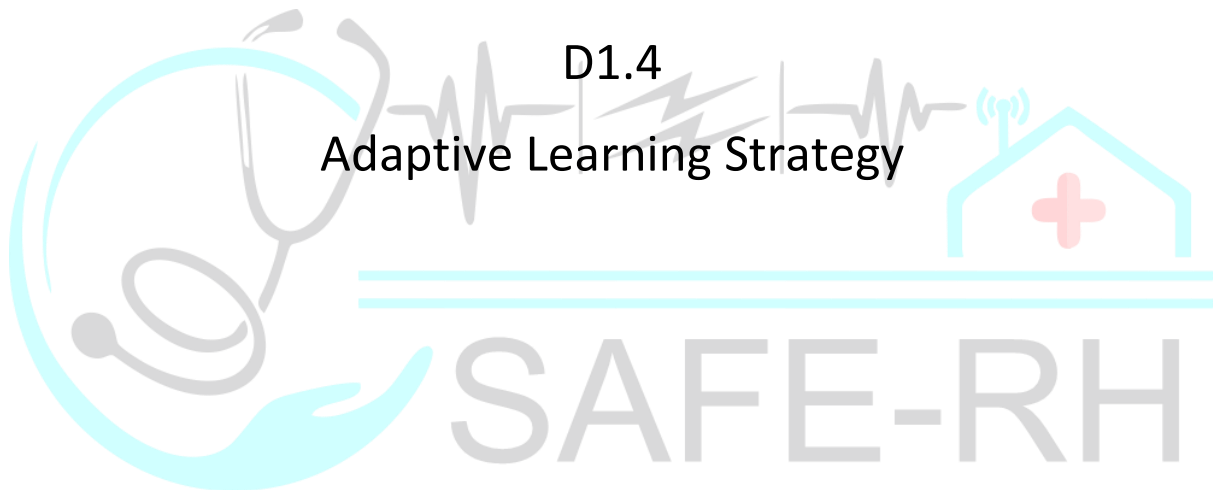


Sensing, Artificial intelligence, and Edge networking towards Rural Health monitoring (SAFE-RH)



D1.4

Adaptive Learning Strategy



SAFE-RH Project no. 619483-EPP-1-2020-1-UK-EPPKA2-CBHE-JP



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Abstract

The medical staff including doctors, paramedic staff, vaccination staff, and medical students are reluctant and slow in adopting technological solutions and advances designed for healthcare. The situation in Pakistan is no different, due to the obvious reasons of low resources availability, relative advantages, and ease of initial adoption. This work aims to summarize different types of learning and tutoring strategies developed on top of information and communication technologies (ICT) from the literature. The output in form of conclusions, key challenges in existing techniques, and potential future research directions identified in this paper, will be used as basis for developing advanced tutoring system. The aim is to provide effectively the necessary training to the medical staff in Pakistan about the potential, ease of use, advantages and applications of technological solutions, e.g., smart healthcare system, in the medical paradigm to support the provision of healthcare services. The future training program is expected to cover both “train-the-health worker”, and “train-the-patient” aspects because the efficiency of healthcare system remains limited if any of the health workers and the patients are left out. The development will follow the appropriate adaptive learning approach for smart health where the initial role of the program is to introduce each components from the two training objective purposes, i.e., “train-the-health-worker” level, and also focusing on what the end-user (patient) ought to know, termed as “train-the-patient”.



1. Introduction

The learning process starts from the first day of life and it continues till the last day, however, with varying rate of learning at different periods of life. Learning can be defined as “the internal processes to update the existing information or acquiring new information due to the learner’s experience” [1, 2]. The efficiency of learning strategies (also known as teaching or tutoring strategies) has always been under investigation and has not been concluded yet. Usually, it depends on the respective features of learner as well as the teacher (tutor) such as learning and teaching habits, pace of learning, ability to process and absorb knowledge, area of background knowledge, skills, learning style, motivation, topic and course contents, nature of course (theoretical or practical), and goals and objectives. Intuitively, a specific learning strategy ideal for one scenario may not be a good choice for the other. However, considering a particular case with defined parameters of learners and teachers for a pre-determined course, the learning strategies can be analysed to assess its efficiency in given context.

Worldwide, the medical educators face different challenges in teaching future health workers including physicians, paramedic staff, and vaccination staff. These challenges are mostly related to the trainings about recent developments and advances in health sector from technological solutions perspective. In fact, the medical staff are reluctant to adopt technological solutions whose applications can be found in different areas including detection, diagnosis, and treatments of diseases. However, intelligent tutoring system (ITS), a technique developed on top of information and communication technologies (ICT) for intelligently teaching and learning activities according to the preferences, habits and background knowledge of learners, can be used to help them fight their fear.

An ITS is sometimes referred as e-learning, Web-based learning, online learning, computer-assisted instructions, or Internet-based learning [3]. It uses existing infrastructure of ICT such as Internet, computers, and personal devices or mobile phones, to effectively transfer knowledge to the learner adaptively. The knowledge transfer is achieved by delivering instructions and learning materials to learners. The learning material may include different types of media, for instance, text, animations, infographics, avatars, graphics, audio, and video.

The medical staff are comparatively slower than members from other fields to adopt e-learning strategies [4]. The reasons may include unavailability of the resources, unawareness of relative advantages, and ease of initial adoption. In some cases, the resources are not available to the medical staff that leads to difficulty in accessing the contents of e-learning. In these cases, the access to the technology is restricted and its integration with the existing infrastructure is troublesome. The relative advantages are related to the perceived usefulness and impact of the new technologies which usually the medical staff are unaware of. Furthermore, the efforts needed by the medical staff initially to get used to these technologies are reflected through ease of initial adoption.

