Development of a Mobile-Healthcare Application for Safety and Prevention in Emergency Assistance at Marathon Events: A Case Study in CMU Marathon

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Abstract—The majority of marathon deaths are caused by sudden cardia arrest which occurs in approximately 1 in 100,000 runners around the world. In such cases, sudden resuscitation of first aid, including an early use of automated external defibrillator (AED) on runners by medical staff is immediately necessary. However, in some cases patient information of the runner is required to support the clinical decision-making of the medical staff, including the admission to hospital with certain symptoms. To make marathon events safer, we developed a mobile-healthcare emergency assistance application for safety and prevention in marathon events. Our project covers three phases: registration, data analytics and running phases. In the registration phase, we designed and developed a form containing the runner's electronic personal health record filled in during the registration of the runner at the event. For the analytics and running phases, we analyze the data from the registration phase in order to prepare the capacity of resource and medical staff necessary to prevent and treat injuries and accidents including a sufficient number of AED devices. Finally, for the running phase, we developed a mobile application Medic and Track based on the qr code scanning in BIB for patient information that allows to locate the runner's emergency aid point and bring the patient to that rescue point or hospital. We also tested the application on a large number of runners participating in the CMU marathon 2020 with 9721 runners. The results of this study suggest that the purpose of our application can be generally accepted for the medical staff, and it also proved to be a suitable technology to prevent serious accidents in future marathon events.

Keywords—mobile-healthcare emergency, running, marathon, patient health information, sudden cardiac arrest

1 Introduction

The marathon has recently garnered international recognition as a result of increased participation [1] as this kind of long-distance race is considered as one of the most popular individual sports in the world as well as a major component of track and field competitions. Nevertheless, longitudinal epidemiological studies of marathoners

[2] and sports reveal that overuse injuries are a prevalent and devastating problem in these groups [3,4] In a report, the International Olympic Committee concluded that sports load is a cause of injuries and illnesses. High loads can have either a favorable or unfavorable impact on injury risk, depending on the rate at which they are applied and the athlete's internal health conditions [5, 6]. Even worse, in Japan, 107 occurrences of sudden cardiac arrest (SCA) have been documented in the last ten years (2002–2011) [1]. Cardiogenic diseases, such as ischemic heart disease, cause the majority of SCAs during marathons; moreover, nearly half of the participants die. According to prior research, SCA happens in roughly 1 in 57,000 marathoners in the United States, is more prevalent in older men, and several incidents happen in the last 4 miles [7] Significantly, both studies show that rapid resuscitation, including the use of an AED as soon as possible, increases survival rates in runners with SCA. Although qualified medical personnel and adequate AEDs are required along the racecourse, both are restricted due to the exorbitant expense of several of these events. Nevertheless, before the marathon, a cardiac screening test utilizing an electrocardiogram (ECG) has been used to avoid SCAs; but even so, these instances are still contentious due to high costs and numerous false-positive findings [8]. Thus, a better knowledge of the relationships between sports load, health, and performance among competitive long-distance runners [9, 10] are needed, especially in environments where running is a known profession [11].

In Thailand, Marathons have become increasingly popular, because many individuals are eager to participate in such events [12] and people in Thailand are becoming more health-conscious and exercising more [13]. According to the data, Thailand had 15 million runners in 2018, up from 12 million in 2016 and 5.8 million in 2002 [13]. Therefore, several marathon events have been arranged and held in various places, giving runners a variety of alternatives. The Bangsaen21 Half Marathon is a well-known option among runners and has been rated Thailand's finest marathon competition by a number of organizations. This event not only has an economic influence on the locals, but it also has a social impact. In spite of only having a 35% possibility of participation, more than 37,000 runners still enrolled [12]. However, due to the COVID-19 situation in Thailand [52] the marathon events were refrained in 2020.

Mobile healthcare technology has become popular during the past decade among runners and at marathon events. Devices such as smartphones or tablets can provide up-to-date information as reference for healthcare providers. We propose a case study for the development and design of mobile technology for the safety and health competence in emergency assistance for runners. In this study, we describe the framework for the mobile application designed for the emergency assistance of runners. First, we propose the emergency system and medical support framework for runners in marathon events. Second, we demonstrate a case study based on the use of our system at the CMU Marathon 2020 event. This research is structured as follows: some related work is presented in section 2. Section 3 presents the design system architecture including the step-by-step case study of the mobile application. Section 4 showes the results of the CMU Marathon 2020. Discussion is provided in section 5. Finally, section 6 contains the conclusion and the future work related to our study.

2 Related work

2.1 Health and injury of runners

Marathon running has grown in popularity over the last decade, both in terms of the number of events organized and the number of people who participate in them [14]. According to the 2010 Running USA annual report, the population of marathon finishers has increased by 32% in the last decade [15]. The current increase in marathon participation is possibly due in part to increasing knowledge of the health advantages of regular physical activity. Physical activity has been shown in several studies to have positive benefits on physical and mental health, as well as enhancing lifespan [16, 17]. Marathon running has also been linked to a lower incidence of hyperlipidemia, hypertension, and diabetes [18]. Regular runners have been reported to have decreased rates of death and disability from all causes [19], [47].

