

User Needs and Factors Associated With the Acceptability of Audiovisual Feedback Devices for Chest Compression Monitoring in Cardiopulmonary Resuscitation

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The use of audiovisual feedback devices to guide the quality of chest compressions during cardiopulmonary resuscitation has increased in recent years. Audiovisual feedback devices can be classified as integrated (eg, Zoll AED Plus defibrillator) or standalone (eg, CPRmeter). This study aimed to explore users' needs and factors affecting the acceptability of audiovisual feedback devices. Semistructured interviews were conducted with healthcare professionals involved in lifesaving activities. The Unified Theory of Acceptance and Use of Technology was used as a theoretical framework for the study. The Unified Theory of Acceptance and Use of Technology model has four constructs: performance expectancy, effort expectancy, social influence, and facilitating factors. Ten themes were identified under the four constructs. The performance expectancy constructs include three themes: perceived usefulness, outcome expectation, and applicability in diverse situations. The effort expectancy construct encompasses two themes: user-friendliness and complexity. The social influence construct has two themes: social and organizational factors. Lastly, the facilitating factors construct includes three themes: staff competence, perceived cost, and compatibility of devices. Exploring the needs and factors influencing the acceptability of audiovisual feedback devices used during cardiopulmonary resuscitation will inform healthcare providers, managers, manufacturers, and procurers on how to improve the efficiency and use of these devices.

KEY WORDS: Audiovisual feedback, Cardiopulmonary resuscitation, Medical devices, Technology adoption

Cardiac arrest is a challenging event and remains one of the public health burdens across the world.^{1,2} Factors influencing survival after cardiac arrest are well understood, but there is still considerable variation in incidence and outcome.³ Survival after a cardiac arrest depends on several factors, such as the cause of the cardiac arrest, response time, the place where the cardiac arrest occurred, the initiation of bystander cardiopulmonary resuscitation (CPR), the availability of a defibrillator, the quality of CPR, the age of the victim, and the quality of postresuscitation care.¹⁻³ Based on data from 2008 to 2017, the rate of in-hospital cardiac arrest in the United States ranged from 9 to 10 per 1000 admissions, and survival to hospital discharge ranges from 0% to 42%.⁴ In Europe, annual in-hospital cardiac arrest rates ranged from 1.5 to 2.8 per 1000 hospital admissions, with survival rates of 15% to 34%.³ The incidence of out-of-hospital cardiac arrest per 100 000 inhabitants is 67 to 170 in Europe³ and 51 to 107 in Australia and New Zealand, with an average survival rate of 8% and 12%, respectively.⁵

Cardiopulmonary resuscitation is a lifesaving procedure performed on cardiac arrest patients. Cardiopulmonary resuscitation aims to provide artificial blood flow to the vital organs until the natural circulation is returned.⁴ High-quality chest compressions are an essential part of successful resuscitation.⁶ However, there have been instances when even experienced healthcare professionals have failed to perform chest compressions as recommended by CPR guidelines.⁷ For example, a study evaluating the impact of CPR quality and adherence to CPR guidelines on patient outcomes found that only 37% and 63.9% of compressions were within the recommended range for rate and depth, respectively.⁸

Several medical devices have been developed to provide real-time audiovisual feedback (AVF) to inform rescuers about the quality of chest compressions during CPR.⁹ These devices can be broadly divided into integrated and standalone

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AVF devices. Integrated AVF devices are integral to complex multifunctional medical devices such as defibrillators or simulation manikins.¹⁰ Despite their advanced features, integrated AVF devices are more expensive, relatively complex, and inaccessible to community-based rescuers. Standalone AVF devices are freestanding and typically placed between the rescuer's hand and the patient's chest.¹⁰ Unlike integrated AVF devices, standalone AVF devices often have fewer features. They are less expensive and portable, potentially helpful in guiding inexperienced healthcare professionals and laypersons in hospital and community settings.^{10,11}

Technological innovations can transform our lives and bring new values and practices to society.¹² However, as technological innovations continue to evolve, it is difficult to predict how influential they will be. Adoption of new technologies is unpredictable and prone to failure, as the success of an innovation depends on end-user acceptance of a particular technology.¹² The features of technology play a crucial role in whether the people involved in an activity will accept and use it.¹³ Therefore, exploring the needs and understanding users' perceptions of acceptability may help further promote the adoption of new technologies.^{12,13}

Previous studies have explored participants' perceptions of the acceptability of various health-related medical technologies, including digital health technology,¹⁴ electronic medical records,¹⁵ and wearable health devices for different purposes.¹⁶ Despite this reality, medical devices that provide feedback on the quality of chest compressions have not been studied from a user perspective. Therefore, this study aimed to explore the needs and factors that influence the acceptability of AVF devices that monitor chest compression quality during CPR from the users' perspective.

