

## PAPER

# Effectiveness of an E-learning System for Emergency Signs and CPR Emergency Preparedness in Marathon Events: A Comparative Study

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## ABSTRACT

This study investigates the implementation, effectiveness, and impact of a unique e-learning system designed specifically for emergency signs and cardiopulmonary resuscitation (CPR) emergency preparedness in marathon events. Our approach introduces the first e-learning system specifically designed for marathon events. It delivers engaging content, including infographic stories, expert lectures, and interactive modules, to provide registered runners with comprehensive knowledge of first aid and emergency signs for CPR. To evaluate the e-learning application, we conducted a comparative experiment during the CMU (Chiang Mai University) marathon with 9,761 participants. We used pre- and post-tests, as well as a survey questionnaire. The results showed significant improvements in participants' CPR knowledge across all educational backgrounds. The integration of e-learning into the registration process contributed to a safer marathon environment, as participants felt more confident in handling emergencies. Approximately 85% of participants expressed a willingness to recommend the e-learning system. This increased confidence among participants in handling emergencies benefits both runners and marathon organizers by enhancing safety measures and emergency response during events. In conclusion, our findings strongly support the integration of e-learning into the registration process for marathon events. Recommendations based on our research include providing comprehensive guidelines for other marathon events, instilling stakeholder confidence, and emphasizing the suitability of e-learning for medium- to large-scale events. However, caution is advised for smaller events due to potential complexities and costs. Additionally, we suggest limiting the validity of e-certificates to ensure that participants have up-to-date CPR knowledge.

## KEYWORDS

e-learning, marathon events, basic life support, cardiopulmonary resuscitation (CPR)

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## 1 INTRODUCTION

Higher education has undergone significant advancements, transitioning from conventional pedagogical approaches to modern methods that utilize computer technology for information delivery and acquisition. The progress in technology has offered educators valuable opportunities to enhance their instructional skills and empower learners to improve their learning capabilities [1] [2] [3]. One prominent example of technological advancement in higher education is e-learning. This approach offers a promising instructional method and provides an opportunity to study its impact on learner knowledge acquisition and instructional techniques. Various organizations have embraced e-learning to educate their employees, while academic institutions have integrated Internet-based technologies to enhance the quality of education [4] [5] [6].

E-learning serves to support educators by easing their workload in the classroom and providing learners with hands-on experience through virtual laboratories and simulated settings to acquire essential knowledge and skills [7] [8]. Moreover, e-learning has emerged as a promising educational tool in the medical setting, facilitating the management of academic initiatives and helping hospitals achieve their educational objectives [9]. Its popularity is also growing in healthcare as a method to efficiently train a large number of professionals [10]. A systematic study by [11] found that e-learning, or “Internet-based education,” significantly influences the knowledge, abilities, behaviors, and ultimately, patient outcomes of healthcare workers.

## 2 RELATED WORK

### 2.1 E-learning in medical education

Continuous learning is crucial for nurses to develop a wide range of clinical performance skills throughout their careers [12]. In lifelong learning, various academic approaches have been utilized, including face-to-face learning, e-learning, and simulation. Among these methods, e-learning stands out as an accessible and flexible educational approach that utilizes various technologies, enabling increased connectivity and adaptability in design without the limitations of time and space [13].

E-learning offers potential benefits beyond conventional teaching approaches, such as interactivity, practice tasks, repetition, and valuable feedback [14] [44] [46]. Its flexibility, accessibility, and user-friendly nature provide nurses with numerous opportunities to enhance their skills and expertise [15]. Research comparing e-learning and conventional classroom teaching has demonstrated that both methods are equally effective in facilitating knowledge acquisition among nursing groups [16]. However, in the short term, e-learning courses have been shown to have a more significant impact on the accuracy of pressure ulcer classification compared to traditional classroom education [17] [45].

Moreover, e-learning has proven to be effective in enhancing specific nursing competencies. For instance, a computer-assisted multimedia intravenous injection teaching significantly improved participants’ understanding of intravenous injection techniques compared to a hospital orientation lesson [18]. In the case of psychiatric nursing, an e-learning ongoing training course for case management had a beneficial impact on knowledge levels compared to no intervention after a 3-month follow-up [19]. Similarly, implementing an e-learning program on delirium significantly increased the nursing staff’s understanding of delirium in a before-and-after research design [20].

Considering the mental health of medical students is of paramount importance due to the stress associated with medical school and their future responsibilities

as healthcare professionals [21]. Neglecting mental health issues can have adverse effects on students' ability to manage their workload, attend classes, and participate, which can lead to increased suicidal thoughts and other detrimental consequences [22] [23]. To address this, Mental Health First Aid (MHFA) programs aim to increase learners' mental health literacy and their ability to provide support to individuals facing mental health issues or crises [24]. Recently, the MHFA program has been adapted for e-learning distribution, including a specific program tailored for medical students [23]. Learners often find e-learning more adaptable and approachable [25], and online MHFA may be more cost-effective as it eliminates the need for physical educators or attendance at a specific location [26].