In spite of these advantages, marathon running might have a negative impact on one's health. Injury has been claimed to occur up to 90% of the time in a person training for marathons, with the large number of these injuries involving musculoskeletal [20, 21] problems. After running a marathon, there are biochemical and physical indications of cardiac injury that may be seen right afterwards [22, 23, 24]. When compared to individuals who train more intensively, those who have less rigorous pre-marathon training schedules had greater levels of heart damage indicators identified in the serum after a marathon [22]. With the rapid rise in marathon popularity, others have expressed worry that several of the newer marathoners are less physically strong and properly trained [25], [48], likely increasing their risk of heart damage. Marathoners are susceptible to sudden death, which is most commonly caused by cardiac issues [26]. For these reasons, the emergency runner systems and healthcare applications for runners have prevalently been developed to prevent injuries and illnesses of runners and provide early resuscitation.

2.2 Emergency runner systems

In Japan, the frequency of marathons and other road events has grown significantly [27], as has the incidence of abrupt cardiac arrests occurring during these events [28], [50]. For marathoners who experience cardiac arrest during road events, the authors created a rapid mobile automated external defibrillator (AED) system to give early cardiopulmonary resuscitation (CPR) and AED assistance [29,30]. The system is made up of mobile teams (paramedics riding bicycles while carrying AEDs and emergency medical equipment) and on-foot groups (paramedic trainees carrying AEDs and providing assistance for daily living). Medical communications emergency responders, personnel at a first-aid stop, and doctor participants who run the marathon and are ready to help if required through a global positioning system–enabled cellphone are all part of the system [31]. Furthermore, through the study of device data, new potential for estimating participant medical requirements throughout these events arise with consumer activity monitor devices. Consumer activity monitors are prevalent, having 13% of people tracking their physical condition using a smartphone app

or gadget [32], [49]. Due to the prevalence of these gadgets, researchers now have a new method of obtaining participant data in medical studies and analyzing obtained information to help understand health and patient results [33], [51]. Consumer activity devices, as opposed to self-reported surveys, give more detailed information on parameters, including energy consumption, heart rate, step counts, recorded lengths, and elevation changes [34]. These non-invasive gadgets, which are generally worn on the wrist or hip, increase the practicality of passively and constantly gathering data on both personal and community scales.

In addition to consumer activity devices, the telemonitoring gadget in the healthcare system gained popularity as a result of societal concerns, such as increased health awareness and the rise of medical expenses caused by an aging society. ECG telemonitoring, especially that equipped with 'duranta', is helpful in the diagnosis of certain illnesses, such as underlying atrial fibrillation and cerebral infarction [35]. The duranta is a tele-monitoring device for patients with chronic illnesses that was designed to be used at home [36]. The system consists of a wireless ECG sensor and cellphones that perform as transmitters, enabling real-time remote monitoring using cloud servers over a cellular or Wi-Fi network. The European Society of Cardiology has also suggested that athletes undergo cardiac screening through the use of an ECG before running a marathon. Nonetheless, due to the large investment expenses involved and the likelihood of false-positive findings, the usefulness of SCA prevention is debatable [8]. Apart from the emergency system, recent advances in ICT and sensor technology have made it feasible to observe the physical elements of human behaviors at any time. As a result, the accessibility and usage of physical activity-related mobile phone applications have increased exponentially [37, 38, 39].

2.3 Healthcare application for runners

Mobile applications have the potential to promote and encourage physical activity [37, 40, 41]. They have a wide range of functions and are convenient to use, individuals easily carry them and access data anyplace and anytime, they can give feedback possibilities, GPS navigation data can be used, and so on [37,40]. Although smartphones are intriguing devices for (e-) coaching [42], most fitness and health-related applications (mainly) give performance feedback, with minimal personalized assistance [38]. Inspirun is a customized running-app for Android devices [43]. An innovative technology for recreational runners, it distinguishes itself by combining a customized coaching approach with automated customization of training schedules based on biofeedback and GPS location. Three user tests provided positive results; users were delighted with the customized approach, both in characterizing and de-adapting their training schedule. It is proposed that applications in terms of sports performance monitoring and targeted advice can have an influence on physical activity, liveliness, and active lifestyles in urban places [43]. Besides, Tseng et al. [44] designed and evaluated the International Institute of Race Medicine (IIRM) Medical Recommendations app for ios and Android platforms in collaboration with an application development company (Boston Technology Corporation Inc, Boston, Massachusetts). The IIRM application included treatment recommendations for the following

conditions: changed mental state, chest discomfort, exercise-related collapse, heat sickness, suspected hyponatremia, suspected hypothermia, and muscular cramps. Participants considered the IIRM app to be simple to use and easy-to-incorporate into their medical practice. This was to be envisioned, since the design prioritized quick navigation, a simplified user interface, and minimized text-heavy data to ease point-of-care utilization. The objective was to deploy the app prior to the marathon day so that users could become acquainted with it before using it at the point of care. According to survey results, participants did, as predicted, download and utilize the app prior to the event. The majority of respondents said they would use the IIRM app again and suggest it to other providers, confirming the program's usefulness and acceptance among users. Regardless of the fact that most participants found the IIRM app to be simple to use, most of them did not refer to or utilize it throughout the event [44]. Since medical knowledge and people's health are the most crucial considerations, aside from smartphone application, e-learning in resuscitation has also been considered as an effective method of providing medical information to people who are health-conscious and work or study in the medical field.

3 The development of the emergency assistance system for marathon runners

In this study, to prevent an emergency, we developed an application for the safety and health competence of emergency assistance for marathon runners, since their health and safety should be regarded as the most important concern before participating in a marathon. To develop the system, we differentiated three phases: the registration, data analytics and running phases are shown in Figure 1. In this chapter we provide a step-by-step description of the phases.