METHODOLOGY

Theoretical Framework

The Unified Theory of Acceptance and Use of Technology (UTAUT) guided the study. We chose the UTAUT model for its comprehensiveness because it is derived through analysis and consolidation of eight commonly used Technology Acceptance Models, including the Theory of Reasoned Action, Technology Acceptance Model (TAM 1), Technology Acceptance Model (TAM2), Diffusion of Innovation Theory, Theory of Planned Behavior, Model of Personal Computer Use, Social Cognitive Theory, a Combined Theory of Planned Behavior/Technology Acceptance Model, and the motivational model.¹⁷ This work aimed to develop a unified acceptance model that predicts better technology acceptance variance.¹⁷ The UTAUT model has been successfully applied to understand the adoption of various health-related technologies, including digital health technology,¹⁴ electronic medical records,^{15,18} and wearable devices for different purposes.^{16,19} The UTAUT model evolved with four

fundamental constructs that determine the acceptance of behavior: performance expectancy, effort expectancy, social influence, and facilitating conditions.¹⁷ This model was used in developing the interview guide and data analysis. The coding matrix used in the data analysis is shown in Table 1.

Design

This study adopted a qualitative descriptive approach, using focus group discussions and individual interviews to gather more detailed information to explore the needs and understand the factors associated with AVF devices' acceptability during CPR.

Setting and Participants

The sample was drawn from active members of departments involved in lifesaving activities, including the Ghana Red Cross Society—Ashanti Branch, Komfo Anokye Teaching Hospital, Ghana, Southwest Finland Emergency Services, and the Emergency and Intensive Care Departments of Turku University Hospitals.

The Ghana Red Cross Society is the country's largest volunteer humanitarian relief organization, serving the region.²⁰ There is a first aid department in all 10 regions to strengthen first aid training activities for individuals, organizations, institutions, and communities.²⁰ Volunteers trained in Basic Life Support by the Ghana Red Cross Society provide first aid services for patients with various injuries.²⁰ The Komfo Anokye Teaching Hospital is a large tertiary healthcare facility in Kumasi, Ghana. The hospital is vital in providing medical education and training to healthcare professionals and acts as a referral and teaching hospital. It is affiliated with the Kwame Nkrumah University of Science and Technology and is responsible for training medical students and other healthcare professionals.

The Southwest Finland Emergency Services is part of Finland's national rescue service system, which aims to ensure the safety and welfare of citizens by responding to emergencies and promoting fire safety. Turku University Hospital, on the other hand, offers extensive specialized healthcare services to the residents of Southwest Finland. Turku University Hospital is also responsible for the university hospital-level services in Satakunta and Vaasa, which have a total population of 869 786 inhabitants. In Finland, professionals handling resuscitation cases are typically physician anesthesiologists and nurses with extensive paramedic training.

Nursing education in Finland is unique. The comprehensive paramedic degree program aims to equip students with the necessary knowledge and skills to become both paramedics (known as "ensihoitaja" in Finnish) and RNs (known as "sairaanhoitaja" in Finnish). The program consists of 240 ECTS (European Credit Transfer and Accumulation System) credits and is designed to be completed in 4 years.

Table 1. Coding Matrix Used for Categorizing the Data

UTAUT Model Constructs	Definition From UTAUT ¹⁷	Adapted Definition Relevant to AVF Devices
Performance expectancy	The degree to which an individual believes that using the system will help him or her to attain gains in job performance	The degree to which an individual believes that using the audiovisual feedback devices will help him or her attain gains in terms of CPR performance
Effort expectancy	The degree of ease associated with the use of the system	The degree of ease associated with the use of the audiovisual feedback devices for the purposes of CPR performance
Social influence	The degree to which an individual perceives that important others believe he or she should use the new system	The degree to which an individual perceives that important others can influence him or her on the use of the audiovisual feedback devices during CPR
Facilitating and impeding conditions	The degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system	The degree to which an individual believes that an organizational and technical infrastructure exists to support use of the audiovisual feedback devices during CPR

Upon graduation, students receive two-degree titles: a nurse and a paramedic. Their job titles, therefore, depend on the specific work they perform, such as paramedics (who work in ambulances), emergency nurses (who work in emergency rooms), and intensive care nurses (who work in ICUs). In addition, general nurses with qualifications in the competence area of Basic Life Support may be involved. The general nursing program is a degree program that lasts approximately 3.5 years and comprises 210 ECTS credits.