The situation in Pakistan is no different from the whole world in this regard where the medical staff are reluctant about adopting the technological solutions of healthcare. In addition to the healthcare providers, the patients also face several challenges in adapting these solutions due to lack of knowledge about the technologies. Moreover, they barely trust technological solutions and want to be treated by humans instead. In this report, the adaptive learning strategies used in different parts of the world are summarized. Furthermore, different ways to train medical doctors, paramedic staff, vaccination workers and medical students have been suggested that can increase the efficiency of the healthcare sector which will ultimately help improve the quality of life in rural areas, specially, and all over the country in general.

The multidisciplinary approach of adaptive learning strategy integrates 4 principles: anticipative - cooperative - adaptive – reflexive. For anticipative principal, we need knowledge not only of the situation of health sector but also the situation of patients and their real needs. This implies information gathering and interviews. Even if there are experiences from different locations that deliver conclusions on skills to develop remote health monitoring in the geographical area of interest, we need to adapt the method to target the needs in that area. For cooperative principal, we need first, to define an upstream and downstream KPIs for learning objectives. It's important to early integrate health workers and patients in the co-construct approach process and in the evaluation of the achievement of the learning objectives (on the spot and later). To develop a multidisciplinary approach, it's important to consider that remote health monitoring is more than technological change: economic, social, societal change etc. This change could improve the rural health efficiency and environmental impact but also create new economic opportunities and change health professions and practices. Indeed, we need to help these changes of mind (while respecting the will and needs of patients).



2. Adaptive Learning Strategies

The advancement and modernization of learning is regarded to the deployment of Information and Communication Technologies (ICT) in education sector. Studies show that the involvement of these technologies in learning domain improves the learning efficiency by providing personalized environments and learning strategies to students according to their intellect, habits, and background knowledge. The training techniques that can make decisions about contents and pace of the course for each individual learner through real time assessment are broadly termed as adaptive learning strategies. In other words, the adaptive learning strategies refer to the strategies used to train the learners according to their background knowledge, learning environment, learning habits, and skills [5]. Another definition regards adaptive learning strategies as the ways of designing and conducting the course, either online or face-to-face, for a huge group of people, however, can be tailored to smaller groups or even individual learners [8]. The level of engagement can vary for each individual learner or group of learners classified based on, for instance, pedagogical characteristics (e.g., methodologies, requirements of course etc.). The property of adaptivity comes from the information about the relevance and the characteristics of learners including learning styles, habits, expectations, motivation, and relevant personal requirements. Such characteristics are the motivation behind designing adaptive learning strategies against the conventional invariable educational methodology. There exist different learning systems such as AHA, APeLS, 3DE, Blackboard, WebCT and Moodle, that either are equipped with very low to no adaptivity at all or with respective limitations mostly including providing a limited number of options, incompatibility, one-use contents.

Kerr [6] states that the adaptivity in learning systems can be achieved from three perspectives.

1. The learning material perspective where the course contents are usually selected according to the learner's properties including requirements, level and area of background education, relevant skills, and experience.
2. The adaptivity can also be achieved from the perspective of presentation of course contents. They can be presented in various modes and forms with a sequence selected from the list of varied learning contents.
3. The third form of adaptivity is achieved by combining the first two perspectives.

The commonly used adaptive techniques are based on presentation of contents (text/multimedia), adaptive navigation, and adaptation founded based on type of contents. However, the adaptivity of learning system can be provided relying on the characteristics and requirements of learner including area and level of background knowledge, strengths and weaknesses, goals and objectives, skills, and learning styles.

The Felder-Silverman Learning Styles Model (FSLSM) [7] is most widely used model to achieve adaptivity through learning styles in e-learning that classify the learning styles into four categories: active or reflective, sensing or intuitive, visual or verbal, and sequential or global. These models are described as follows

1. **Active or reflective:** This model represents the learner's preferred method of learning process. The active learners prefer to learn in teams whereas the reflective learners can process information better individually where they are given responsibility to think about the given information.
2. **Sensory or intuitive:** The sensory learners usually learn easily if the material presented are associated with real life examples. On the other hand, the intuitive learners can easily learn abstracts and theoretic information.

3. **Visual or verbal:** Some learners prefer visual contents such as diagrams, graphs, or figures, in their learning contents. Such learners are regarded as visual learners. Others prefer verbal contents including spoken or verbal information.
4. **Sequential or global:** This model inspects learner's way of progress toward the understanding of whole concept. Sequential learners are easy to understand the information provided in stepwise trajectory. On the contrary, the global learners are comparatively better at understanding if provided with large chunks of information.

The adaptivity of learning model can be achieved through two themes: the static theme and the dynamic theme. The static adaptability approach utilizes some form of questionnaires filled by the learner during course registration so that the model can adapt to the features of learning habits. The dynamic adaptability is associated with the ability to constantly monitor the learning activities of the learner in real time to perform personalization according to the needs. The data mining and machine learning algorithms are usually applied to extract useful knowledge from the database with stored information about the learner's activities. This technique also allows for more efficiency in terms of personalization of the learning contents for new learners.