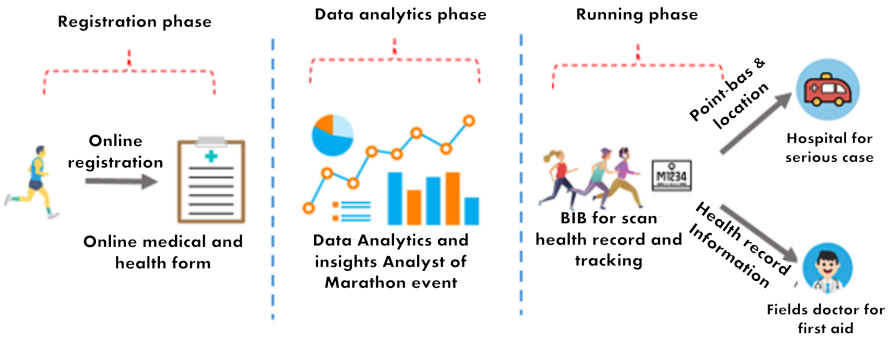

Fig. 1. Emergency assistance system for marathon runners

3.1 Registration phase: Design form for an electronic personal health record

In the registration phase, the objective is to design and develop a form for the registration of the runner's electronic personal health record [46] which is the medical history of runners supporting the field doctors in any serious cases of emergency. After that, we developed a web-based registration application and a health database for prevention and assistance in the case runners encounter an incident during the race. This includes the runner's basic information form and the module, which contains basic information, the runners' personal information, address, birthplace, etc. Furthermore it includes the medical and health form, a system for collecting and managing runners' medical and health information that consists of information such as the medical history and eventual drug allergiesetc., as shown in Table 1 and in appendix A. These forms are filled during the registration of the runners who participated in the CMU MARATRON 2020. It is important to note that we had designed the form so that it contains only the most important data because participants may feel stressed if the form to be filled in before the marathon event is too long.

Table 1. Form of the runner's electronic personal health record

Form	Information	Objective
Part 1: Basic Health Information	Demographics, Health history, injury report	Basic runner information and medical history of runners focusing on serious emergency cases
Part 2: Running race experience	personal running record	Health database and statistics of running
Part 3: Knowledge and understanding of basic life support (BLS)	Basic life support(BLS)	Raising the awareness of the runner on the basic knowledge of life support and first aid for other runners.

3.2 Data analytics phase

In this phase, we analyzed the data from the registration phase in order to prepare the capacity of resource and medical staff to prevent and treat any injuries and accidents. The application was based on the CMU Marathon 2020 (https://run.cmu-marathon.com/episode-2020/) event, which was held at Sala Ang Kaew, organized by Chiang Mai University on February 9, 2020, to celebrate the 55th Anniversary of Chiang Mai University and the 5th anniversary of the CMU Marathon under the slogan, "Together we are one".

We summarize the runner data of the CMU Marathon 2020. Based on the testing of the applications by the runners, we can determine that there were 9,761 runners participating in the running event, which included 2,469 runners in the marathon (25 %), 3,174 runners in the half marathon (33%), 3,247 runners in the mini marathon (33%), and 871 runners in the Fun Run (9%), as shown in Table 2. As regards the gender distribution, therewere 5,734 male runners (56%) and 4,027 female runners (44%). As shown in Table 3, there were 1,920 runners in the 20-29 years old group, (19.67%), 3,517 runners in the 30-39 years old group (36.03%), 2,320 participants in the 40-49 years old group (23.76%), 918 runners in the 50-59 years old group (9.40%), and 152

participants in the age group 60 years and above (1.55%). The other 934 runners of the CMU marathon did not specify their age.

Table 2. The number of participants in each type of running events

Running event types	Number of participants	Percent
Marathon	2,469	25%
Half marathon	3,174	33%
Mini marathon	3,247	33%
Fun Run	871	9%
Total	9,761	100%

Table 3. The number of runners by age (CMU Marathon 2020)

Age	Number	Male	Female	Percent
Did not specify	934	503	431	9.56%
20-29	1,920	1141	779	19.67%
30-39	3,517	2050	1467	36.03%
40-49	2,320	1371	949	23.76%
50-59	918	555	363	9.40%
More than 60	152	114	38	1.55%
Total	9761	5,734	4027	100%

In addition, medical histories of runners' family members identified that 74 people experienced sudden cardiac arrest or died of an unknown cause (Figure 2). The most common three health conditions specified by 2,310 runners were high blood pressure, hyperlipidemia, and asthma (Figure 3). Furthermore, during breaks, runners with swollen feet or legs were the most common health issues, followed by chest tightness, pain in the neck and jaws, fainting, and fatigue respectively, as shown in Figure 4.