We included participants from Finland and Ghana to obtain data from the perspectives of developed and developing countries. The inclusion criteria were health professionals (1) who have participated in basic and/or advanced cardiac life support, (2) who had at least Basic Life Support training, and (3) who had at least 1 year of experience in actual patient resuscitation.

Data Collection

Purposive sampling was used to explore the issue from different experiences and locations. We used maximum variation sampling to cover a broader range of perspectives and capture a wide range of information and experiences.²¹ In the qualitative research approach, researchers select participants purposefully rather than randomly, allowing them to focus on the most relevant and appropriate informants who can provide rich data and insights on the phenomenon of interest.²² In this research approach, the research question can usually be answered more effectively by people with relevant experience or expertise.²² It is essential to include participants with varying viewpoints and a range of perspectives to prevent a single group's viewpoint from being overrepresented in a situation.^{22,23} The selection of participants who represent various roles, perspectives, experience levels, and demographics allows a comprehensive understanding of the phenomenon being studied.²⁴ To enhance the rigor of the study, we carefully selected participants based on theoretical perspectives, research questions, and the existing

evidence.²⁴ Therefore, one of the strengths of this study lies in the inclusion of ideas, opinions, and experiences from individuals with different geographical locations, training backgrounds, and working environments.

The primary analysis was started after a few interviews, as Elo and Kyngäs²⁵ recommended, to ensure data saturation was achieved.²¹ Sampling was stopped when a thorough understanding of the phenomenon under study was reached, an endpoint often referred to as saturation.²¹ Researchers consider sample saturation when interviewing more participants does not generate new concepts, categories, or themes.^{21,25}

Two authors conducted the interview sessions. Healthcare professionals in departments that deal with emergency patients typically have a very tight schedule. Organizing a time that worked for everyone was a challenging task that resulted in conducting seven interviews with two participants each, commonly called dyadic interviews.²⁶⁻²⁸ In addition to the dyadic interviews, we conducted two focus group discussions with three participants and two individual interviews. All the interviews, including the dyadic, focus group, and individual interviews, were performed using the same questions.

The interviews were conducted via Zoom. The virtual interview had advantages over the face-to-face interviews, such as safety due to the COVID-19 pandemic, access to diverse locations, and greater flexibility of schedules. The semistructured questions and probes were based on the four UTAUT constructs: performance expectancy, effort expectancy, social influence, and facilitating conditions (Table 2). Each interview session lasted between 36 and 75 minutes (average, 57 minutes). The interviews were audio recorded and stored on a secure platform, that is, Sea file at the University of Turku. The audio records were transcribed verbatim into text.

Ethical Consideration

Ethical approval was received from the Human Research, Publications and Ethics Committee, Ghana, and the Ethics Committee for Human Science Research at the University

Table 2. Interview Questions Guided by UTAUT Model

UTAUT Domain	Question	Probes
Performance expectancy	Can you share your experience in using devices that help you evaluate chest compression performance during CPR training and actual patient resuscitation	What are these devices' key strengths? What are the specific issues, concerns, or problems that you have faced when using this product? What are the most common issues that need to be addressed?
	If you had the opportunity to choose the best device that provides real-time feedback on the quality of chest compression during CPR, what features would you like to include to use it effectively?	What features of the device do you think need to be addressed for better performance and outcome?
Effort expectancy	Can you tell how easy or difficult it is to learn or operate the available medical devices that guide you on the quality of chest compression during CPR?	In your opinion, which features of the devices make the available devices easy or difficult to use? If you think they are difficult to use, what do you think the solution is?
Social influence	What influence do others have on the use of medical devices that provide feedback on the quality of chest compressions during CPR?	What is the influence of your organization, senior managers, and colleagues? How much do their opinions or suggestions matter to you in using the AVF devices?
Facilitating factors	In your setting, what organizational and technical infrastructure would facilitate the implementation/acceptance and use of medical devices that provide guidance on the quality of chest compression during CPR?	Can you tell any support that would facilitate the implementation of the devices? Can you tell possible barriers that may hinder implementation of the devices?

of Turku, Finland. Permission to conduct the study was also obtained from all involved institutions. The organizations distributed the study information sheet and consent form, after which participants announced their interest. The participants' autonomy was guaranteed by allowing them to decide voluntarily about their participation, including the right to withdraw at any time. The principal investigator collected the signed consent forms from the institutions before the interview sessions.

