

ORIGINAL RESEARCH

Smart Glasses with Augmented Reality Workflow; A Modern Tool for Triage in Mass Casualty Incidents

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Abstract: **Introduction:** Smart glasses with an augmented reality workflow have emerged as a new tool for triage in mass casualty incidents (MCIs). This study aimed to investigate the accuracy and time efficiency of smart glasses in MCIs triage. **Methods:** A retrospective field exercise study was conducted in November 2024 at EMS Srinagarind Hospital, Thailand. All participants performed self-assessments and used smart glasses for triage sieve. Data were recorded in terms of accuracy and time required for triage. **Results:** A total of 108 participants were enrolled, with a mean age of 33.4 years, of whom 57.4% were female. The smart glasses group achieved the highest accuracy in triage level 1, with 98.3% compared to 79.3% in the self-assessment group ($P < 0.001$). The smart glasses group also completed triage significantly faster than the self-assessment group, with a time of 23.5 versus 72.4 seconds for triage level 1 and 31.3 versus 89.1 seconds for level 2. **Conclusion:** The use of smart glasses with an augmented reality workflow for triage sieve in MCIs is beneficial, improving both accuracy and evaluation time for patients in triage levels 1 and 2.

Keywords: Artificial intelligence; Emergency medical services; Health care systems ; Technology

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1. Introduction

A mass casualty incident (MCI) is a situation in which multiple patients require simultaneous medical attention (1–3). Such incidents place significant strain on both personnel and medical equipment in emergency medical services (EMS) and emergency department (ED). Managing resources effectively becomes increasingly challenging as the number of affected individuals rises. In particular, assessing MCIs outside the hospital requires experienced or specially trained personnel capable of handling crises efficiently (4–6). In many countries, designated physicians are responsible for managing MCIs outside hospital settings. These physicians undergo specific training in resource allocation, personnel management, risk assessment, and threat assessment to ensure the safety of both the public and emergency responders at the scene (7,8).

In managing an MCI, after assessing the safety of the situation, EMS personnel are dispatched to the scene to classify patients based on the severity of their condition. In Thailand,

the Simple Triage and Rapid Treatment (START) adult triage algorithm is used for primary triage, also known as triage sieve (9,10). This protocol, developed by the Newport Beach Fire and Marine Department and Hoag Hospital, assesses patients based on their ability to walk, airway status, respiratory rate, pulse rate or capillary refill, and ability to follow commands (11,12). Patients are categorized to determine treatment priority, with the immediate category (marked in red) receiving the highest priority, followed by the delayed category (yellow) and the minor category (green).

The use of the START triage system in MCIs requires the expertise of EMS personnel to perform on-site triage, particularly in high-pressure situations where violence or danger may threaten both patients and medical personnel. Additionally, the need to rapidly triage a large number of patients within a limited timeframe adds to the challenge. Errors in the triage process can lead to delays in treatment or transportation of critically ill patients, potentially increasing disability and mortality rates. Studies have shown variability in triage accuracy in MCIs, with percentages of errors reported between 20% and 55% using traditional methods (13,14).

Cognitive load theory illustrates the decision-making processes in emergencies. The theory of cognitive load provides an example of how decisions are made in emergency situations. According to this theory, a person's ability to make de-

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cisions is limited by their working memory's capacity to process information. During high-stress situations, like mass casualty events, emergency personnel face high cognitive demands because they must quickly assess and prioritize several patients at once. The need for tools that can reduce cognitive strain and promote more effective triage procedures is highlighted by the fact that this significant cognitive load can affect the accuracy of decisions (15,16).