A study at Colorado Technical University (CTU) of implementing adaptive learning strategies outlines the following conclusions through the written feedbacks from students [8]

- The learners (students of CTU) find the adaptive learning more enjoyable and promising toward efficient learning of the course contents. The appreciation came through different comments from students, such as viewing adaptive e-learning as portable system that can be accessed from computers and mobile phones. A student suggested to integrate discussion boards into the learning model where different viewpoints of students can be shared. Others desired to have a model with additional contents that allow for engagement in discussions, case studies, and video contents.
- The adaptive learning contents should be combined with additional learning areas and activities such as recommended reading or writing assignments and discussion boards. Such integration increases engagement of learners with more interest and enjoyment during task completion and allows the learners to practice and improve skills, and gain mastery in the course.
- The multimedia contents, such as images of infographics, avatars, videos, and case studies, provide help in the learning process of the course. The same recommendation is given by the teachers (faculty members at CTU).
- The learners have provided more positive feedback when the faculty engagement and continuous guidance was provided. The adaptive learning should not follow "plug and play" approach and the faculty must be engaged in classroom which reportedly increases the student access rate. The faculty presence is termed as regular involvement in principal teaching areas of the classroom. This approach further provides an opportunity to improve the course in terms of level and quantity of course contents from a teachers' point of view. The argument is supported by the study of [9] where a problem-based e-learning model is proposed and verified on the learning problems faced by students having special requirements. In this study, the importance of teachers' characteristics and knowledge is emphasized in addition to the features and limitations of learners and the problems associated with the courses and topics being taught.
- Learners are happier about the mobile access to adaptive learning through mobile applications developed for this purpose. This increases students' engagement time periods in

the course because of easy access from anywhere.

The adaptive learning strategies are associated with several advantages and disadvantages. The adaptive learning saves learners' time by filtering the contents according to their needs, habits, skills and goals [10]. It can be modified to add value for the learner and provides to monitor the learning performance by teachers. In some cases, this information can be used to predict the learning performance of other learners from similar characteristics. When conjoined with other activities such as physical classrooms, online/offline discussions, ongoing projects, the adaptivity can increase the enthusiasm of learners. Furthermore, the load of irrelevant and unnecessary contents can be reduced. Self-assessment can be considered as a strength of adaptive learning over conventional learning strategy. Additionally, the learners are given opportunity with their own pace and level through a powerful learning experience with a continuous support of teachers.

The adaptive learning model requires large time by developers and a deep knowledge of course contents is mandatory. The variations in contents according to different profiles of learners and ingenuity in assessment materials (tests and quizzes) such that they complement the course content is required. Sometimes, frequent assessment can be discouraging. Additionally, online platforms can make learners feel lonely. Moreover, the learner could take a shortcut to significant topics and may miss out necessary underlying contents. Other limitations of adaptive learning include failure to present examples related to recent events or personal experiences, underlying the exact hardships to students, for instance, dropout reasons, higher complexity in relating assessments and contents to the course contents, difficulty of designing a single platform to support multiple learning styles, and the definition of the acceptable level of adaptivity.

Kok [10] outlines the step toward an efficient and powerful adaptive learning model to support learner as follows

- Extra time should be given dedicated to thinking about the design of model.
- Various areas of the model should be considered to apply the adaptivity in order to select the best scenario.
- The learning model must contain both online and offline sessions along with different formats of delivering contents such as texts, verbal and visual contents, experiments, discussions, assessments, active interaction between learners and teachers, etc.
- The assessment should be done with inconsistent configuration of quizzes, multiple choice question, drag-and-drop, etc., to avoid the learners from getting bored.
- Use appropriate quality of multimedia contents to be suitable for learners from different backgrounds.
- The time requirements of the course and the bonus of taking assessments should be indicated.

The adaptivity in learning systems is enabled through implications of recently developed techniques in data science and machine learning. The adaptive learning approaches have been praised by a dominating number of higher educational leaders due to their potential of improving learning efficiency, however, only 8% of educational institutions practically adapted these approaches [11]. The reasons are linked to the technological solutions (managing continuously generating data, incorporating to existing learning management systems (LMS), high complexity, and ease of usability), pedagogical aspects (redesigning curriculum and resistance from faculty toward technology) and management issues (incorporating adaptive learning into overall strategy, adapting to a new culture, allocation of resources). This study conducted at different universities in different countries, South Africa and Switzerland, classify the challenges associated with implementation of adaptive learning

into technological issues, teaching and learning issues, and organisational issues. The basic issues including internet accessibility and its quality, hardware specifications of learning systems, and personal issues of teachers and learners in the context of teaching and learning paradigm are represented in technological issues. The teaching and learning comprise issues related to instructional and content elements, motivations, skills and necessary attitude of teachers and learners in adaptive environments. Functional strategies of organisation and management-related issues are part of the organisational issues.

Other challenges associated with designing and implementation of adaptive learning strategies include the issues of finding relevant contents among the whole materials for the given concept and the specific learners requirements [12]. Additionally, the compatibility issues among various learner models with such a huge quantity of materials needs to be addressed. Presenting a good learners' observations and the relevant optimistic outcomes to other learners can improve their learning experience and efficiency. Therefore, the recommendations from good learners, selected among the learner of course, should be incorporated while achieving the adaptivity of learning strategies. This concept is slightly different from traditional filtering based on the similarity index between learners used to prioritize the contents with no consideration of the level of learners. The advantages of the recommendation systems incorporating personalized preferences and the good learners' recommendations are two folds. First, the contents that are relevant to the learners' objects are identified. Secondly, new interesting contents determined by recommendations from good learners are suggested. The results in [12] shows the efficiency of such as hybrid recommendation learning system. In this paper, the adaptivity is achieved using two blocks, an adaptive navigation block to select next learning topic for given learner, and a recommender block to identify the learning material for the selected topic. When an active learner is assigned a new topic, the system identifies relevant material based on similarities with the assigned topic and recommendation from good learners. The recommendation is assessed in terms of ratings given to each topic by good learners. The good learners are the ones having an above average performance in the topics they have learned. Therefore, the system should be equipped with the capabilities of measuring and maintaining achievements of learners in order to classify good learners. After content-based filtering and collaborative filtering (through good learners' recommendation), a recommendation score is calculated for each item in the list of contents. Higher the recommendation score higher the probability to recommend the content to learner.

The e-learning can be considered as adaptive learning strategy that utilizes the recent technological solutions to train the learner.