Data Analysis

Data were analyzed using qualitative thematic content analysis. We began the analysis with several readings of the transcribed text to familiarize ourselves with the data, as described by Braun and Clarke.²⁹ We developed a structured categorization matrix based on the UTAUT model for deductive analysis.²⁵ The developed matrix was used as a lens to categorize codes that represent similar meanings. Our deductive coding was composed to reflect the four UTAUT model constructs: performance expectancy, effort expectancy, social influence, and facilitating conditions. Reviewed contents and meanings corresponding to the matrix were coded and transferred to the respective construct. The first author (D.T.K.) primarily performed the analysis but in constant consultation with the coauthors to ensure trustworthiness.²⁵

RESULTS

We interviewed 22 participants, 18 from Finland and four from Ghana (Table 3). The demographic characteristics of

participants are shown in Table 3. Fifty percent (50%) of the participants were paramedics, 13.7% were emergency nurses, 13.7% were intensive care nurses, 9% were anesthesiologists, and 13.7% were Red Cross-trained first aiders. There were more males (63.6%) than females. They had a wide range of work experience: Eight participants had less than 10 years of experience, nine had 10 to 20 years of work experience, and five had more than 20 years of work experience.

Despite the significant differences in their backgrounds, all participants agreed that real-time AVF devices were beneficial in delivering quality chest compressions during CPR training and actual patient resuscitation. We have identified 10 themes that fall under the four UTAUT model constructs (performance expectancy, effort expectancy, social influence, and facilitating factors) that define the needs and acceptability of AVF devices. The performance expectancy construct includes three themes: perceived usefulness, outcome expectation, and applicability in diverse situations. On the other hand, the effort expectancy construct consists of two themes: user-friendliness and complexity. The social influence construct has two themes: social and organizational factors. Lastly, the facilitating factors construct includes three themes: staff competence, perceived cost, and compatibility of devices (Figure 1).

Performance Expectancy

In the performance expectation construct, study participants often focused on discussing how the AVF devices help them make a gain in terms of CPR training and actual patient resuscitation. Three themes were identified under this construct:

Table 3. Participants Characteristics

Participants Characteristics	n (%)
Country	
Finland	18 (81.8)
Ghana	4 (18.2)
Setting	
Southwest Finland Rescue Department	11 (50)
Turku University Hospital	7 (31.8)
Ghana Red cross	3 (13.7)
Komfo Anokye Hospital	1 (4.5)
Work experience, y	
<10	8 (36.4)
10-20	9 (40.9)
>20	5 (22.7)
Sex	
Female	8 (36.4)
Male	14 (63.6)
Profession	
Paramedics	11 (50)
Intensive care nurses	3 (13.7)
Emergency nurses	3 (13.7)
Anesthesiologist	2 (9)
First aid-trained Red Cross personnel	3 (13.7)

perceived usefulness, outcome expectation, and applicability of the device in diverse situations (Figure 1).

Perceived Usefulness

Perceived usefulness was often cited as the main factor in accepting AVF devices. All participants emphasized the need for convincing evidence of the device's usefulness in providing real-time guidance for their CPR performance. Participants said that AVF devices that monitor chest

compression performance should offer efficient and reliable feedback and eliminate any uncertainty for better acceptance and higher user rates. In addition, some participants linked the AVF device acceptance rate with the option of possible access to stored data.

We should have the option to extract or print data from the devices. When we go through the situation after the task, we can see how we performed, which would undoubtedly increase the resuscitation quality. Also, we should be able to extract the recorded feedback data from the device easily for other purposes. (Participant from Finland)

Outcome Expectation

Participants preferred AVF devices to traditional CPR because they felt the AVF device improved the quality of chest compressions and could potentially improve patient outcomes after cardiac arrest. Participants felt that a feedback device could help them achieve their goals more effectively. Goals could range from maintaining high levels of compression to improving patient survival. Participants described how the AVF device helped them increase the effectiveness of chest compressions by increasing their alertness and focus.