Furthermore, research indicates that MHFA delivered through e-learning is as effective as face-to-face MHFA learning in achieving objectives related to mental health first aid. These objectives include self-reported confidence in helping others, understanding of mental health issues, and reducing individual stigma towards mental health disorders [26].

## 2.2 E-learning of cardiopulmonary resuscitation

Many companies and professional institutions in the healthcare sector require their employees to undergo proper and ongoing cardiopulmonary resuscitation (CPR) education [27]. However, finding a balance between service provision and training remains a challenge for numerous organizations [28]. Traditional CPR programs, such as advanced pediatric life support (APLS) or shorter pediatric life support (PLS), often require employees to be absent from work for one to three days. These programs can be costly for learners who have to pay program fees, and companies may also face financial consequences due to study leave and short-term program arrangements [29].

Various CPR training methods, including CD-ROM pre-learning and video instruction, have been recognized. However, these methods are generally integrated with practical, hands-on training. E-learning has proven to be effective in educating healthcare employees, with the added benefits of being cost-efficient, easily accessible, self-paced, interactive, and capable of providing relevant feedback [30]. The CPR e-learning program is structured into modules, each accompanied by a multiple-choice knowledge test before and after completion. The modules cover various subjects, including airway positioning, mouth-to-mask and mouth-to-mouth techniques, bag and mask airway skills, CPR, rhythm identification, effective defibrillation, and administration of first-line cardiac medications. Learners can take the entire course in parts, with a total duration of 1–2 hours if completed in one sitting [31].

In the context of nursing education, students with low self-efficacy and problem-solving abilities often experience emotional distress during clinical practicum, which can affect their psychomotor skills. Enhancing the psychomotor abilities of nursing students is crucial in order to enable them to integrate their knowledge and deliver effective care for patients in clinical situations. To address this, a blended e-learning course has been implemented to enhance the decision-making abilities of nursing students. This approach integrates face-to-face teaching and guidance from experienced educators with learner-directed online lessons. Blended e-learning allows nursing students to engage in self-learning on relevant topics using material databases instead of relying solely on face-to-face instruction with instructors. Mosby's *Nursing Skills*, which has been translated into Korean with the approval of the Korean Society of Nursing Science, has been integrated into the e-learning content. This program, exclusively designed for nursing education, consists of practical instructional content that has been thoroughly reviewed by experts and deemed accurate and reliable [32].

### 2.3 Cardiopulmonary resuscitation for runners

The increasing recognition of the perceived health advantages of regular exercise have resulted in a rise in the number of people participating in marathons. However, as more elderly individuals participate in competitive events such as marathons, there has been an increase in the risk of sudden cardiac death (SCD). These tragic incidents have raised concerns about the potential negative health risks associated with marathon racing, especially considering that marathon runners are often in peak physical condition [33].

In the event of cardiac arrest, it is essential to promptly perform emergency CPR, use an automated external defibrillator (AED), and activate emergency medical response teams [34]. Immediate bystander resuscitation and access to an AED have been shown to improve outcomes, given the tendency for ventricular dysrhythmias [35]. CPR guidelines have recently been updated, shifting from A-B-C (Airway-Breathing-Circulation) to C-A-B (Circulation-Airway-Breathing). The *2015 AHA Guidelines* emphasized the importance of compression-only CPR, focusing on achieving the correct depth and speed of compressions while also minimizing interruptions during resuscitation efforts [36].

While there might be a natural inclination to move affected individuals immediately, it is critical to provide on-site resuscitation and use an AED to monitor the patient's rhythm. Immediate CPR and defibrillation within 3–5 minutes of collapse have been associated with higher chances of survival [37]. Sudden cardiac arrest (SCA) is a life-threatening condition that requires prompt and well-coordinated medical intervention. Preparing and practicing an emergency action plan (EAP) is essential to reducing the likelihood of a catastrophic event. All potential first responders, including team medical professionals such as athletic trainers, physiotherapists, and doctors, as well as coaches and relevant school or venue staff, should receive training in CPR and the application of AED. This training should emphasize the rapid and accurate identification of SCA. In the case of any fallen and unconscious runner, SCA should be suspected, and the EAP should be activated [38].

## 3 PURPOSE OF DEVELOPING THE E-LEARNING SYSTEM FOR CPR IN MARATHON EVENTS

The main objective of this study is to develop an e-learning system specifically tailored for participants in marathon events, with a focus on CPR. With the increasing popularity of marathons and the growing number of individuals participating, there is heightened concern about the risk of SCD during these competitions, particularly among older participants [33]. Therefore, this e-learning system aims to address the critical issue by providing comprehensive CPR training and knowledge to marathon runners before they participate in any marathon event.