Smart glasses with an augmented reality workflow are a modern tool designed to address these challenges (17,18). Smart glasses use cutting-edge display technologies like waveguides or organic light emitting diodes (OLEDs) to superimpose digital information onto the user's field of vision. In order to guarantee that digital overlays stay precisely in place while the user moves, they incorporate sensors and cameras that monitor motion and orientation. They handle data and establish wireless connections with other devices, thanks to processors that resemble those found in smartphones. Software for augmented reality makes it easier to recognize images and gestures, allowing digital content to blend in with the physical world. Hands-free operation is facilitated through voice commands, gestures, head movements, or touch controls on the frame. They can provide real-time decision support by gaining access to cloud-based data and algorithms through instant analytics or alerts. These features make smart glasses useful in fields like healthcare and industry that demand heightened situational awareness.

By lowering cognitive load and boosting situational awareness, augmented reality has been shown to be useful in a number of time-sensitive medical applications, including improving surgical precision and trauma resuscitation effectiveness. With regards to MCIs, smart glasses with an augmented reality interface allow for triage instructions right in the respondent's line of sight, which could improve triage accuracy and shorten the amount of time needed to make decisions under pressure (19,20).

EMS personnel responding to triage duties wear smart glasses, which display a screen with diagrams and criteria based on the START algorithm. This allows personnel to quickly and accurately reference triage guidelines, enhancing the efficiency of primary triage. This study aimed to investigate the accuracy and time efficiency of smart glasses with an augmented reality workflow for triage sieve in MCIs.

2. Methods

2.1. Study design and setting

This single-center, retrospective field exercise study was conducted using a database from closed-circuit television (CCTV) recordings and assessment record forms documenting the use of smart glasses for triage in MCIs. The study took place from November 1 to November 30, 2024, at Srinaragind Hospital, Faculty of Medicine, Khon Kaen University, Thailand. The primary objective was to evaluate the accuracy and time efficiency of smart glasses with an augmented

reality workflow for triage sieve in MCIs.

This study adhered to the principles of the Helsinki Declaration and the recommendations of Good Clinical Practice. The Ethics Committee for Human Research at Khon Kaen University approved the study (HE671774). To ensure confidentiality, all identifiers were removed from the data collected.

2.2. Participants

All EMS personnel, including emergency physicians (EPs), emergency nurse practitioners (ENPs), registered nurses (RNs), and advanced emergency medical technicians (AEMTs), were enrolled in this study. Participants who experienced dizziness while using the smart glasses were excluded. All of the participants had no experience in using smart glasses or other augmented reality devices.

2.3. Data gathering

On the days of the field exercise, participants were introduced to the test, which was divided into two rounds. The first round involved a self-triage assessment, while the second round used smart glasses for triage assessment. Each participant was evaluated using 20 simulated scenarios, each with different triage levels of casualties. Accuracy and time taken for triage were measured by trained research assistants, with time recorded using a synchronized clock.

After completing the self-triage assessment, participants underwent a 60-minute training session on the use of smart glasses with an augmented reality workflow. Following the training, they independently repeated the triage assessment in the simulation field. To prevent communication between participants, individuals were immediately removed from the testing area after completing each assessment.

The smart glasses used in this study were the HMT-1 model from RealWear Inc. (Vancouver, Washington, USA). This device featured a 2.0 GHz 8-core Qualcomm chipset and operated on Android 10.0. It supported connectivity via Bluetooth Low Energy 4.1 or Wi-Fi (2.4 GHz and 5 GHz). The START augmented reality workflow was modified by Brochesia Company (Rome, Italy) to display digital operational processes via augmented reality. During the test, participants monitored the START adult triage algorithm for primary triage through the smart glasses display (Figure 1).

Data included the accuracy and time taken for START triage assessment by each participant and were retrieved and evaluated by two independent, well-trained EPs. A second round of data entry was then conducted. In cases where discrepancies were found, a senior EP was consulted to verify and finalize the data.

2.4. Statistical analysis

The sample size was determined based on an analysis of two samples with repeated measures, with an estimated minimum of 108 participants required. Statistical analysis was conducted using IBM SPSS for Windows version 27.0 (SPSS

Inc., Chicago, Illinois, USA) under a Khon Kaen University license. Unless otherwise specified, continuous variables are reported as mean and interquartile range (IQR), while categorical variables are presented as number (n) or frequency (percent).