Even for an experienced person, it's incredibly good help. When you are sure your strength will start to fade, and your pace will get confused, it's nice when the machine tells you to concentrate and pay attention. (Participant from Finland)

Applicability in Diverse Situations

Participants stated that AVF devices should come in different sizes and shapes to fit in the hands of all rescuers (health professionals and laypersons) and on the chest of all victims. They mentioned that current AVF devices are primarily for adults, and they would like to have a device that can be used

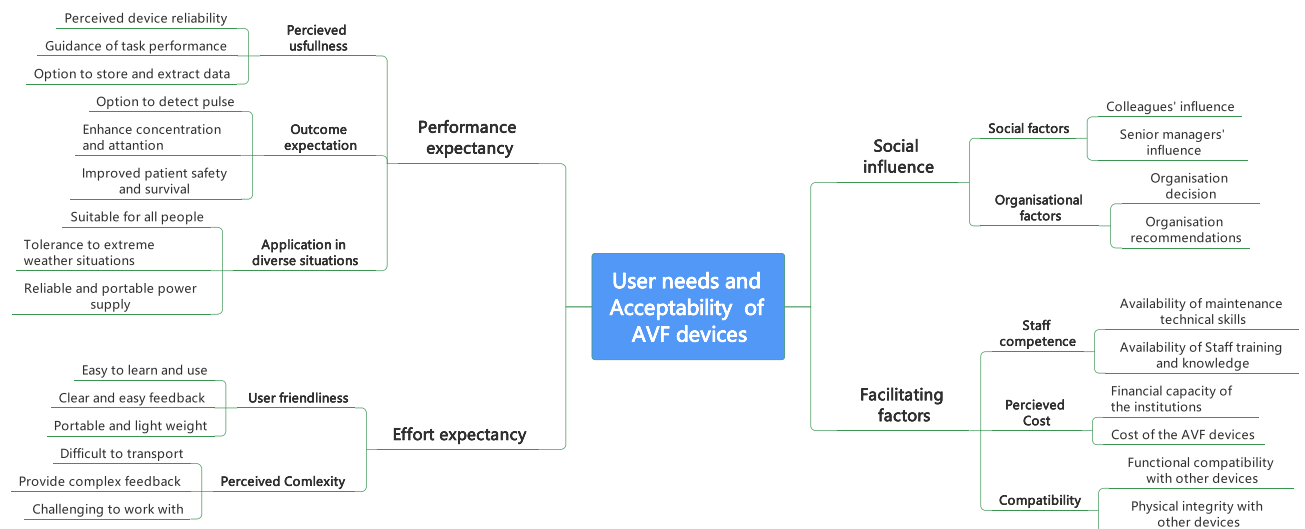


FIGURE 1. Constructs, themes, and subthemes identified through qualitative analysis to define the needs and acceptability of AVF devices used in CPR.

to resuscitate children as well. According to the participants, wearable AVF devices should be designed to be used by both left- and right-handed individuals. Moreover, they wanted devices that were suitable for both professionals and laypersons.

The devices intended for a layperson and professional use should be such that if, for example, a layperson cardiac monitor was placed on a patient in a shopping center, it would not require any action from us (the professionals). When the layperson is changed, the device should not require any action for the feedback device itself. (Participant from Finland)

In addition, participants mentioned that AVF devices that do not malfunction when wet due to rain or extremely high temperatures may have a high adoption rate. According to participants from Finland, some devices fail in freezing weather conditions, which could affect their acceptance. Participants also stressed the need to use these devices in healthcare facilities without reliable power supplies. In the case of Ghana, power sources appear to be a particular concern, as power outages are common in healthcare facilities. A participant from Ghana expressed this with the following quote:

Here in Ghana, we have our problem. When it comes to power in the city, we have a proven problem. So, if you come out with any device that uses much power or electricity, we will face a problem. So, it should not consume much power and can be rechargeable. It would be great if we could get a solar aspect on it. (Participant from Ghana)

Effort Expectancy

We identified two themes from the group discussion and individual interview content that were captured by the effort expectancy: user-friendliness and complexity (Figure 1).

User-Friendliness

Participants expressed that devices that are easy to learn and use are preferable for CPR training and actual patient resuscitation. If the devices are difficult to understand and operate, they can pose a significant challenge, especially to people who are unfamiliar with them. In addition, they indicated that it would be easier to achieve their mission if the AVF devices were small and lightweight.

Well, we carry a lot of stuff to the floors or wherever we go. Of course, carrying a kilo bundle is more fun than a 50-kilo bundle. Therefore, the feedback devices should be small and lightweight, and every feature should be in one place. Making the devices as light and small as possible makes our work much more manageable. (Participant from Finland)

Complexity

Participants sometimes felt constrained by the complexity of the feedback provided by the devices. According to the participants, the level of complexity depends not only on the device itself but also on the situation in which it is used. Although they prefer visual feedback to audio feedback, devices that display feedback on a small screen were also difficult to read.