The e-learning system being developed will aim to educate marathon runners on effectively and promptly responding to emergency situations when a fellow runner experiences SCA during a competition. By providing participants with essential CPR skills and knowledge, the system aims to empower runners to take immediate action and perform CPR accurately. This has the potential to save lives and reduce the impact of SCD incidents during marathon events. The development of this specialized e-learning system for marathon events is expected to significantly improve the safety and well-being of marathon participants. By enhancing runners' preparedness and confidence in managing emergency situations, the e-learning system aims to establish a safer marathon environment and enhance the overall management

of sudden cardiac events during these physically demanding competitions. The questions that this study proposes to address include:

- RQ1: How does the implementation of a specialized e-learning system for Emergency Signs and CPR Emergency Preparedness in marathon events impact the CPR knowledge of marathon participants?
- RQ2: What is the effectiveness of the e-learning system for Emergency Signs and CPR Emergency Preparedness in marathon events in terms of improving participants' knowledge of CPR?
- RQ3: What impact does the specialized e-learning system have on the overall management of first aid and sudden cardiac events during marathon events for both runners and marathon organizers?

These research questions aim to explore the effectiveness and impact of the e-learning system on marathon participants' knowledge, skills, confidence, and overall management of sudden cardiac events during marathons. Addressing these questions will provide valuable insights into the potential benefits and implications of incorporating e-learning for CPR training in the context of marathon events.

## 4 DESIGN AND DEVELOPMENT OF THE E-LEARNING SYSTEM

We have designed and developed a specialized e-learning system for marathon runners. This system aims to equip them with the necessary skills to respond to emergency situations during races. In such circumstances, runners may need to provide basic support to fellow participants by performing CPR or promptly calling an emergency number to ensure the patient receives appropriate medical attention at the nearest hospital.

The development of the e-learning system followed a structured approach comprising four stages: the concept stage, preparation stage, implementation stage, and evaluation stage. Each stage played a crucial role in shaping the overall process, as illustrated in Figure 1.

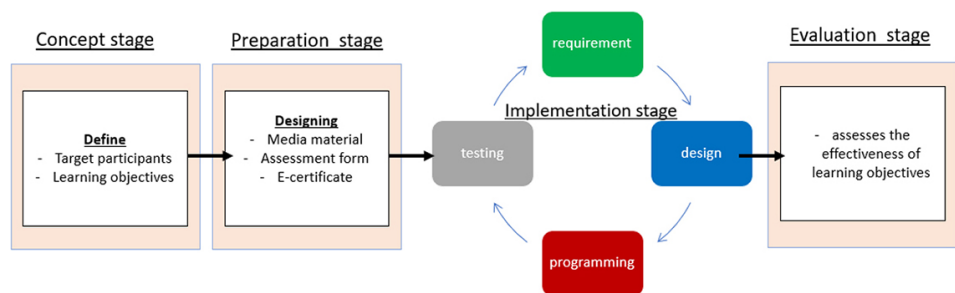


Fig. 1. Overall process of e-learning system for CPR in marathon events

### 4.1 Concept stage

During the initial phase of developing the e-learning system, we outlined the conceptual framework, with a focus on defining clear and measurable learning objectives. The identified objectives aim to equip marathon runners with essential CPR skills and knowledge. This includes understanding the importance of CPR in emergency situations during marathon events, recognizing signs of SCA in fellow runners, mastering effective CPR techniques, and familiarizing themselves with the proper usage of AEDs. Additionally, we identified the target participants for the program, specifically tailoring it for marathoners. This includes both experienced and



novice runners who actively participate in marathon events. By focusing on this particular audience, the e-learning system tackled the distinct challenges and circumstances that marathon runners may face during races. Moreover, a thorough review of existing CPR training materials was conducted to ensure the integration of evidence-based practices and relevant guidelines into the e-learning content. This process aligned the program with established best practices in the field.

## 4.2 Preparation stage

During the preparation stage, we conducted detailed planning and content development. The curriculum was carefully designed to specifically cater to the needs of marathon runners, ensuring that it addresses the unique challenges and circumstances they might encounter during races. The e-learning materials were developed, encompassing instructional videos and interactive modules, all intended to facilitate an engaging and effective learning experience.

**Designing media material for e-learning.** The e-learning media content consists of six storylines, which are divided into two sets. The first set features three engaging infographic-style modules (see Figure 2) designed to educate runners on critical topics. The first module provides valuable information on identifying warning signs for runners, equipping users to recognize potential health issues during marathons. The second module focuses on essential knowledge for promptly making an emergency call to medical services (1669) when encountering an injured runner on the race course. The third module instructs users on the correct application of first aid techniques for common injuries that may occur during accidents, including falls, cramps, and muscle pain while running [31].