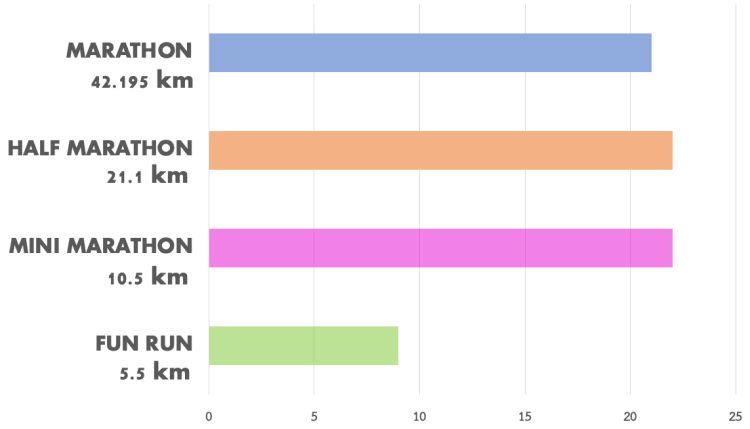

Fig. 2. Bar chart of the number of medical histories of runners' family members

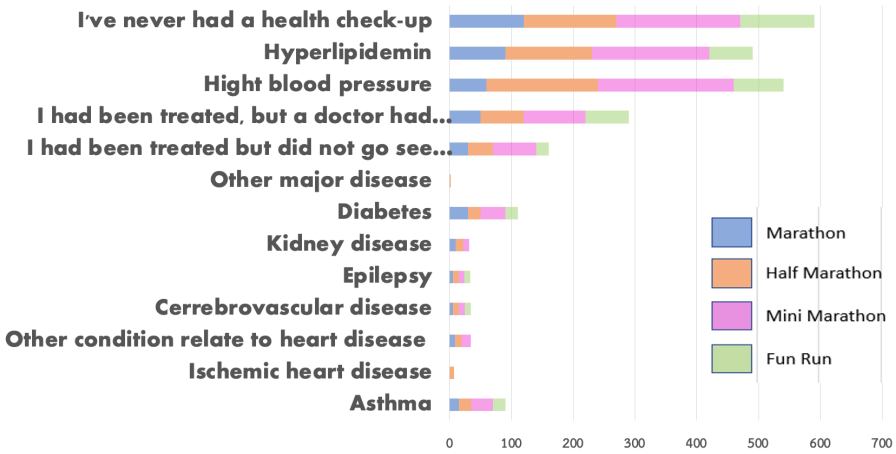

Fig. 3. Bar chart of the health conditions of runners

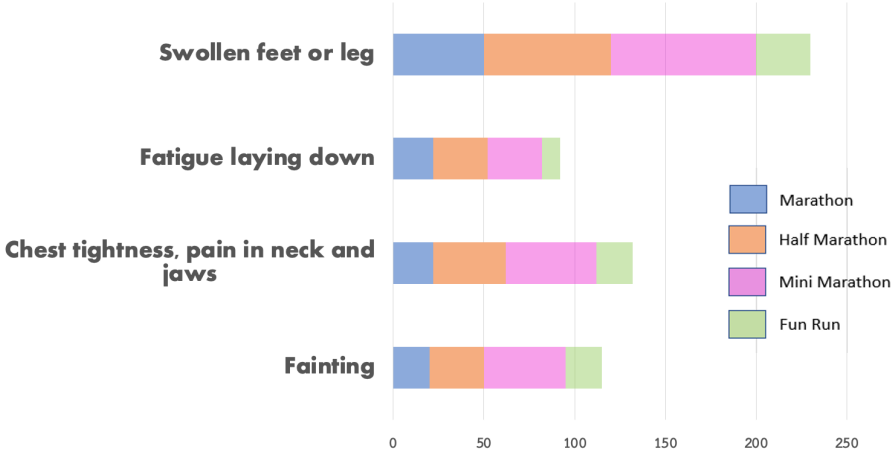

Fig. 4. Symptoms occurred during breaks

3.3 Running phase: Applications for the real-time running event

In terms of the running phase, we developed an application for the exclusive use of staff such as medical teams of field nurses who take care of runners in case of emergency cases.

Medic application: History report and information for CPR. The application of medics was developed to display the health information, and health history of runners, including telephone numbers and contact information of relatives for emergency cases (History Report and Information for CPR). When runners signed up for the CMU marathon 2020, the basic information they provided, as we mention before, is used to create a personal health record database. A unique QR code is then generated and

placed on the corner of each runner's BIB, as shown in Figure 6. Runners could access the database via a website to modify the additional information, such as health conditions, medications and allergies. In terms of emergency cases, only the medical officials can scan the QR code and then display the person's name, health history and emergency contact information shown in Figure 5. Please note that after the race, the QR code is disabled,making the information no longer available, thus supportinginformation security.

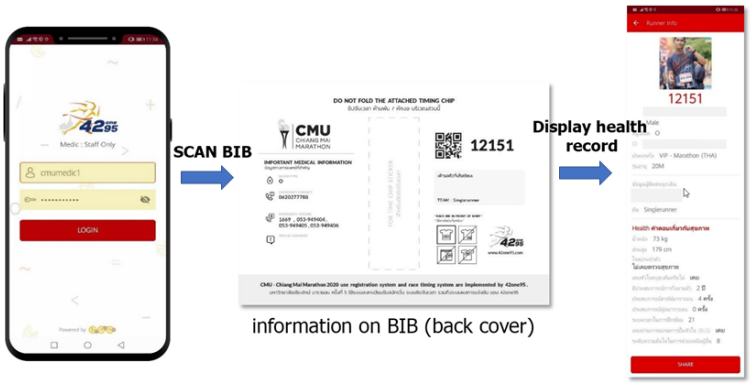

Fig. 5. Example of using the medic application

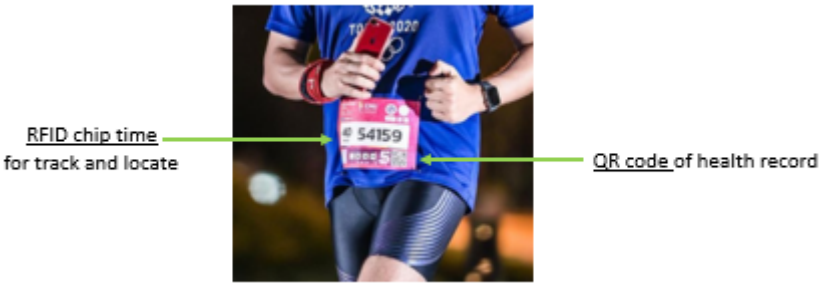

Fig. 6. Example of BIB used at the marathon event including a QR code and RFID chip

Application Track: Point-based & location-based runner tracking. Moreover, we also developed the application Track, a mobile-based application, utilizing point-based and location-based technoology, allowing staff and other medical teams to locate the runner's emergency aid point and also to bring the patient to that rescue point or a point where the ambulance can bring the runner to the hospital, as shown in Figure 7. A technology based on the RFID chip time was used to calculate and track the location of the runner, located in the back cover of the BIB.