Well... if there is audio feedback, "press harder," for example, then the person presses deeper on the chest, and then suddenly, there is the feedback that you are pushing too hard. You know! ...The resuscitator gets discouraged by the feedback he/she gets because he/she does not precisely know what he/she is doing. If a layperson is doing it, there will be a sense of failure and discouragement, and then the person will stop resuscitation because he/she feels he/she cannot do it properly. (Participant from Finland)

Social Influence

In the social influence construct, some participants mentioned how others influenced them to use AVF devices. Social factors and organizational influence were the themes identified from this construct (Figure 1).

Social Factors

The experiences of respected colleagues and supervisors influenced the use of an AVF device. They were affected when they saw their colleagues properly using a new device. In addition, the participants would trust the competence of their supervisors and use the devices as recommended by their supervisors. One participant put it this way:

If someone recommends a device, it means the person might have had an experience. Therefore, I will go for the brand that a colleague recommends, but I will still ask for some instruction or a video to observe. I should also assume that my seniors might have experience in the use of the device. So, whether they are well trained in using it or not, I can trust the experience and use it the same way after seeing my managers using it. (Participant from Ghana)

Organizational Factors

Participants addressed the influence of organizational decisions and recommendations on acceptance and intent to use AVF devices. They agreed that they were happy to accept any device introduced by the organization as it helped them perform high-quality chest compressions. Their experience shows that the organization directs them to use the devices because they have no other options. They agreed that there was not a single time they had a say in purchasing a new device.

Decisions are usually made without the workers being informed. They do not discuss them at all with the persons who use them. It happens that we now have a new device. Yesterday, however, we did not know that something like that was coming. So, I would be ready to use what my organization wants because I could not do much about it. (Participant from Finland)

Facilitating Factors

Participants mentioned conditions that facilitate the adoption and use of AVF devices during CPR. Three themes were

identified under the facilitating factors construct, including *staff competence, perceived cost, and compatibility of the devices* (Figure 1).

Staff Competence

Participants emphasized that the provision of regular training on the presented devices improves the knowledge and competence of the users and thus promotes the acceptance and use of the AVF devices. However, users had different experiences with the availability of training at their facilities. Many mentioned that regular training is provided, and professionals have sufficient knowledge and skills to adapt and use newly introduced AVF devices. Some said the training was inadequate. Interestingly, participants from Ghana were reluctant to accept a device without access to qualified technicians and reliable spare parts to service it. In their opinion, the availability of spare parts and a skilled technical professional are essential for maintaining the newly launched device.

We must know the brand of the device we are going to adopt or use. A technical framework should assure us that if we buy this device, we have these replacement parts. Also, technical arrangements and how to maintain these devices must be in place so that we can maintain these machines for the next 5 years or more. (Participant from Ghana)

Perceived Cost

Participants believed high costs could be a barrier to adopting and using an AVF device. They felt that the cost of an AVF device could be a barrier to adoption and use, but the organization's financial performance would influence this. Most participants from Finland felt that only unjustifiably high costs could be a barrier to adopting and using these devices. In contrast, participants from Ghana saw cost as the main barrier to adopting these AVF devices.

Because of the cost element, we are where we are now, and we have much distance. If they are very high quality, and they have a price that people or organizations cannot easily afford. Then, yes, it will be good, but just a few will have the advantage of it in their life, although any life is precious. (Participant from Ghana)

Compatibility of the Devices

Participants discussed AVF device compatibility in terms of functional and physical compatibility. Regarding physical compatibility, few participants wanted an AVF device to be an integral part of other multifunction devices such as defibrillators. Regarding functional compatibility, participants agreed that the AVF device should be functionally compatible with devices from different manufacturers and in various departments. Participants explained that devices that work the same way in hospitals or places such as shopping malls would be adopted quickly.

Feedback devices used in public areas such as the shopping center should be compatible with those in emergency units and assess the

same thing in the same way. When the emergency team arrives at the site, they should be able to connect it to their own and continue working with it. (Participant from Finland)

DISCUSSION

This study aimed to explore user needs and factors associated with the acceptability of AVF devices for monitoring chest compressions during CPR. Our finding indicated that the four UTAUT constructs (performance expectancy, effort expectancy, social influence, and facilitating factors) could explain health professionals' decision to accept and use AVF devices. Ten themes were identified under the four UTAUT constructs defining the needs and acceptability of AVF devices, including perceived usefulness, outcome expectation, applicability in diverse situations, user-friendliness and perceived complexity, social and organizational factors, staff competence, perceived cost, and compatibility of devices. Most themes had a positive association with the intended use of AVF devices, whereas increased cost and device complexity had a negative association. The participants' experiences, perceptions, and expectations of the AVF devices varied slightly, reflecting the different backgrounds of the participants.