The second set includes three expert lecture recordings (see Figure 3) from the esteemed Faculty of Medicine at Chiang Mai University. The fourth module demonstrates how to effectively use CPR and AED, teaching life-saving skills to marathon runners. The fifth module delves into the standards for organizing marathon events, ensuring safety and fairness in the races. Additionally, the sixth module features a simulated emergency running event, preparing runners to handle critical situations during races. The combination of infographic-style and expert lecture modules ensures an engaging and comprehensive e-learning experience for marathon participants. The contents of both sets are shown in Tables 1 and 2.

**Table 1.** The content of the e-learning program for infographic story

Content of the E-learning Program (Infographic Story)		
Module: 1 “Warning signs for runners” Warning Signs for Runners: Identifying Early Indicators of Health Issues during Marathons	Module: 2 “Emergency call 1669 Know before you call” Emergency Call 1669: Know Before You Call – Swift Response Measures for Injured Runners	Module: 3 “First aid for runners” First Aid for Runners: Providing Essential Immediate Care for Common Injuries in Marathons
<b>Media content</b> – Understanding the Importance of Monitoring Physical Signals – Recognizing Key Warning Signs: Dizziness, Shortness of Breath, Chest Pain – Identifying Signs of Fatigue and Dehydration – Noticing Abnormal Heart Rate or Irregular Rhythms – Being Alert to Symptoms of Heat-Related Illnesses	<b>Media content</b> – The Vital Role of Prompt Emergency Calls during Marathons – The Emergency Medical Service Number “1669” – Providing Essential Information during Emergency Calls – Communication with Dispatchers	<b>Media content</b> – Equipping Runners with First Aid Know-How – Addressing Common Injuries: Cuts, Scrapes, and Bruises – Managing Muscle Cramps and Sprains on the Race Course – Handling Falls and Impact Injuries with Quick Responses – Assisting Runners with Dehydration and Heat-Related Issues

**Table 2.** Expert lecture content of the e-learning program

Content of the E-learning Program (Expert Lectures)		
Module: 4 “Demonstration of how to use CPR and AED” Demonstration of How to Use CPR and AED: Equipping Marathon Runners with Life-Saving Techniques	Module: 5 “Standards for Marathon Running Events” Standards for Marathon Running Events: Ensuring Safety and Fairness on the Race Course	Module: 6 “A simulated event of emergency running” A Simulated Event of Emergency Running: Preparing Runners for Critical Scenarios
<b>Media content</b> – Understanding the Vital Role of CPR and AED in Saving Lives – Step-by-Step Demonstration of Proper CPR Techniques – Correct Usage of Automated External Defibrillators (AED) – Simulated Emergency Scenarios: Applying CPR and AED in Marathon Context	<b>Media content</b> – Emphasizing the Importance of Set Standards in Marathon Events – Participant Eligibility and Health Requirements for Marathons – Monitoring Weather Conditions and Safety Precautions – Balancing Competition and Fairness: Implementing Rules and Regulations	<b>Media content</b> – Practicing Quick and Effective Responses during Simulated Emergencies – Collaborating with Medical Personnel and Emergency Services



สัญญาณเตือนภัยสำหรับนักวิ่ง  
สัญญาณเตือนภัยสำหรับนักวิ่งทดสอบ



สายฉุกเฉิน 1669 รู้ไว้ก่อนโทร  
สายฉุกเฉิน 1669 รู้ไว้ก่อนโทร



การปฐมพยาบาลเบื้องต้น  
การปฐมพยาบาลเบื้องต้น

**Fig. 2.** Infographic content



การสาธิตวิธีการใช้หุ่นจำลองสำหรับการช่วยฟื้นคืนชีพ (CPR)



งานวิจัยที่ได้มาตรฐาน  
งานวิจัยที่ได้มาตรฐาน



KIC Running  
KIC Running

**Fig. 3.** Content provided by expert lectures

**Development of the assessment form.** To assess the effectiveness of our e-learning system in teaching CPR knowledge to runners, we conducted a pre-test and a post-test. Runners were encouraged to learn how to perform CPR correctly through the use of e-learning. After each CPR learning lesson, participants were required to complete a quiz consisting of five to ten questions, which covered both first aid and emergency preparedness topics. Upon completion of each quiz, the participants received test results, including their scores and the time taken, which could be downloaded in the form of an e-certificate.

**Development of an e-certificate.** The e-certificate system was designed for runners who studied on our e-learning platform and completed tests after each lesson, demonstrating their knowledge of CPR and emergency preparedness. Considering the challenges posed by the COVID-19 pandemic, we have integrated electronic certificates into our system, offering a paperless and contactless approach to credentialing. The e-certificate, which is a digital version of a traditional paper-based certificate, was referred to as a “paperless reward credential” by Chen-Wilson et al. [40]. Each e-certificate displays the runner’s information, such as their name and the completed lesson. Runners have the flexibility to download the e-certificate in PDF format and print it at any time, which facilitates the collection of their credentials for portfolios or other purposes.