3. Results

3.1. Baseline characteristics of studied cases

During a one-month study period, 112 participants were enrolled in the study. Four participants were excluded due to dizziness or incomplete smart glasses training. The mean age was 33.4 ± 5.25 (range: 28.1-39.1) years, and 57.4% of the participants were female. The characteristics of participants are shown in Table 1. Emergency nurse practitioners and students were the most common EMS roles in this study. Additionally, 90.7% of participants had prior triage experience in MCI.

3.2. Outcomes

In terms of accuracy (Table 2), participants in the smart glasses group had the highest scores for triage level 1, with 98.3% compared to 79.3% in the self-assessment group ($P < 0.001$). For triage level 2, the smart glasses group also had higher scores than the self-assessment group (99.4% vs. 78.5%; $p < 0.001$).

Table 2 presents the time required to assess the triage sieve of casualties. The smart glasses group completed the assessment significantly faster than the self-assessment group for both triage level 1 (23.5 vs. 72.4 seconds; $p < 0.001$) and triage level 2 (31.3 vs. 89.1 seconds; $p < 0.001$).

4. Discussion

The purpose of this study was to evaluate the use of smart glasses with an augmented reality workflow in the MCI triage sieve process. The primary assessment factors were accuracy, and the time required for EMS personnel to triage patients in an MCI.

In the MCI triage process, EMS personnel performing patient sorting must remember protocols and vital signs data on their own (21,22). However, due to high pressure and time constraints in MCI situations, the sorting process may not be as effective as needed. Modern technology plays a crucial role in addressing these challenges and improving efficiency by reducing the need for memorization through digital displays (23). Previous studies have demonstrated that the use of smart glasses in emergency care enhances workflow efficiency (24–27). In terms of EMS roles, this study focused on nurses, including ENPs, ENP students, and RNs. This is because, in Thailand's EMS system, most out-of-hospital emergency personnel are nurses. As a result, nurses play a crucial role in the MCI triage process. Therefore, implementing modern technology to support their work can enhance overall efficiency.

In terms of triage accuracy, the use of smart glasses with an

augmented reality workflow improved accuracy in triaging level 1 and level 2 patients. The MCI triage process relies on multiple indicators, such as respiratory rate, pulse rate, and capillary refill time, which may be difficult for personnel to recall accurately under pressure. The continuous display of these indicators through smart glasses, along with digital work charts, enhances efficiency and accuracy (28–30). For triage level 3 patients, there was no significant difference in accuracy between the self-assessment and smart glasses groups. This is likely because level 3 triage is determined solely by the patient's ability to walk away from the scene, which is the first criterion assessed in an MCI. EMS personnel are already familiar with this criterion, making digital assistance less necessary for this particular assessment.

In terms of the time used for triage, it was found that the use of smart glasses can shorten the time of triage in patients with level 1 and level 2. This is due to the display of the digital criteria that appear on the smart glasses at all times during triage made convenient and takes time quickly to assess patients (29,31,32). In addition, it was found that the time of triage in patients with triage level 3 was also assessed. There was no difference between the use of smart glasses and self-assessment groups, because the triage level 3 assessment did not use vital signs or any parameters. It is only based on the ability to walk away from the scene of the MCI. Therefore, it can be quickly evaluated.

Our results show that smart glasses seem to improve triage decision accuracy and speed; the importance of greater scenario familiarity cannot be understated. Participants may naturally perform better on their second try because they have a better understanding of the procedure and expectations, which could help explain some of the better results.

The use of smart glasses plays a crucial role in integrating modern technology to enhance efficiency and improve EMS work processes, contributing to a higher standard of care (33–35). In MCI situations, triage, treatment, and the transportation of critically ill patients are the top priorities for EMS personnel.

A crossover study design should be considered in future research to lessen the impact of this familiarity effect and gain a better understanding of the advantages of smart glasses. Participants would be split up into groups under such a design, and they would use various assessment instruments in different order. For example, one group may initially employ traditional methods, subsequently utilizing smart glasses, whereas another group might use the reverse sequence. In contrast to experience or practice effects, this method can assist in determining the degree to which the technology itself enhances performance.