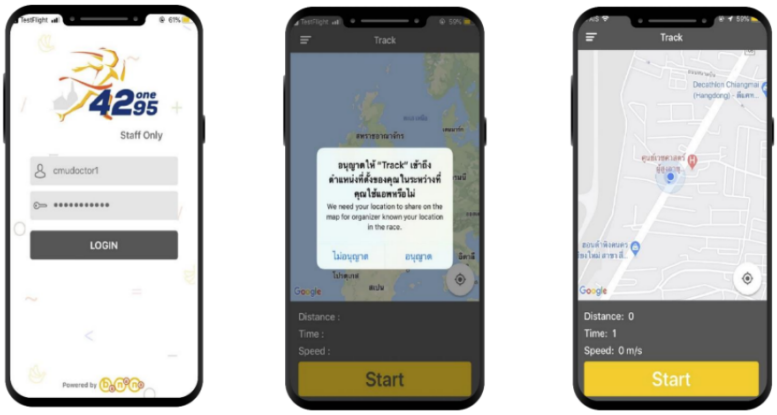

Fig. 7. Example of the application Track using point-based & location-based technology to track runners

4 Result and discussion

4.1 Result

The overall number of staff and volunteers was estimated to be around 300 people working to support the CMU marathon 2020. Thus, we used a questionnaire to survey the usefulness of the mobile application. 32 medical staff completed the survey through Google form. The result of the post-event are shown in Table 4 and Table 5 respectively.

Table 4. The survey questionnaire on mobile application usefulness (n=32)

	Strongly Disagree (%)	Disagree (%)	Neutral (%)	Agree (%)	Strongly Agree (%)
The app was easy to use	2.94	14.70	11.76	29.41	41.17
The app provides useful information	0	8.82	23.52	38.23	29.41
The app contributed to clinical decision-making	11.76	14.70	44.11	20.58	8.82
I will use this app again	0	5.88	29.41	44.11	20.58
I recommend using this app at the next marathon event	0	0	11.76	52.94	35.29

As Table 4 reveals, the majority of staff (41.17%) strongly agreed that the app was simple to use while running a marathon. The app's capacity to provide useful information was confirmed by 38.23% of staff members, choosing 'agree' for the related section, as opposed to only 8.82% of staff strongly agreeing that the app could contribute to clinical decision-making. However, as regards the sections 're-using the app' and 'recommending the app for the next marathon event' no staff members

marked 'strongly disagree', showing that they preferred using the app and suggesting it for a future running race, with 44.11% and 52.94%, respectively.

Table 5. Examples from open response questions regarding the mobile application

Positive feedback about the application:	
	Very easy to use and helpful
	Great, it can display the personal healthcare data easily
	The application can prevent the runner in case of emergency
Negative feedback about the application:	
	The concept of application is useful but I could not find the health information when I scanned the QR code
	The app is great but I just didn't have time to use it out during patient care.
	The application was great but in case of emergency t no one is going to open the application. As a medical staff, I think most of the staff members tend to act by instinct.
Specific feedback for technical improvement:	
	I use android mobile phone, it was quite slow
	Sometimes the GPS in the application is not accurate
	Some versions of androids cannot work properly

4.2 Discussion

This study proposed and implemented a mobile application to provide clinical decision support for marathon events. We also tested the application on a large number of participants, using it at the CMU marathon 2020 event with 9721 runners. The data generated by the registration phase were useful for preparing the capacity of medical staff and the AED equipment including the definition of the number of ambulances. However, the runners reported that the health history form during the registration of the marathon event was quite long and made them feel stressed and some runners decided to input incorrect information because they preferred to finish this task as soon as possible. The mobile application was reported to be useful and helpful by the medical staff,making them feel confident in case of advice giving or a runner accident during the event.

As shown in the Table 5, in terms of positive feedback regarding the mobile application, users stated that the app was simple and capable of giving various useful information. Moreover, the app was excellent at thoroughly providing personal healthcare data and could help runners avoid emergency situations.

On the contrary, the app received several negative feedback responses from users. The app did not always display the health information for users when they scanned the QR code. Additionally, they did not have time to open and use the app when experiencing an emergency situation, assuming that the staff tend to act instinctively.

As far as specific feedback on technical improvement is concerned, Android mobile phone users mentioned that the app was relatively slow and sometimes could not function properly. They also reported that the GPS in the app was not always precise.

5 Conclusion & future work

Marathon is becoming more and more well-known as an individual sport since many people become concerned of their well-being and health. A lot of marathoners, however, experience an emergency during the race, leading to injuries or, in the worst case, deaths. To prevent such incidents, in this study, we developed an applications for the safety and health competence of the emergency assistance for runners. We tested the applications and collected information about runners' medical and health information in the CMU Marathon 2020 (https://www.cmu-marathon.com/).