### 4.3 Implementation stage

During this phase, the e-learning system was launched, providing marathon participants with accessible training content through the e-learning platform. Runners can conveniently engage with the training materials at their own pace. The implementation stage also involves gathering user feedback and providing support to identify areas for improvement, ensuring an optimal user experience. Following the principles of agile software development [39], the implementation phase comprised four stages: requirement gathering, design, programming, and testing. Figure 4 showcases the first page and the initial interface of the e-learning system, providing an enticing preview of the platform’s capabilities.



Fig. 4. E-learning system for CPR in marathon events

### 4.4 Evaluation stage

The evaluation stage marks the culmination of the development process, with a focus on thoroughly assessing the effectiveness and impact of the e-learning system on both runners and medical professionals. To assess the effectiveness of the system, we used comprehensive metrics to measure participants’ progress, engagement, and comprehension of the CPR training content. For runners, interactive exercises, quizzes, and simulated emergency scenarios were implemented to monitor their performance and assess their knowledge acquisition in accordance with the predefined learning objectives. Similarly, customized learning objectives were utilized to assess



the competency of medical professionals in CPR techniques, decision-making abilities, and readiness to manage sudden cardiac events during marathons. Participants' feedback and insights were actively collected through user surveys, enabling improvements to the platform. Additionally, a knowledge assessment form was administered to measure the understanding and retention of essential CPR concepts. This meticulous evaluation process provided valuable insights and facilitated necessary refinements to enhance the e-learning system's ability to effectively prepare marathon participants and medical professionals for responding to emergencies.

## 5 RESEARCH METHODOLOGY

The research methodology for this study focuses on the development of the e-learning system and assessing its effectiveness in preparing marathon participants and medical professionals. It adopts a combination of research and development (R&D) approaches, which serve two primary objectives: first, to develop the e-learning product, and second, to evaluate the effectiveness of the system. Drawing on our knowledge and conducting a comprehensive literature review, this study represents the first exploration of an e-learning system specifically designed for CPR in marathon events. To assess the impact of the system, we collected both quantitative data, such as knowledge questionnaires and system usage metrics, and qualitative data through open-response questions. These data were gathered with the aim of addressing the research questions. The comprehensive research methodology employed in this study aims to shed light on the effectiveness of the specialized e-learning system and its potential to improve emergency response capabilities in the context of marathon events.

### 5.1 Participants

The participants in this study were individuals who took part in the CMU marathons held to celebrate the 55th anniversary of Chiang Mai University. The running event saw a total of 9,761 participants, with 5,734 males and 4,027 females taking part. The demographics of runners are shown in Table 3. These individuals represented a diverse group of marathon runners, including both experienced athletes and amateur enthusiasts. Additionally, medical professionals, including doctors, nurses, and first aid responders, were also involved in the study as potential users of the e-learning system. Their active participation and engagement provided valuable insights into the effectiveness of the system in preparing not only marathon participants but also healthcare providers to respond effectively to emergency situations during marathon events.

**Table 3.** Demographics of the participants of this study

Variables (N = 9761)	N (%)
Age	
Did not specify	934 (9.56%)
20–29	1920 (19.67%)
30–39	3517 (36.03%)
40–49	2320 (23.76%)
50–59	918 (9.40%)
Above 60	152 (1.55%)

(Continued)

**Table 3.** Demographics of the participants of this study (*Continued*)

Variables (N = 9761)	N (%)
Sex	
Male	5734 (58.75%)
Female	4027 (41.25%)
Education	
Undergraduate	2312 (23.68%)
Bachelor Degree	5623 (57.60%)
Master Degree	1511 (15.47%)
Doctoral Degree	315 (3.22%)

## 5.2 Experimental design and procedures

The experimental design and procedures for this study were conducted during the CMU marathon event. Once participants registered for the marathon, they were informed that both a pre-test and a post-test assessment were mandatory for everyone in order to receive their bib numbers for the race. The pre-test served as a baseline measurement of their CPR knowledge and skills, capturing their initial level of preparedness for responding to emergency situations during the marathon event.

After completing the pre-test, participants were granted access to the e-learning system. They engaged with interactive modules, instructional videos, and quizzes that were specifically designed to enhance their CPR knowledge and abilities. Following the training period, all participants were required to undergo a post-test assessment to measure their improvement in CPR knowledge and skills after using the e-learning system.

Additionally, after completing the post-test, participants were given the option to voluntarily participate in a survey questionnaire to provide feedback on their experience with the e-learning program. Participation in the survey questionnaire was entirely optional, and participants were free to decide whether or not to take part in it.

Throughout the experimental procedures, strict adherence to ethical guidelines and obtaining informed consent were ensured for all participants. They received the necessary support and guidance to ensure a seamless and meaningful learning experience. The comprehensive experimental design and procedures allowed for a rigorous evaluation of the impact of the e-learning system on marathon participants' preparedness to handle emergencies during the marathon event. This study provided valuable insights into the effectiveness of the CPR e-learning program in this specific context.