A. E-Learning

Generally, the adaptivity in e-learning is associated to either pedagogical or technical aspects. Arsovic and Stefanovic [5] proposed an approach that highlights the importance of considering both aspects while designing and e-learning strategy. They argue that by only taking both characteristics into account, the limitation of the existing personalized strategies can be overcome. The pedagogical facet is further classified into the learner's background and level of knowledge, and the preferred learning approach.

E-learning can significantly improve the efficiency and effectiveness of learning and adapting such technologies by the medical staff and medical students. It has gained popularity in the past decade; however, it is used more commonly in the other fields as compared to the medical field and clinical clerkships. The E-learning has several advantages over the traditional method of learning that increases the efficiency of teaching and learning. A major advantage is to have access to the standard

learning material remotely. Furthermore, it provides standard course contents; unlike, for instance, a lecture given to different groups of learners of the same course. It provides with the opportunities to track and report the learners' activities automatically that reduces the administrative workload of the teachers. A strength of e-learning is the real-time assessment of the learners provided to the teacher that can help assess the quality of the learning process followed by further improvements. Another aspect of e-learning is its ability to provide with interactive sessions that ensure active participation of learners which can enhance the learning experience. This can further increase the learner's interest in the contents and provides an opportunity of individual practice and reinforcement. Studies show that the e-learning experience provide faster gain of knowledge, and skills as compared to traditional teaching and learning methods. It can provide the learners with flexibility of time for learning and with selection from a large list of contents to accommodate their diverse learning capabilities.

i. Intelligent Tutoring Systems

Intelligent learning systems or intelligent tutoring system (ITS) are systems that can offer a personalised learning experience by adapting the learning process to the performance, knowledge, capabilities, and needs of their users [13, 14]. A fundamental ITS is composed of communication, tutorial, learning and expert modules [15]. The communication module provides a means to exchange the information between learner and the tutoring system. The tutorial module is the most important part, of the tutoring system, which is responsible for making decisions about the contents of the course and the whole strategy during the course. The learning module keeps information about the learner that is used to monitor his/her activities along the journey of course, for instance, background area of expertise, time and frequency of login sessions to the course, learning habits, etc. The expert block contains all the contents of knowledge of the course concepts and topics, and the assessment quizzes and tests.

Research on the process of learning has demonstrated that the emotion of the learners has an overall impact on the learning ability, as negative emotions can severely impair the learning process, while positive emotions can provide a boost to it. These systems are designed to assist in the learning process by providing immediate and customised feedback and/or instructions to their users, requiring minimal to no input by instructors after the design of the learning material. Their advantage over traditional learning systems lies in their ability to adapt to the abilities, knowledge, and needs of individual learners, thus providing a learning experience tailored to the needs of each user. Motivated by the fact that emotions help in identifying the state of learner during learning activities, Alqahtani et. al. [1] proposed an ITS that takes the emotional behaviour of learners into account, besides the fundamental components such as selected answers, while assessing their knowledge. The potential of EEG, ECG, and EMG physiological signals for detecting the affective state of users participating in a computerised English language test is investigated. Affective state refers to the human emotional state or being and the term affective computing expresses the field of computing related to human emotions.

ii. Dialog Systems

A dialog system is a software that is capable of communication with humans through natural language, i.e., the words, sentences and associated rules in natural language [15]. A dialog manager usually keeps track of current state of the ongoing conversations to make decisions about the next action or speech. The natural language processing (NLP) is a major aspect of dialog system where the computers try to learn, understand, and produce response in form of natural language to humans from a machine-understandable format.

The tutoring dialog systems are designed such that they can adapt according to the habits, requirements and preferences of learners. They provide feedback to learners in a natural language with inherently processing given information and applying teaching tactics just like humans. Such a system require flexibility, triggering and defined objectives for a seamless performance. The fact that any input can be received from learner should be realized. Furthermore, it should be capable of acquiring new information whenever available, however, without interrupting the current activity of dialog system, such as providing feedback to learner. The dialog systems can provide instructions adaptively according to the environment, requirement, and necessary actions to the human. Such systems have been widely adapted while designing the tutorial systems where they can present information that needs to be learned, asking questions to assess the level of understanding, assigning tasks to the learner and providing feedback about the inputs from the learner. The learner can benefit from such systems even using personal assistants in the mobile devices.



3. Training Health Staff in Pakistan

The aim is to highlight the challenges to develop an education and training System that will help health workers understand the effectiveness of the new technologies in healthcare sector. The overall objective of developing Smart Healthcare system in Pakistan is to support the provision of health care services. The common healthcare related challenges of the partner country Pakistan include the high mortality rate of women and children (especially during delivery), the unavailability of timely healthcare for the maternity related issues in remote areas, and medical issue related to old people usually 60plus-years old. These challenges will be addressed in logical structure begging by the identification of the skill priorities and the requirement of smart health workers, developing an appropriate adaptive learning approach for smart health workers and design training programs and learning materials to be trained in local and regional target partners' rural areas.

A. Training Medical Doctors

The medical doctors, who comes first in the list of health workers, are the most important part of healthcare systems and must be trained to adopt the technological solutions to provide effective health care. These doctors must be provided with appropriate contents and training sessions as first step toward the "train-the-health-worker" objective of the SAFE-RH project, where they are trained to use the computer-based solutions. The interactive e-learning sessions can provide with assessment of whether the learning by these doctors have occurred. The trained doctors would then pass on the knowledge and experience to other health worker that will help transfer the knowledge quickly. During the Smart-Rural-Health project, 100 smart health trainers will benefit with Smart-Rural-Health programs. Each program will take 5 days. At least, 300 health workers and 5000 patients will be trained by the smart health trainers. With this approach, knowledge transfer will be fast and efficient. The number of trained health workers crosses quickly.