The results of this study suggest that our proposed application can be generally accepted by the medical staff, and it can also provide the technology to prevent serious accidents in future marathon events. We conducted our study during the CMU Marathon 2020 event, utilizing the9,761 records of the participating runners. We believe that this study provides an example for the better understanding of the effectiveness of applications designed for the improvement of medical care of marathon participants.

In the future, we intend to continue collecting information at more running events and develop the Runner's CPR Data Input Mobile Application with no limitations in order to accurately and quickly present runners' health information.

6 Acknowledgment

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7 References

[1] T. Shirakawa, H. Tanaka, T. Kinoshi, H. Takahashi, "An investigation of sudden cardiac arrest during marathons in Japan," *Annu Rep Health Phys Educ Sport Sci, vol. 31,* pp. 121–124, 2012.

[2] A. Hulme, R. O. Nielsen, T. Timpka, E. Verhagen, and C. Finch, "Risk and protective factors for middle- and long-distance running-related injury," *Sports Med., vol. 47,* no. 5, pp. 869–886, 2017. https://doi.org/10.1007/s40279-016-0636-4

[3] K. L. Bennell and K. Crossley, "Musculoskeletal injuries in track and field: incidence, distribution and risk factors," *Aust. J. Sci. Med. Sport,* vol. 28, no. 3, pp. 69–75, 1996.

[4] J. Jacobsson et al., "Injury patterns in Swedish elite athletics: annual incidence, injury types and risk factors," *Br. J. Sports Med.,* vol. 47, no. 15, pp. 941–952, 2013. https://doi.org/10.1136/bjsports-2012-091651

[5] M. Schwellnus et al., "How much is too much? (Part 2) International Olympic Committee consensus statement on load in sport and risk of illness," *Br. J. Sports Med.,* vol. 50, no. 17, pp. 1043–1052, 2016. https://doi.org/10.1136/bjsports-2016-096572

[6] T. Soligard et al., "How much is too much? (Part 1) International Olympic Committee consensus statement on load in sport and risk of injury," *Br. J. Sports Med.,* vol. 50, no. 17, pp. 1030–1041, 2016. https://doi.org/10.1136/bjsports-2016-096581

[7] D. Webner, K. M. DuPrey, J. A. Drezner, P. Cronholm, and W. O. Roberts, "Sudden cardiac arrest and death in United States marathons," *Med. Sci. Sports Exerc.,* vol. 44, no. 10, pp. 1843–1845, 2012. https://doi.org/10.1249/MSS.0b013e318258b59a

[8] D. Corrado et al., "Recommendations for interpretation of 12-lead electrocardiogram in the athlete," *Eur. Heart J.,* vol. 31, no. 2, pp. 243–259, 2010. https://doi.org/10.1093/eurheartj/ehp606

[9] M. K. Drew and C. F. Finch, "The relationship between training load and injury, illness and soreness: A systematic and literature review," *Sports Med.,* vol. 46, no. 6, pp. 861–883, 2016. https://doi.org/10.1007/s40279-015-0459-8

[10] R. Johnston, R. Cahalan, M. O'Keeffe, K. O'Sullivan, and T. Comyns, "The associations between training load and baseline characteristics on musculoskeletal injury and pain in endurance sport populations: A systematic review," *J. Sci. Med. Sport,* vol. 21, no. 9, pp. 910–918, 2018. https://doi.org/10.1016/j.jsams.2018.03.001

[11] M. Mooses and A. C. Hackney, "Anthropometrics and body composition in East African runners: Potential impact on performance," *Int. J. Sports Physiol. Perform.,* vol. 12, no. 4, pp. 422–430, 2017. https://doi.org/10.1123/ijspp.2016-0408

[12] W. Boonsiritomachai and C. Phonthanukitithaworn, "Destination attributes that attract marathon runners: a case study of the Bangsaen21 half marathon," *Modern Management Journal,* vol. 16, no. 1, pp. 251–262, 2018.

[13] S. Promnoi, "A study of people's motivation to participate in mini marathons in Thailand," Mahidol university, Thailand, Bangkok, 2019.

[14] S. C. Mathews et al., "Mortality among marathon runners in the United States, 2000-2009," *Am. J. Sports Med.,* vol. 40, no. 7, pp. 1495–1500, 2012. https://doi.org/10.1177/0363546512444555

[15] Running USA, "RRIC annual marathon report," Dec. 2010.

[16] W. L. Haskell et al., "Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association: Updated recommendation for adults from the American college of sports medicine and the American heart association," *Med. Sci. Sports Exerc.,* vol. 39, no. 8, pp. 1423–1434, 2007.