## 6 RESULT AND DATA ANALYSIS

### 6.1 Analysis of knowledge questionnaires

The analysis of knowledge questionnaires aimed to evaluate the effectiveness of a specialized e-learning system for emergency signs and CPR emergency preparedness at marathon events. The questionnaire was carefully crafted by experts from the Faculty of Medicine to ensure its validity and relevance to the context of marathon participants and medical professionals. It consisted of two parts: the first part focused on first aid knowledge, while the second part addressed emergency signs for CPR emergency preparedness.

Participants were categorized according to their educational backgrounds, which consisted of undergraduate, Bachelor's, Master's, and Doctoral degrees. Table 4 displays the descriptive statistics of the pre-test and post-test scores for each group, including the mean and standard deviation. The results of the analysis revealed a significant improvement in CPR knowledge across all educational levels after engaging with the e-learning system. For the undergraduate group (N = 2312), the mean pre-test score was 5.58 (SD = 3.29), and the mean post-test score increased to 11.85 (SD = 4.67). Similarly, the Bachelor Degree group (N = 5623) exhibited a significant increase in CPR knowledge, with a mean pre-test score of 6.56 (SD = 4.20) and a mean post-test score of 12.53 (SD = 4.69). The Master's Degree group (N = 1511) also showed substantial improvement, with a mean pre-test score of 7.31 (SD = 3.51) and a mean post-test score of 12.15 (SD = 5.08). Lastly, the group with Doctoral degrees (N = 315) displayed an improvement in CPR knowledge, with a mean pre-test score of 10.21 (SD = 3.41) and a mean post-test score of 12.93 (SD = 3.04).

**Table 4.** The descriptive statistics of the pre-test and post-test scores for each group

Group	N	Pre-Test (SD)	Post-Test (SD)	T-Value	P-Value
Undergraduate	2312	5.58 (3.29)	11.85 (4.67)	-54.382	.000*
Bachelor Degree	5623	6.56 (4.20)	12.53 (4.69)	-79.155	.000*
Master Degree	1511	7.31 (3.51)	12.15 (5.08)	-32.007	.001*
Doctoral Degree	315	10.21 (3.41)	12.93 (3.04)	-10.499	.001*

Note: \*p-value less than 0.01.

## 6.2 Analysis of the survey questionnaires

The analysis of the survey questionnaires was conducted to gather feedback on participants' perceptions of the e-learning system, as shown in Table 5. A total of 1036 participants responded to the survey. Participants rated the user-friendliness of the e-learning platform with a mean score of 4.12 (SD = 0.48), indicating that the majority found it to be user-friendly. The instructional videos provided in the e-learning system received a mean score of 3.94 (SD = 0.51), indicating that participants perceived them to be of good quality. Interactive modules were utilized to evaluate participants' comprehension of CPR and first aid for emergency response during marathon events. The average score for improvement in understanding was 4.22 (SD = 0.49), indicating the effectiveness of the modules. In terms of recommendations, 81.17% (n = 683) of the 841 respondents expressed that they would recommend the e-learning system to others, while 18.82% (n = 158) would not. Overall, the survey responses provide valuable insights into participants' satisfaction with the e-learning system and its potential as a training tool for CPR and emergency preparedness during marathon events. The responses emphasize the system's effectiveness and its potential for broader adoption.

**Table 5.** The result of survey questionnaires

Question	N	Mean (SD)
How user-friendly was the e-learning platform?	1036	4.12 (0.48)
How was the quality of the instructional videos provided in the e-learning system?	1036	3.94 (0.51)
How did the interactive modules enhance your understanding of CPR and first aid for emergency response during marathon events?	1036	4.22 (0.49)
Would you recommend the e-learning system to other marathon participants and medical professionals?	841	Yes (81.17%)
	195	No (18.82%)

### 6.3 Feedback of the open-end questionnaire

Feedback from the open-ended questionnaire revealed a majority of positive responses regarding the usefulness of the e-learning system and its potential to elevate the standard of marathon events. Participants expressed satisfaction with the user-friendly interface and engaging instructional videos. They found these features beneficial for enhancing their CPR knowledge and first aid skills during marathon events. However, some participants provided negative feedback, suggesting that the pre-test and post-test assessments, as well as the mandatory video watching, could be annoying and should be made optional in order to obtain the BIB number. Furthermore, they recommended reducing the number and length of instructional videos to prevent overwhelming learners with an excessive amount of content. Participants also proposed incorporating interactive games or implementing gamification concepts to further enhance the e-learning experience. These valuable insights and suggestions will be considered for refining and improving the design and implementation of the e-learning system in future iterations.