SAFE-Rural-Health care system is to enhance the efficiency and potential of rural health system through research and development in both public and private sectors to transform from traditional health provision to smart health services. The overall objective of developing Smart Healthcare system in Pakistan is to support the provision of health care services in Pakistan and diminish the lack of expert medical advice in remote and rural areas. SAFE-Rural-Health care system will reduce the high mortality rates of women and infants due to delay in medical assistance. Furthermore, it reduces the cost and time for consultation and provide ease to the patients for medical advice. Moreover, SAFE-Rural-Health system will provide an Education and Training System to help health workers understand the use and usefulness of the new technologies.

In the rural areas, SAFE-Rural-Health system can be useful for those who have mobility challenges and the patients who cannot go immediately to health facility and can also be used in critical care and emergency situations. SAFE-RH system can be invaluable to the provider and the patient. These remote care services allow for the provider to assess a patient without utilizing increased facility resources, but while increasing the patient's access to care. This permits the patient to have a timely, interactive conversation and initial assessment to determine if a patient needs to visit the closest health facility centre, change a course of medication treatment, or in some cases review vital signs to determine next steps.

i. Patient Technology

Remote encounters often involve technology or internet connections that are not provided by the SAFE-RH program. Patient computers, tablets, or smartphones may be used to connect with providers. SAFE-RH application can be connected through the patient's home Wi-Fi network. For some patient

Table 1. Introduction to ICT - Module 1

Module	Outcomes	Training Strategies	Resources
Module 1 Introduction to ICT (Information & Communication Technology) 3 hours Prerequisite: None	On completion of the unit participants will be able to: - Identify the relevant components of a computer - Create a word document - Send an email - Save a document to hard drive - Save a document to a memory stick - Open web browser - Conduct a Google search	Information Session: 1 hour - What is a computer - Basic Internet and email - Basic filing - Basic MS Word - Introduction to the Web Practical Session: 2 hours - Individual sessions in front of a computer - Activities - Turning on a computer - Do a mouse exercise - Create a word document - Create a folder and file word document - Print out article - Transfer files to a memory stick - Send an email	PowerPoint Slides Data projector Computer Resource manual Computer: 1 per participant - Internet access - email address - Web browser - MS Office or equivalent - Memory stick - Intel or similar training CD

Table 2. Introduction to SAFE-RH healthcare system - Module 2

Module	Outcomes	Training Strategies	Resources
Module 2 Introduction to SAFE-RH healthcare System. 3 hours Prerequisite: None	On completion of the unit participants will be able to: Describe the feature of the SAFE-RH healthcare System.	Information Session: 1 hour Concepts and Features of SAFE-RH healthcare System. To be Developed after the system development.	PowerPoint Slides Data projector Computer Resource manual

encounters, the technology itself can be a challenge. Some patients may not be as familiar with the functionality of their mobile devices, internet connection, or SAFE-RH application. Hence, it is important to provide the basic training and guidance to use this system. In rural areas, the use of technology can be provided using local clinics or health care centre for patients to go for the services. These clinics help to avoid technology issues that may arise at the patient's home.

ii. SAFE-RH System Stakeholders

Engaging the various health staff by Smart Healthcare system is critical to the success of the project. According to the 2017 AHIMA Information Governance Toolkit 3.0 [16] "A stakeholder refers to an individual, group, or organization that has a direct or indirect interest or stake in a particular organization." The SAFE-RH System Stakeholders are:

- Medical Doctors
- Paramedic Staff
- Health Workers
- Medical Students

iii. Training

The awareness and adherence to any program implementation and procedures is essential to successfully execute the system. For the awareness to the SAFE-RH System are crucial for the successful implementation of the project. As a result, it is necessary that all healthcare staff are made aware of the SAFE-RH program policies and procedures and their individual roles in the system. This can be achieved through periodic staff training and updates about the SAFE-RH System. Technologies and monitoring should be in place to ensure staff awareness and adherence is met. The main objectives of the training are as follows.

- To access and search for information about SAFE-RH healthcare Application.
- To apply various techniques involved in synchronous SAFE-RH healthcare System.
- To demonstrate skill in the use of digital scanning equipment and sensors.
- To understand how to design and set up a SAFE-RH healthcare System consultation venue.
- To demonstrate skill in use of peripheral diagnostic equipment (Arduino, GSM module, LCD Display, Heart rate (HR), Body temperature, Humidity, GSR, Accelerometer, and Glucometer) where appropriate.

iv. Modules

In SAFE-RH system, medical doctors are the most significant part of healthcare systems and must be trained to adopt the technological solutions to provide effective health care. To achieve the objective to "train-the-health-worker", doctors must be trained and provided with appropriate contents in the form of user manuals. Doctors are trained in the following area to understand the complete insight of the use of SAFE-Rural-Health care system.

- Introduction to ICT (Information & Communication Technology)
- Introduction to SAFE-RH healthcare System.
- Basic Technology using SAFE-RH healthcare System.
- Introduction to SAFE-RH diagnostic equipment

Furthermore after the training session, the doctors will be able to transfer the knowledge and experience to other health workers. During the Smart-Rural-Health project, 100 smart health trainers will benefit with Smart-Rural-Health programs. Each program will take 5 days (subject to change). At

Table 3. Introduction to basic technology - Module 3

Module	Outcomes	Training Strategies	Resources
Module 3 Introduction to basic Technology using SAFE-RH healthcare System. 3 hours Prerequisite: Module 1 Module 2	On completion of the unit participants will be able to: - Identify the different computer options available and the relevant advantages and disadvantages of each - Identify the different kinds of access to Internet and email available locally - Discuss different communication options - Discuss the latest ICTs such as mobile phones, PDAs	Information Session: 1 hour - How do you get access communication options - Dial up, broad band, wireless, phone cards, phones - Modem, LANs, VPN - What skills are needed - Computers - Desktops vs Laptop vs Tablets vs PC vs Smart Phone - Basic requirements for PCs - Sound - Memory - Monitor - Resolution - CD/DVDs - Storage - Hard drives - Flash-cards, CD/DVDs - Good Practice - Back up, Virus protection, Security - Smart Phones - PDAs - Health Information Systems and Medical Informatics	PowerPoint Slides Data projector Computer Resource manual Readings Equipment: Flash cards Laptop Tablets Smart Phone PDA Wired LAN connection Wireless connection 3G/GPRS card