Performance Expectancy

Overall, the perceived usefulness of AVF devices by health-care professionals was the key driver behind the adoption of AVF devices. Participants agreed that AVF devices that guide CPR performance should be reliable and accurate, allowing users to store and extract data for various purposes. Because chest compressions are one of the lifesaving techniques in cardiac arrest,¹¹ devices that monitor the quality of chest compressions should not provide unnecessary information that could affect the quality of CPR. Our findings from the qualitative analysis are well supported by previous studies that have described technology usefulness as a critical factor in predicting health device adoption.^{30–32}

Participants preferred AVF devices over traditional techniques because they helped them achieve a better patient outcome after cardiac arrest. Like our findings, participants in previous studies had positive attitudes toward using AVF devices because they believed that AVF devices made their job easier and improved patient outcomes.^{10,33} According to the participants, in addition to the corrective feedback they receive, individuals performing chest compressions with AVF devices do not need to count while performing chest compressions, which can help them conserve energy and focus on monitoring signs of patient recovery.

There is evidence that considering the user characteristics and the context in which health technologies are used is crucial for the smooth acceptance of modern technologies.³⁴ Likewise, the participants in this study were particularly interested in innovative AVF devices applicable in diverse

situations. Applicability in diverse situations has been described in terms of usability by all people, reliable power supply during power outages, and tolerance to extreme conditions. Participants indicated that when the intended task and the design of the AVF device match, institutions may not need to invest in multiple devices unnecessarily, which could motivate institutions and healthcare professionals to adopt the device.

Although previous research has shown that engineers generally understand comfort and usability metrics, it can be challenging to tailor all specifications well to a target user population in the medical context.³⁵ Therefore, involving stakeholders in a medical device's prototyping, designing, and development process can help designers and developers better understand the usability requirements of a medical device. Design processes that encourage early and frequent stakeholder engagement can increase the impact of medical devices by improving the acceptance and sustainable use of such devices.³⁶

Participants from Ghana admitted that the country's lack of reliable power supply could hamper the acceptance of new devices. Studies conducted in Nigeria and Uganda also identified energy supply as one of the main barriers to adopting new technologies.^{14,37} Therefore, new technology innovators targeting African countries should consider the energy source to improve medical device acceptance. Audio-visual feedback designers must also figure out how best to respond to the different environments in which these devices will be used so that they can meet the humidity, rain, and temperature requirements of a given environment.

Effort Expectancy

Various studies have yielded inconsistent results regarding the acceptability and usability of medical devices, depending on the type of service and user experience. Generally, medical technologies that are easy to learn and operate tend to encourage users to adopt and use them.^{16,30} In contrast, technologies that are difficult to use because of their complexity have been unfavorable to users.^{19,31} In this study, participants preferred to adopt small and lightweight devices with all functions in one place. Devices that gave audible and excessive feedback were also distracting and discouraging. This finding is well supported by previous studies in which participants chose wearable heart technologies that are easy to use, small, lightweight, and easily accessible.³⁸ In this study, a device that seems easy to learn and use during CPR training may suddenly prove complex when resuscitating actual patients, as rescuers are careful not to cause further harm to the patient.³⁹ Participants noted that integrated devices provide experienced healthcare professionals with various options that are usually incomprehensible to laypeople. It was, therefore, difficult for inexperienced rescuers to know where to place the different parts and which button to press in a stressful situation. This description suggests that

AVF devices designed for actual patient resuscitation should be even easier to use than those used for training. In addition, the finding indicates that standalone AVF devices that monitor chest compression quality without complex features appear to be preferred by inexperienced rescuers.

Social Influence

Many studies identified social influence as one of the critical factors for accepting and adopting new technology.^{14,17,37} Organizational culture and individuals' willingness to use and adopt new technologies are linked to each other.¹⁶ Similarly, in this study, participants agreed that the recommendations of respected colleagues and senior managers were likely to impact the adoption and use of new AVF devices. Participants would consider using AVF technology if they saw people around them using it safely and effectively. Consistent with our findings, most studies reported a positive effect of social influence on technology adoption.^{16,17}

Furthermore, our results suggest that users are strongly influenced by organizational decisions and recommendations to accept and use a newly introduced AVF device. Participants emphasized that user opinion is not considered when new equipment is purchased. Therefore, participants would immediately adopt a new AVF device recommended by the organization. Similarly, Venkatesh et al¹⁷ concluded that social influence becomes important in binding contexts when individuals have no say in adopting modern technologies.