## 7 RESULTS AND DISCUSSION

### 7.1 Summary of the results

RQ1: This research question focuses on implementing a specialized e-learning system for emergency signs and CPR emergency preparedness in marathon events. Based on our knowledge, this is the first e-learning system specifically designed for marathon events, with a focus on emergency signs and CPR emergency preparedness. The system provides engaging infographic stories, expert lectures, and interactive modules, effectively delivering comprehensive knowledge on first aid and emergency signs for CPR to runners. The content offers six modules that participants can access after registering for the marathon event. According to the survey questionnaire, participants felt that this e-learning platform was user-friendly (mean = 4.12, sd = 0.48) because they could access it through the website and sign in using their Facebook or Gmail accounts, which were connected to the registration for the marathon events. Upon completing the pre-test and post-test, participants will receive an e-certificate that can be utilized for other marathon events. In our experiment, we required every participant to complete these assessments before receiving the BIB number at the registration counter prior to the marathon events. This system ensures that every runner has a basic knowledge of first aid and emergency signs for CPR, which could improve the standard and quality of marathon events.

RQ2: This research aimed to assess the effectiveness of the e-learning system for emergency signs and CPR emergency preparedness at marathon events. The goal was to determine if the system improved the knowledge and CPR skills of marathon participants. According to Table 4, the results of the pre-test and post-test assessments conducted during the experimental procedures demonstrated a significant improvement in CPR knowledge across all educational backgrounds ( $p < .001$ ). Participants who engaged with the e-learning system showed significant improvements in their understanding of CPR and first aid for emergency response during marathon events. The positive feedback received from participants further validates the effectiveness of the e-learning approach in improving participants' CPR knowledge and skills. The data from the survey questionnaire also supported these findings, with participants indicating that the e-learning system enhanced their understanding of CPR and first

aid during marathon events (mean = 4.22, SD = 0.49). However, the open-ended survey revealed that some participants recommended reducing the number and length of instructional videos to prevent overwhelming learners with excessive content.

RQ3: The investigation into the impact of a specialized e-learning system on the overall management of first aid and sudden cardiac events during marathon events for both runners and marathon organizers revealed significant positive outcomes. The analysis of the survey questionnaires, with 1,036 participants responding, provided valuable insights into their perceptions of the e-learning system. The participants' high rating of user-friendliness, with a mean score of 4.12 (SD = 0.48), indicated that the majority found the e-learning platform to be easy to use. The instructional videos, with an average score of 3.94 (SD = 0.51), were perceived to be of good quality. The interactive modules, which received a mean score of 4.22 (SD = 0.49), effectively enhanced participants' understanding of CPR and first aid for emergency response during marathon events. Furthermore, 81.17% (n = 683) of the 841 respondents expressed their willingness to recommend the e-learning system to others. The positive feedback and increased confidence among participants in handling emergencies highlight the effectiveness of the e-learning system in improving preparedness among runners. The impact was not limited to runners alone. Marathon organizers reported enhanced safety measures and more efficient emergency response during events. These findings highlight the potential of the e-learning system to enhance the level of first aid and CPR knowledge for both runners and marathon organizers. This, in turn, promotes a safer and more secure environment during marathon events.

## 7.2 E-learning in marathon events

Marathon events attract a diverse range of participants, including experienced runners, novices, and individuals from different age groups and fitness levels. However, marathon events also come with inherent risks, especially when it comes to sudden cardiac events and other medical emergencies. As the popularity of marathon events continues to grow rapidly, with approximately 1800 events per year in Thailand alone, the demand for effective and accessible training in emergency preparedness and basic life support knowledge [40], including CPR, becomes increasingly crucial.

Based on our knowledge, this study is the first to implement e-learning for basic life support and integrate it into the registration process for marathon events. Traditional methods of delivering knowledge on basic life support related to marathon events, such as in-person workshops or lectures, may be limited by logistical constraints and may not effectively accommodate the large number of participants. In this context, e-learning proves to be a helpful and practical alternative [41]. Our e-learning content on emergency signs and CPR emergency preparedness in marathon events has demonstrated a notable enhancement in CPR knowledge among individuals with varying educational backgrounds, aligning with the findings of other relevant studies [42] [43].

The e-learning system not only improves participants' understanding of emergency signs and CPR emergency preparedness but also boosts their confidence during marathon events. This ensures that all runners feel prepared to assist each other in case of emergencies. However, in terms of management, some participants may find the registration process complex. They may also recommend reducing the number and length of instructional videos to prevent overwhelming learners with excessive content. Despite these suggestions, the implementation of e-learning in marathon events has shown promising results in improving participants' readiness



and understanding of emergency response, leading to safer and more secure marathon environments.