Table 4. Introduction to diagnostic equipment - Module 4

Module	Outcomes	Training Strategies	Resources
Module 4 Introduction to SAFE-RH diagnostic equipment 3 hours Prerequisite: Module 1 Module 2 Module 3	On completion of the unit participants will be able to: - Understand the use of peripheral diagnostic equipment and sensors (Arduino, GSM module, LCD Display, Heart rate (HR), Body temperature, Humidity, GSR, Accelerometer, and Glucometer) - Demonstrate skill in use of peripheral diagnostic equipment ((Arduino, GSM module, LCD Display, Heart rate (HR), Body temperature, Humidity, GSR, Accelerometer, and Glucometer) where appropriate. - Recognise and address ethical issues in the practice of SAFE-RH healthcare System	To be Developed after.	

least, 300 health workers and 5000 patients will be trained by the smart health trainers that would be helpful in the successful implementation of the SAFE-Rural-Health care system.

Pre-requisite

A basic level of computer literacy (as listed in Module 1) is required. If participants do not meet these basic criteria – the pre-module Module 1 has to be completed.

Teaching Methodology

A mixture of information sessions/lectures and practical sessions or training manuals.

Module Programme

The programme is made up of different modules, which can be combined depending on the learning needs of the target groups. The module, including the introduction to computing, total up to 12 hours and can be put together to create workshops ranging from a half day to 5 days depending on the target group and the purpose of the training. The modules 1 to 4 are illustrated in Table 1, Table 2, Table 3, and Table 4, respectively.

v. User Training Manual

The medical equipment user training manual is specifically for the user trainers, who will be responsible for training equipment users in the health facilities. A manual for pulse oximeter is given in Table 5.

B. Training Paramedic Staff

Training the medical doctors is not effective enough unless the paramedic staff has been trained to provide necessary services to the patients. These are the members whose primary role is to provide necessary healthcare services to the crucial and emergent patients where usually the medical doctors are not available, for instance, the medical staff that provides medical care in ambulance. Nurses, therapists, technicians, and other supporting workers participating in medical care are considered

Table 5. Pulse oximeter

PULSE OXIMETER	
Pulse Oximeter is medical equipment used for monitoring the patient's/client's pulse and oxygen concentration in the Blood circulation.	
	Types Desk top -Electrical Sports pulse Oximeter (non-electrical)
	Parts of Pulse Oximeter 1. Body 2. Control panel 3. Control knob 4. Cable and top plug 5. On/off switch 6. Battery compartment 7. Screen 8. Charger
	4: Accessories 1. Finger probe (adult and children)



2. Skin sensor
3. Finger probe cable
4. Cable and Top plug
5. Connector

Preparation

1. Ensure that the Pulse Oximeter is on a firm surface
2. Make sure the equipment is clean and in good working condition.
3. There should be a stabilizer if possible.

Operation

1. Plug the electric cable in the socket.
2. Switch on the mains, stabilizer and machine.
3. Put the finger probe on the patients finger (index)
4. Read the pulse and the amount of oxygen in the blood.
5. Record the readings. (Normal pulse 60 to 100 bpm, Normal oxygen concentration 90 to 100%)

Care

Immediate Care

1. Disconnect the finger probe from the patient/client.
2. Switch off from the machine, stabilizer then socket.
3. Un-plug the cable from the socket.
4. Fold the cable properly.
5. Place the probe with equipment in its proper place.

Routine Care

1. Make sure the equipment is in good working condition.
2. Dump dust when the equipment is dusty.
3. Keep the equipment dry at all times.
4. Check the cable and the finger probe for any damage.

Note:

1. Some people compensate for low oxygen concentration e.g. Sports people, regular swimmers, mountain climbers, sickler and heavy smokers.
2. Artificial, long and painted nails interfere with the readings.

paramedical staff, although the term is often used to refer to highly trained individuals who share direct patient care duty with physicians.

Nurse practitioners, physician assistants, and emergency medical technicians all fall within this group. These paramedical professionals undertake regular diagnostic and therapeutic operations, such as collecting blood samples and giving injections or wound caring, as well as relieving physicians from performing routine health assessments and recording medical histories. These staff can be trained to adapt the technological solutions such as using computers, electronic health records, and other related software that are designed for emergencies.

i. Training and educating paramedical staff

Women make up most of the nursing and paramedical personnel in Pakistan. Over half of the paramedical personnel have only completed matriculation, and just 2.5% have completed higher education and are directly involved in research-based activities. Another concern is the rising disparity between full-time and part-time paramedical workers; despite receiving excellent education and training, nurses appear to be increasingly diverting their attention away from patient care [17, 18]. Adaptive learning strategies can be used to give training to these paramedics to cope up the needs of modern world.

ii. Duties of paramedical staff

The following are examples of typical work responsibilities of paramedics in Pakistan

- Driving and Staffing ambulances and other emergency vehicles.
- Answering emergency calls.
- Monitoring and delivering medicine, pain relief, and intravenous infusions, as well as evaluating patients, providing emergency care, and establishing diagnoses.
- Dressings for wounds and injuries.
- Regular use of sensor-based machines for routine check-ups, as well as ventilators and defibrillators.
- Taking patients to the hospital and continuing to treat them while they're on the way.
- Collection and management of patient information, including condition and treatment
- assisting in the delivery of patient care in hospitals and other medical settings.
- Effective communication with patients and their relatives.
- Properly utilization of first-aid procedures.

iii. Behaviour of paramedical staff

Excellence, empathy, self-denial, responsibility, obligation, rectitude, and respect are seven universal components of medical professionalism as recognized by the American Board of Internal Medicine [19]. After excellence, empathy for a patient is the most important quality, and it is described as the capability to comprehend the patient's point of view. Studies have shown that a lack of empathy leads to malpractice, which is learned from the behaviour of seniors and training for impersonal associations with patient subjects during the time of training. Demotivation among healthcare professionals is connected to the supervisor's poor management abilities, clashing relationships with co-workers, and other factors. Lower education levels result in inappropriate use of medical equipment and a lack of knowledge in understanding the function and use of several medical procedures [20].