Further distinguishing between improvements brought about by technology and those resulting from familiarity could be achieved by putting control measures in place, such as creating new, comparable scenarios in later trials instead of repeating the same evaluations. We can more precisely

identify and assess the usefulness of smart glasses as a tool for improving triage performance in emergency medical scenarios if these factors are addressed in subsequent research.

5. Limitations

This study has several limitations. First, it was conducted at a single institution, which may have unique characteristics in terms of population, work experience, and education, potentially affecting the generalizability of the findings to other settings. Additionally, MCI triage criteria vary between countries, requiring EMS personnel to undergo specific training and gain experience for effective triage. The use of smart glasses also necessitates training to maximize efficiency. Lastly, this study was conducted in a simulated environment, and its implementation in real-world situations may yield different results.

6. Conclusions

The use of smart glasses with an augmented reality workflow for triage sieve in MCI is beneficial in terms of accuracy and assessment time for patients at triage levels 1 and 2, outperforming manual triage.

7. Declarations

7.1. Acknowledgments

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7.2. Authors' contributions

Conceptualization: Kamonwon Ienghong, Korakot Apiratwarakul, Lap Woon Cheung, Chatkhane Pearkao; Methodology: Kamonwon Ienghong, Korakot Apiratwarakul; Software: Kamonwon Ienghong, Korakot Apiratwarakul; Validation: Kamonwon Ienghong, Korakot Apiratwarakul; Formal Analysis: Kamonwon Ienghong, Korakot Apiratwarakul; Investigation: Kamonwon Ienghong, Korakot Apiratwarakul; Data Curation: Kamonwon Ienghong, Korakot Apiratwarakul; Writing – Original Draft: Kamonwon Ienghong, Korakot Apiratwarakul; Writing – Review Editing: All authors; Visualization: Lap Woon Cheung, Chatkhane Pearkao; Supervision: Lap Woon Cheung, Chatkhane Pearkao; Project Administration: Kamonwon Ienghong, Korakot Apiratwarakul; Funding Acquisition: Korakot Apiratwarakul All authors read and approved the final version of manuscript.

7.3. Conflict of interest

We declare that we have no conflicts of interest.

7.4. Funding

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7.5. Availability of data

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

7.6. Using artificial intelligence chatbots

During the preparation of this work the authors used the paraphrasing tool Quillbot and Grammarly's AI in order to check and correct grammatical errors during the manuscript writing process. After using this tool/service, the authors reviewed and edited the content as needed and took full responsibility for the content of the publication.

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Table 1: Baseline characteristics of studied participants (N=108)

Variables	Participants (N = 108)
Age (years)	
Median (IQR)	33.4 (28.1, 39.1)
Gender	
Female	62 (57.4)
EMS Role	
Emergency physicians	22 (20.4)
Emergency nurse practitioners and students	51 (47.2)
Registered nurses	28 (25.9)
Advanced emergency medical technicians	7 (6.5)
Experience in EMS (year)	
<1	5 (4.6)
1-5	54 (50.0)
5-10	40 (37.0)
>10	9 (8.4)
Triage experienced in MCI	
Yes	98 (90.7)

Data are presented as median (IQR: interquartile range) or frequency (%); EMS: emergency medical services; MCI: mass casualty incidents.

Table 2: Accuracy and time required for triage in mass casualty incidents (N=2,160)

Triage level	Self-assessment		Smart Glasses		P-value
	N (%)	IQR	N (%)	IQR	
Accuracy of triage					
Level 1 (red)	571/720 (79.3)	74.1,82.6	708/720 (98.3)	97.9,99.1	< 0.001
Level 2 (yellow)	565/720 (78.5)	75.6,82.1	716/720 (99.4)	98.6,99.8	< 0.001
Level 3 (green)	712/720 (98.9)	97.9,99.3	718/720 (99.7)	98.4,99.9	0.892
Average time required for triage (second)					
	Median	IQR	Median	IQR	P-value
Level 1 (red)	72.4	68.1,75.6	23.5	19.1,26.5	< 0.001
Level 2 (yellow)	89.1	85.2,92.3	31.3	28.2,34.7	< 0.001
Level 3 (green)	25.5	23.2,27.8	24.4	22.2,26.9	0.910

IQR: interquartile range; N: number.