[17] R. S. Paffenbarger Jr, R. T. Hyde, A. L. Wing, I. M. Lee, D. L. Jung, and J. B. Kampert, "The association of changes in physical-activity level and other lifestyle characteristics with mortality among men," *N. Engl. J. Med.,* vol. 328, no. 8, pp. 538–545, 1993. https://doi.org/10.1056/NEJM199302253280804

[18] P. T. Williams, "Lower prevalence of hypertension, hypercholesterolemia, and diabetes in marathoners," *Med. Sci. Sports Exerc.,* vol. 41, no. 3, pp. 523–529, 2009. https://doi.org/10.1249/MSS.0b013e31818c1752

[19] E. F. Chakravarty, H. B. Hubert, V. B. Lingala, and J. F. Fries, "Reduced disability and mortality among aging runners: a 21-year longitudinal study: A 21-year longitudinal study," *Arch. Intern. Med.,* vol. 168, no. 15, pp. 1638–1646, 2008. https://doi.org/10.1001/archinte.168.15.1638

[20] G. D. Ewert, "Marathon race medical administration," *Sports Med.,* vol. 37, no. 4–5, pp. 428–430, 2007. https://doi.org/10.2165/00007256-200737040-00040

[21] M. Fredericson and A. K. Misra, "Epidemiology and aetiology of marathon running injuries," *Sports Med.,* vol. 37, no. 4, pp. 437–439, 2007. https://doi.org/10.2165/00007256-200737040-00043

[22] D. S. Jassal et al., "Cardiac injury markers in nonelite marathon runners," Int J Sports Med, vol. 30, no. 2, pp. 75–79, 2009. https://doi.org/10.1055/s-0028-1104572

[23] N. Mousavi et al., "Relation of biomarkers and cardiac magnetic resonance imaging after marathon running," *Am. J. Cardiol.,* vol. 103, no. 10, pp. 1467–1472, 2009. https://doi.org/10.1016/j.amjcard.2009.01.294
[24] T. G. Neilan et al., "Myocardial injury and ventricular dysfunction related to training levels among nonelite participants in the Boston marathon," *Circulation,* vol. 114, no. 22, pp. 2325–2333, 2006. https://doi.org/10.1161/CIRCULATIONAHA.106.647461
[25] Y. B., "Marathons grow, heart-attack risks more apparent," *The Arizona Republic,* Oct. 2010.
[26] D. A. Redelmeier and J. A. Greenwald, "Competing risks of mortality with marathons: retrospective analysis," *BMJ,* vol. 335, no. 7633, pp. 1275–1277, 2007. https://doi.org/10.1136/bmj.39384.551539.25
[27] Sasakawa sports foundation, "Sports life data." [Online]. Available: https://www.ssf.or.jp/research/sldata/tabid/381/Default.aspx [Accessed: 01-Jan-2017].
[28] T. Shirakawa, H. Tanaka, T. Kinoshi, S. Tanaka, and H. Takyu, "Analysis of sudden cardiac arrest cases during marathon races in Japan," *Int J Clin Med,* vol. 8, pp. 472–480, 2007.
[29] T. Maezumi et al., "Importance of bicycle mobile team (Mobile AED team) in citizen marathon," *Journal of Clinical Sports Medicine,* vol. 26, pp. 329–334, 2009.
[30] H. Tanaka, T. Tokunaga, T. Maezumi, and T. Hosokawa, "A development of an effective emergency medical support in the citizens' marathon events," *The Annual Reports of Health, Physical Education and Sport Science,* vol. 27, pp. 115–122, 2008.
[31] T. Kinoshi et al., "Mobile automated external defibrillator response system during road races," *N. Engl. J. Med.,* vol. 379, no. 5, pp. 488–489, 2018. https://doi.org/10.1056/NEJMc1803218
[32] S. Fox and M. Duggan, "Tracking for health," *Pew Research Internet Project Report,* 2013.
[33] V. Constantinou, A. E. Felber, and J. L. Chan, "Applicability of consumer activity monitor data in marathon events: an exploratory study," *J. Med. Eng. Technol.,* vol. 41, no. 7, pp. 534–540, 2017. https://doi.org/10.1080/03091902.2017.1366560
[34] M. L. Dontje, M. de Groot, R. R. Lengton, C. P. van der Schans, and W. P. Krijnen, "Measuring steps with the Fitbit activity tracker: an inter-device reliability study," *J. Med. Eng. Technol.,* vol. 39, no. 5, pp. 286–290, 2015. https://doi.org/10.3109/03091902.2015.1050125
[35] H. Akiyama et al., "Utility of Duranta, a wireless patch-type electrocardiographic monitoring system developed in Japan, in detecting covert atrial fibrillation in patients with cryptogenic stroke: A case report: A case report," *Medicine (Baltimore),* vol. 96, no. 6, p. e5995, 2017. https://doi.org/10.1097/MD.0000000000005995
[36] M. Yoshizawa et al., "A tele-electrocardiographic monitoring system for patients with chronic disease at home," *Austin Emerg Med,* vol. 2, p. 1031, 2016.
[37] J. Fanning, S. P. Mullen, and E. McAuley, "Increasing physical activity with mobile devices: a meta-analysis," *J. Med. Internet Res.,* vol. 14, no. 6, p. e161, 2012. https://doi.org/10.2196/jmir.2171
[38] A. Middelweerd, J. S. Mollee, C. N. van der Wal, J. Brug, and S. J. Te Velde, "Apps to promote physical activity among adults: a review and content analysis," *Int. J. Behav. Nutr. Phys. Act.,* vol. 11, no. 1, p. 97, 2014. https://doi.org/10.1186/s12966-014-0097-9
[39] J. H. West, P. C. Hall, C. L. Hanson, M. D. Barnes, C. Giraud-Carrier, and J. Barrett, "There's an app for that: content analysis of paid health and fitness apps," *J. Med. Internet Res.,* vol. 14, no. 3, p. e72, 2012. https://doi.org/10.2196/jmir.1977

[40] J. M. Dallinga, M. Mennes, L. Alpay, H. Bijwaard, and M. Baart de la Faille-Deutekom, "App use, physical activity and healthy lifestyle: a cross sectional study," *BMC Public Health,* vol. 15, no. 1, p. 833, 2015. https://doi.org/10.1186/s12889-015-2165-8

[41] S. Vos, M. Janssen, J. Goudsmit, J. Bovens, and C. Lauwerijssen, Eds., Creating light and personalised running experiences: an app development study. In Proc. the European Sport Management Conference 2015 September 9-12, EASM: Dublin (Ireland), 2015.