Irresponsibility, procedural mistakes, disagreement among medical teams, and financial stress are all linked to a lack of medical professionalism. In Pakistan, paramedics have been hesitant to acknowledge the legitimacy of modern methods to the paramedic–patient interaction, which may be

a contributing reason for the country's lack of medical professionalism. The lack of a professional motivation to serve humanity, a lack of thought about the subjectivity of human nature, and violations of the Hippocratic Oath are all typical behavioural concerns among paramedical professionals.

iv. Need of essential tools and technologies

According to several surveys, the majority of Pakistan's paramedical workforce is interested in information technology. The majority of them require family planning and prenatal care information. Half of them require childcare education. The vast majority of them want to learn more about how to use medical equipment. The paramedical staff experienced obstacles such as a lack of needed sources, lack of an onsite library, lack of a health science librarian, shortage of health information resources, and a lack of technical infrastructure. To meet their information requirements, they mostly consult seniors, better internet access, and document delivery services. 68 % of paramedical personnel needed information to stay updated, 48 % needed knowledge regarding medications and procedures to employ, 28 % needed information to solve issues encountered in normal activities, and 28 % needed information to adjust within the field. The majority of paramedical staff (92%) said they used to get information from the institution's library. 88% express dissatisfaction with the amount of material available in their profession [21-26].

Paramedic trainees frequently work in complicated and chaotic clinical settings that need solid skills, communication, and cooperation. Due to a lack of public knowledge about the function of emergency responders, as well as cultural, religious, and linguistic disparities between patients and emergency responders, paramedics developed a negative attitude toward patients. To overcome these challenges the Adaptive learning system can be adopted.

Adaptive learning is a method that uses technology to assess a learner's strengths and weaknesses to create a customized learning experience. Once the individual's strengths are identified, computer-based technology may alter the learning material to place a stronger emphasis on the individual's shortcomings [27]. High quality simulation and digital models are two major examples. Online learning modules, electronic portfolios, virtual patient encounters, massive open online courses, and the health related digital applications are some more examples. AL technology can change the learning content so that it focuses more on an individual's limitations [28].

Nobody knows when a serious disease or a mass casualty tragedy will occur, and when it happens, emergency workers rushing to the site must be resilient enough to operate successfully under extreme stress. Aspiring paramedics will be exposed to emergency circumstances where split-second judgments have crucial effects using AI technology. As a result, individuals will learn how to better handle operational stress under pressure and may be far more equipped to deal with life-or-death circumstances. Another benefit of Adaptive learning will be that paramedics will be able to use modern applications for following purposes.

- Collecting feedback, conducting patient rounds, scheduling follow-ups, and managing other information on a consolidated platform. Paramedics may establish reminders and remote care plans by customizing SMS or email alerts.
- keep track of their patients' health in a variety of ways, including blood pressure, temperature, and weight.
- Efficient chronic care management, monitor patient status in real-time, and enhance treatment plan adherence.
- Update workflows & manage patient interactions using telemedicine technology.
- can track bed occupancy, book procedures, generate bills, and handle discharge processes.

v. Post COVID19 Training Paramedical Staff

Paramedics are the ones who are exposed to COVID-19 at a higher rate than others, but they are also the ones that people turned to when the worst happened. Paramedics require smart learning processes, such as e-learning strategies, to enable them to give emergency treatment to people in the event of an emergency, accident, or sickness, and to transfer them to a hospital promptly. These services will aid in reducing morbidity and mortality associated with serious accidents or trauma, acute health issues, and emergencies such as covid19, among other things.

vi. Key Challenges faced by Paramedics in Training

Pakistan is confronted with several security issues. It has affected every aspect of our culture. First-line paramedics are regarded as critical services, and they are actively involved in assisting war-wounded and terrorism-affected patients along the western border. These medical operators are dealing with a variety of security concerns as a result of inadequate security circumstances and a lack of facilities, which is impacting their psychological behaviour. Pakistani paramedics are primarily challenged by a lack of knowledge for clinical practice, patient care, patient issues, new medical trends, and health policies, and self-development. They have a poor grasp of patient care and have little expertise, Paramedics are unable to use ICT and EMS systems, even they have a lack of knowledge in operating basic AI-based medical equipment [29]. Paramedics need the information to address issues that occur during clinical judgments and to keep up with the latest developments in the medical field. They also require access to health information to perform nursing duties in a variety of situations [22].

vii. Future Directions and Recommendations

To guarantee effective services for the paramedics, a dynamic and more responsive way of training is essential. This can be done by employing adaptive learning techniques, where paramedics shall get more personalized content based on their experience and expertise. A few possible options include (a) to employ technology like the smartbook, where the trainee will demonstrate its level of comprehension and the smart system will generate the relevant content or tests and will give individual-specific feedback to highlight the areas of weaknesses, (b) to give personalized education through adaptive courses, where each trainee will be given unique dataset, course activities, and projects. The system will perform the data or performance analytics to provide the most relevant advancements in the course and if required more supportive material, (c) to enable the paramedics to prepare themselves to handle difficult situations by employing VR-based technologies, where the simulations and emulations shall help the trainee to equip itself to handle stress and anxiety in the most difficult situations like a pandemic, natural calamities, and disaster situations.

viii. Modules

The underlying assumption behind designing these modules is to employ the best available adaptive learning technologies. The designed modules are based on the situations that paramedic staff often face. Our main focus will be on Nurse practitioners, physician assistants, and emergency medical technicians who are playing significant role in health care and also working as a front line agent in medical field.