Facilitating Factors

Facilitating conditions that influence the adoption of AVF devices include staff competence, perceived cost, and computability. The availability of regular training on existing and newly introduced AVF devices would increase staff attitude, knowledge, and competence in the safe and appropriate use of the AVF device. Therefore, user training would be crucial when adopting new technologies, as noted by Namatovu et al.³⁷ The experienced users reported that they had a significantly higher level of knowledge and skill in using the AVF device than the inexperienced users. It is, therefore, essential to provide tailored training and support to users with different backgrounds and experiences to increase their knowledge and confidence in using the technology.⁴⁰ According to participants from Ghana, the availability of spare parts and technically qualified personnel could positively influence the acceptance of a newly introduced AVF device. This finding is consistent with a previous study, which reported a lack of knowledge and technical support as significant barriers to adopting modern technologies.³⁷

The cost of AVF devices and the financial capability of organizations have also been identified as important factors influencing the adoption and use of AVF technologies. Price has a positive effect on the intention to use when the benefits

of the technology are perceived to be greater than the monetary cost.⁴¹ The balance between price and quality depends on the type of construct, but quality criteria are more relevant in highly specialized healthcare settings. Similarly, in this study, participants from Finland appeared to be more concerned about the quality of the device. In contrast, participants from Ghana saw cost as the main barrier to adopting new technologies, as reflected in previous African studies.^{14,37} This indicates that users' price expectations vary depending on the financial capacity of a given institution. Therefore, manufacturers should consider the financial situation of different countries and institutions to improve the uptake of new technologies.

Another concept that was discussed as a facilitating factor for the acceptance of AVF devices was compatibility. Yang et al⁴² defined compatibility as the degree to which a new technology integrates with other existing technologies without significantly affecting their functionality. A high degree of compatibility of new technologies with existing technology is positively related to the intention to continue using them.⁴³ In our study, the compatibility of AVF devices with existing technology and other aspects of life shaped the intent of healthcare professionals to continue using them. These findings are consistent with the scientific literature, which found that perceived compatibility is significantly associated with customers' positive attitudes toward technologies.^{14,17,42}

The design and development of AVF devices are not the sole responsibility of engineers. Instead, a multidisciplinary approach is required, involving experts from different educational backgrounds, such as engineering, technology, design, and healthcare professionals. The integrated training of people with varying experiences in the design and development of medical devices can help to synthesize and harmonize the connections between the disciplines into a coordinated and coherent whole. According to the current European Resuscitation Council Guidelines for Resuscitation, all communities, including school-age children, should learn and participate in CPR.⁴⁴ Therefore, future research should consider the perception of laypersons' intent to use AVF devices during CPR training and actual patient resuscitation.

LIMITATIONS

This study had some limitations. Although the discussions and interviews were conducted with individuals experienced in basic and/or advanced CPR, their exposure to AVF device technologies varied widely. This meant some participants could not provide detailed feedback on their experiences with AVF devices. Yet, including participants from diverse backgrounds helped us explore the barriers and enablers of technology adoption in different contexts. Another limitation was the small number of participants in each group. The recommended number of participants per focus group interview should ideally be more than three.⁴⁵ Therefore,

the participation of only two people in each group interview was low in the traditional sense. Nonetheless, the small number of participants in each interview created an interactive atmosphere to explore participants' views, experiences, and future expectations of AVF technologies.

However, the study used a theoretical model to provide conceptual support for the study results, thereby increasing the credibility of the study. In addition, information on participants' characteristics was disclosed to allow an assessment of the transferability of the results to other settings.

CONCLUSION

Healthcare professionals from different backgrounds felt that developing AVF devices with different features would improve the delivery of quality chest compressions during CPR. Although very similar, participants' experiences and expectations of the AVF devices varied based on participants' backgrounds. This result showed that considering the characteristics of the users and including them in the design and development process of AVF technologies are crucial for the smooth and successful adoption of these technologies. The current study defined the needs and identified the factors that influence the acceptability of these devices. Therefore, manufacturers and procurers should consider users' needs and factors affecting the AVF devices' acceptability. The UTAUT theory and identified questions can serve as useful tools for those interested in qualitative research projects exploring the acceptance and use of other similar devices. Including participants from Finland and Ghana helped us understand whether this innovation could be useful from both developed and developing countries' perspectives, and further studies may provide a deeper understanding of AVF device requirements in various settings.

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