In summary, considering our knowledge and findings from this study, we strongly recommend the implementation of e-learning for basic life support and its integration into the registration process for marathon events. Our recommendations for researchers, event organizers, and health providers involved in marathon events are as follows:

- We highly recommend using the content provided in Tables 2 and 3 as guidelines for other marathon events that plan to incorporate customized e-learning.
- The e-learning approach can instill confidence among participants and organizers, ensuring the highest standards in marathon events.
- Implementing e-learning for “Emergency Signs” and “CPR Emergency Preparedness in Marathon Events” is especially advantageous for medium-sized events with 3000–5000 participants or large-scale events with even more participants.
- We do not recommend using e-learning for small-scale marathon events with fewer than 3000 participants due to potential complexities in the registration process and associated implementation costs.
- E-certificates obtained through the e-learning system can streamline future registration processes. However, we suggest restricting their validity to a maximum of two years to ensure that participants have up-to-date CPR knowledge and skills.

## 8 CONCLUSION, LIMITATION, AND FUTURE WORKS

This study is the first to implement e-learning for emergency signs and CPR emergency preparedness and integrate it into the registration process for specialized marathon events. It has shown significant positive outcomes. The e-learning platform effectively delivered comprehensive first aid and emergency signs for CPR knowledge to participants, resulting in significant improvements in CPR knowledge across all educational backgrounds. Participants’ feedback indicated high satisfaction with the user-friendly interface, engaging instructional videos, and interactive modules. They highlighted the system’s effectiveness in enhancing their understanding of CPR and first aid for emergency response during marathon events. The incorporation of e-learning into the registration process has enhanced the safety and security of marathon environments, providing participants with greater confidence and readiness to handle emergencies. This study serves as a valuable foundation for future research and provides insights into the potential benefits of e-learning in other areas of emergency preparedness and medical training.

While the findings of this study provide promising evidence of the effectiveness of the e-learning system in marathon events, it is important to acknowledge several limitations. Firstly, the research was conducted only at a single marathon event in a specific geographical region and with a particular demographic makeup of marathon participants, which limits the generalizability of the results to other contexts. Secondly, the data collected was self-reported through surveys, which may be subject to response biases or inaccuracies. Furthermore, the study had a limited time frame, and it did not assess the long-term effects of the e-learning system on participants’ knowledge retention and emergency response skills.

For future research and enhancements in e-learning for marathon events, several areas can be worth exploring. Firstly, conducting more extensive and diverse studies in various geographical regions with different participant demographics will

help validate and enhance the effectiveness of the e-learning system. Furthermore, integrating advanced data analytics and machine learning algorithms into the e-learning platform could customize the training experience for individual participants according to their learning pace and preferences. This personalized approach could optimize the learning process by ensuring that participants receive the most relevant and effective training materials to enhance their CPR knowledge and emergency response skills. Furthermore, incorporating interactive gaming elements or gamification concepts into the e-learning platform could enhance participant engagement and motivation during the training process.

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## 11 APPENDIX A: EMERGENCY SIGNS FOR CPR EMERGENCY PREPAREDNESS QUESTIONNAIRES

### Part 1: First Aid questionnaires

1. Which of the following is not a purpose of first aid?
2. What is the basic principle of first aid?
3. The patient feels pain in the heel and bottom of the foot while walking or running. What is the first aid treatment for the injury?
4. What is the first aid treatment for an ankle sprain?
5. What is the benefit of using a cold compress?
6. The patient experiences pain in the back of the calf, as well as swelling and difficulty moving. What injury does the patient have?
7. Why should it not be treated immediately after an injury with a hot compress, such as warm water, liniment oil, and balm?
8. What should be done if first aid treatment does not improve the patient’s condition?
9. What is a way to avoid cramps while running?
10. The patient has hot, red skin and a high body temperature. What is the best first aid treatment for a person with an inability to sweat, shortness of breath, a throbbing headache, nausea, and vomiting?

### Part 2: Emergency Signs for CPR Emergency Preparedness Questionnaires

1. What should you do first if you come across an emergency patient while running a marathon?
2. Which of the following is not a symptom of an emergency patient?
3. Which of the following is not a symptom of a high risk of death?
4. When there is an emergency, you need to call an emergency ambulance to take the patient to a hospital near the scene of the accident. You must dial the phone number?
5. Which of the following shows normal respiratory symptoms?
6. Which of the following is a symptom of circulatory failure?
7. When making an emergency call, what information is not required to inform the staff?
8. Which of the following provides complete information for the staff when making an emergency call?



9. In what situations should you dial the emergency number 1669?
10. When should an emergency patient get first aid treatment (before, after, or during a call to the emergency number)?

## 12 APPENDIX B: SURVEY QUESTIONNAIRE

Part 1: Survey Questionnaire (Scale: 1 – Poor, 5 – Excellent)

1. How user-friendly was the e-learning platform?
2. How was the quality of the instructional videos provided in the CPR e-learning system?
3. How did the interactive modules enhance your understanding of CPR and first aid for emergency response during marathon events?
4. Would you recommend the e-learning system to other marathon participants and medical professionals?

Part 2: Open-end Questionnaire

1. Please provide any additional comments or suggestions for improving the e-learning system.

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