, the triage assistants and the physician.

Patients were allocated in an alternated sequence as fairly as possible to first the ca-ISET and then the regular administration or the other way around. However, the ED was sometimes confronted with several patients visiting at the same time. When this happened, the researcher lacked time to allocate the participants to one of the two routes and patients would inevitably go directly to the regular triage assistant first.

The participants were unaware of the triage codes received as a result of the interventions or the reference standard. Furthermore, the researcher, triage assistants and physician were unaware of the other triage codes the patient received during the study. When participants were unable to fill in the ca-ISET, their companion was asked to answer the questions on the ca-ISET with the ca-ISET presenting the questions in the third person format.

2.3. Study participants

Patients ≥18 years old visiting the emergency department for the first time with their complaints were invited to participate. All Dutch citizens have a compulsory social health insurance with guaranteed access to the emergency department.

2.4. Procedures

The ca-ISET and the regular triage procedure are described below.

2.4.1. Ca-ISET

The ca-ISET is based on our previously developed pen-and-paper ISET [3] and was developed by iteratively prototyping, testing, analysing and refining. In a pilot study with three test cycles, 16, 53 and 75 patients respectively were invited to use the ca-ISET in the emergency department, with the regular triage as the reference standard. Sensitivity increased from 0.66 (CI: 0.13–0.98) in the first test to 0.80 (CI: 0.51–0.95) in the third test. Specificity increased from 0.69 (0.39–0.90) to 0.78 (0.65–0.88). To improve validity and usability, several adjustments were made in the text and the flow chart of the ca- ISET. A ca-ISET prototype was developed, with minor textual modification of the pen-and-paper version. The algorithm of the ca-ISET is shown in Fig. 1 and as an electronic supplement.

The ca-ISET is a touch operated software application developed by Delft Dimensions, a company specialised in technical and scientific software development and Interaction Design. The application runs on standard Windows-based computer hardware with touch capabilities. The prototype interface background is white with black and dark blue letters to maximise contrast and therefore readability. The questions are presented one by one on a 21″ computer screen that is placed on a wheeled trolley in the hallway of the waiting room.

To receive a triage colour code from the ca-ISET, participants fill in the questions presented on the ca-ISET. The questions are answered by touching the screen. When all questions are answered, the participant is asked to register at the ED reception desk or to take a seat with the physician to receive the decision for the reference standard.

The ca-ISET consists of 2–24 questions, depending on the main complaints of the patient. Patients with chemical substance injuries, wounds, foreign bodies, recent ophthalmic surgical intervention or ophthalmologist's referral were selected and coded by the first five items. The subsequent items focused on the level of sight deterioration of sight, moving spots in the visual field, pain in the eyes, headache and other main eye-related complaints. Ca-ISET automatically records the time the respondent takes to fill in the questions, the participant's answers and the resulting triage