[42] M. Kranz et al., "The mobile fitness coach: Towards individualized skill assessment using personalized mobile devices," *Pervasive Mob. Comput.,* vol. 9, no. 2, pp. 203–215, 2013. https://doi.org/10.1016/j.pmcj.2012.06.002

[43] S. Vos, M. Janssen, J. Goudsmit, C. Lauwerijssen, and A. Brombacher, "From problem to solution: Developing a personalized smartphone application for recreational runners following a three-step design approach," *Procedia Eng.,* vol. 147, pp. 799–805, 2016. https://doi.org/10.1016/j.proeng.2016.06.311

[44] D. Tseng et al., "Qualitative assessment of a medical protocols mobile application at the Boston marathon 2016," *Clin. J. Sport Med.,* vol. Publish Ahead of Print, no. 1, pp. e8–e14, 2018. https://doi.org/10.1097/JSM.0000000000000693

[45] R. A. Berg et al., "Part 5: adult basic life support: 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care: 2010 American heart association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care," *Circulation,* vol. 122, no. 18 Suppl 3, pp. S685-705, 2010. https://doi.org/10.1161/CIRCULATIONAHA.110.971085

[46] R. Abdolkhani, F. Halabchi, R. Safdari, H. Dargahi, and K. Shadanfar, "Designing an electronic personal health record for professional Iranian athletes," *Asian J. Sports Med.,* vol. 5, no. 4, p. e23809, 2014. https://doi.org/10.5812/asjsm.23809

[47] K. Intawong and K. Puritat, "A framework of developing mobile gamification to improve user engagement of physical activity: A case study of location-based augmented reality mobile game for promoting physical health," *Int. J. Onl. Eng.,* vol. 17, no. 07, p. 100, 2021. https://doi.org/10.3991/ijoe.v17i07.22349

[48] K. Intawong, W. Boonchieng, P. Lerttrakarnnon, E. Boonchieng, and K. Puritat, "A-SA SOS: A mobile- and IoT-based pre-hospital emergency service for the elderly and village health volunteers," *Int. J. Adv. Comput. Sci.* Appl., vol. 12, no. 4, 2021. https://doi.org/10.14569/IJACSA.2021.0120465

[49] K. Intawong, K. Puritat, and P. Jarusawat, "Short Term prediction of statistics for Bigdata in video surveillance," In *2018 22nd International Computer Science and Engineering Conference (ICSEC),* 2018, pp. 1-4. https://doi.org/10.1109/ICSEC.2018.8712725

[50] K. Intawong, P. Ong-artborirak, and W. Boonchieng, "Seamless Electronic Medical Record for Health Management System in Emergency Patients," In *2021 Joint International Conference on Digital Arts, Media and Technology with ECTI Northern Section Conference on Electrical, Electronics, Computer and Telecommunication Engineering*, 2021, pp. 189–192. https://doi.org/10.1109/ECTIDAMTNCON51128.2021.9425689

[51] K. Intawong, P. Prompantakorn, and W. Boonchieng, "An improved automatic zone detection algorithm based on mechanic flow for complex scene event," In *2021 Joint International Conference on Digital Arts, Media and Technology with ECTI Northern Section Conference on Electrical, Electronics, Computer and Telecommunication Engineering*, 2021. https://doi.org/10.1109/ECTIDAMTNCON51128.2021.9425776

[52] K. Intawong, D. Olson, and S. Chariyalertsak, "Application technology to fight the COVID-19 pandemic: Lessons learned in Thailand," *Biochem. Biophys. Res. Commun.,* vol. 538, pp. 231–237, 2021. https://doi.org/10.1016/j.bbrc.2021.01.093

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9 Appendix A: Health history form

Gender: ☐ Male ❒ Female

Age: ……

1. Weight: ……. 2. Height: …….

Part 1: Basic Health Information

3. Do you have chronic illnesses? ☐ Yes ☐ NO

Check any conditions you have had:

☐ High blood pressure ☐ Diabetes
☐ Hyperlipidemia ☐ Asthma
☐ Emphysema ☐ Ischemic heart disease
☐ Other conditions related to heart disease ☐ Kidney disease
☐ Cerebrovascular disease ☐ Other conditions related to cerebrovascular disease
☐ Epilepsy ☐ I've never had a health check-up
☐ Other major diseases: ……
☐ I had been treated, but a doctor had suspended the treatment
☐ I had been treated but did not go see a doctor regularly

4. Have you had any of these symptoms during rest or activities? (Check more than one item)

☐ Chest tightness, pain in the neck and jaws ☐ fainting ☐ swollen feet or legs ☐ fatigue lying down

5. Have your family members' medical histories had a sudden cardiac arrest or died of an unknown cause?

OYes ONo

Part 2: Running race experiences

1. How long have you been running? ……..
2. How many times have you participated in a half-marathon race? ……..
3. How many times have you participated in a full-marathon race? …….
4. How long did you run in a week? …….

Part 3: Knowledge and understanding of basic life support (BLS)

1. Have you ever had basic life support (BLS) training?

O Yes O No

2. How prepared and confident are you to help if a runner has a cardiac arrest? (10 points)

……

3. What is the number of emergency medical service in Thailand?

……