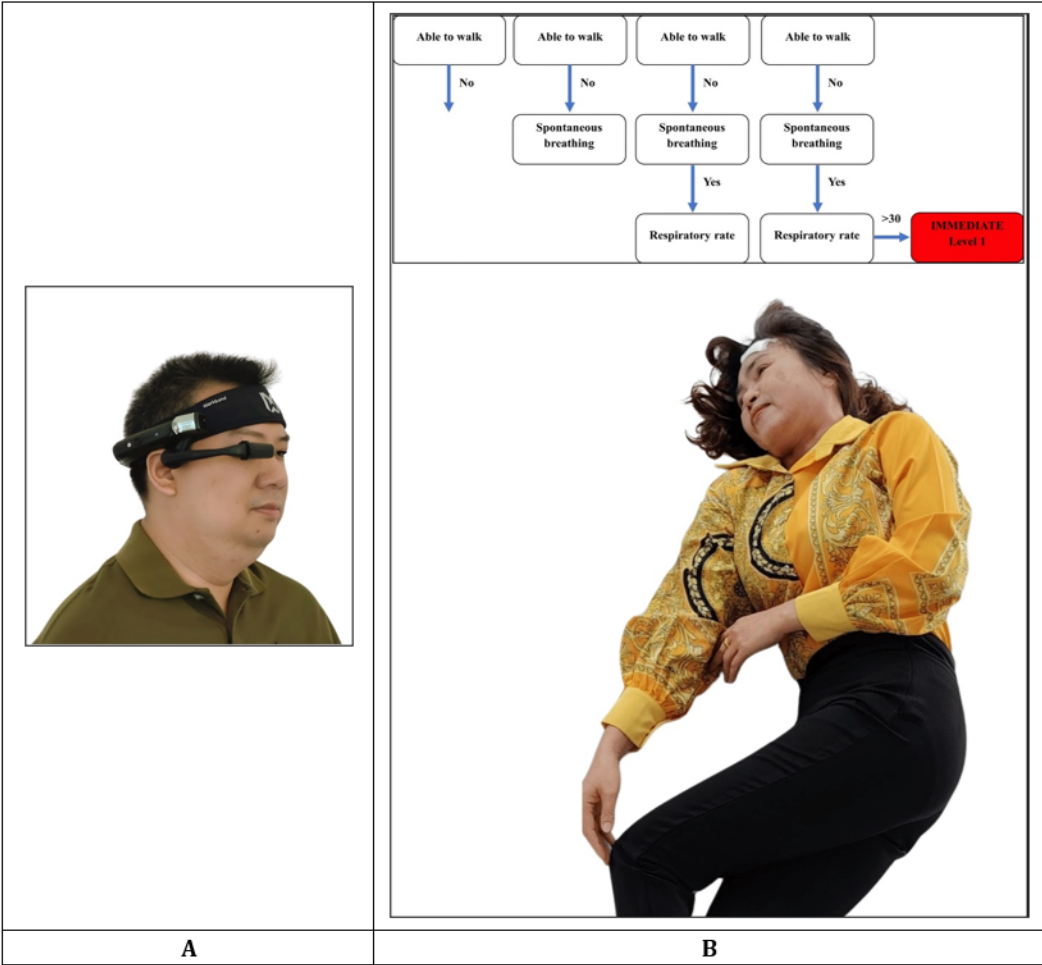


Figure 1: Real wear smart glasses (A); triage by using smart glasses with augmented reality workflow (B).