Viral Epidemics

Viral epidemics have a significant and often severe influence on mental health, particularly among healthcare professionals. So training workshops or short term courses are needed to educate them to handle such situations with a peaceful mind. A list of potential training contents with possible outcomes is given in Table 6.

Table 6. Training for viral epidemic – Module 1

Module	Training Content	Outcomes
Module 1 A short course to combat any viral epidemic/Pandemic 1 Month Prerequisite: None	Introduction - Understanding epidemics, pandemics, and outbreaks - Efforts to prevent and respond to them Understanding Infectious Diseases - Tools needed to understand the infectious diseases - Development of knowledge and familiarity to outbreaks, epidemics, and pandemics Global Health security - Ability to prevent, detect, and respond to infectious disease threats - Self-Protection/Self Care/Precautionary Measures - Collective ability to combat these threats with the coordination of the international community multilaterally Local Countermeasures - Use of legal options given by the state/country to combat epidemics, pandemics, and outbreaks - Understanding the ethical and practical issues associated with disease, effects of calling an emergency, ban on travel, quarantine, and isolation.	On completion of the unit participants will be able to: - Identify the relevant disease - Use tools to identify disease nature - Protect their selves and others - Coordinate at the global level to solve issues related to epidemics/ pandemics

Table 7. Training for anxiety and depression – Module 2

Module	Training Strategies	Outcomes
Module 2 Workshop to overcome anxiety issues 1 day Prerequisite: None	Information Session: 3 hours (10 am to 1 pm) - What is a media distancing - Focus on Being Productive - Engage in Stress Reduction Activities Practical Session: 3 hours (2 pm to 5 pm) - Meditation - Use of popular meditation apps (Headspace, Calm, Stop, Breathe & Think, etc.) - Relaxation practice - Physical activity, Deep breathing, Yoga, workouts, etc.	On completion of the unit participants will be able to: - Reduce the level of anxiety - Active and more energetic - Maintain normal eating pattern - Good sleep

Table 8. Training to increase awareness about medical equipment – Module 3

Module	Training Strategies	Outcomes
Module 3 Workshop on Introduction to Basic medical equipment and their use 10 Days Prerequisite: None	Introduction session: 3 Days • Infusion Devices ◦ Volumetric Pumps, Suction Pumps, Oxygen Cylinder, Nebulizer, Suction Units • Safe Use of Moving and Handling Equipment (sensors based tools) ◦ Blood Pressure Machine, Weighing Scale, Pulse Oximeter, Electrocardiogram, Glucometer, Vacuum Extractor, Diathermy (Electric Surgical unit), fitness trackers, Apnea monitor, fetal meter. etc • IMS • ICT related concepts/tools • Fog infrastructure • Test Kits ◦ Cholesterol test, Allergy test, HIV test, Hepatitis C test, Drug, alcohol, nicotine test • First Aid Equipment ◦ Bandages, Ace bandage, compression stocking, Snakebite kit, Heating pad, Traction, Defibrillator • Assistive Technology ◦ Eyeglasses, Hearing aid, Dentures (full or partial), Prosthetic device, Orthotic device, including braces, Cane or crutches, Walker, Wheelchair, Scooter • Durable Medical Equipment ◦ Hospital bed, Specialized mattress, Chair (e.g., Geri-chair or lift chair), Lift equipment, Commode, urinal, bedpan • Practical Session: 7 Days • Individual sessions • Activities • Use of aforementioned tools • Operating and understanding • Result analysis	On completion of the unit participants will be able to: • Paramedics will be able to use all of the available equipment. • Utilize the appropriate equipment for the job. • Identify all defective equipment and send it to the medical technicians for repair. • Change in Paramedics' attitudes regarding the proper use and upkeep of medical equipment.

Table 9. Motivational seminar – Module 4

Module	Training Strategies	Outcomes
Module 4 Motivational seminar 3 hours Prerequisite: None	3 Hour session • Overview of time Management • Skills development for personal time and Self-Management • Getting Organized ◦ Planning for Results • Overcoming Delay	On completion of the unit participants will be able to: • Use time management's fundamental ideas and concepts. • Identify and remove roadblocks to effective time management. • Understanding of the distinction between reactive and proactive planning. • Personal scheduling methods to be more productive. • Juggle multiple goals, tasks, and deadlines • Overcome procrastination

Anxiety and Depression

Several studies have found that anxiety levels are higher than usual, and Lower anxiety appears to be linked to better-coping skills. This can be achieved by providing them e-learning facilities at their doorstep. An illustration of a workshop to overcome anxiety issues along with training strategies and relevant outcomes is given in Table 7.

Lack of Awareness

One of the biggest hurdles to the active association is a lack of awareness of how to utilize basic medical equipment. This may be overcome by giving practical seminars to paramedical personnel to educate and teach them on how to use and operate basic medical tools. The module 3 for training about introduction to basic medical equipment and how to use them is summarized in Table 8.

Personality Traits

The attitude of paramedical workers toward patients is influenced by their workload. Practice and motivation will help them achieve better results. An overview of a motivational seminar with training strategies and outcomes is given in Table 9.

Educational Difference

There is an ever-increasing disparity between full-time and part-time midwives. Providing high-quality education and training will help them accomplish their professional goals. Through training workshops, successful implementation of e-learning and adaptive learning technologies will be achieved by building adequate infrastructure, implementing needed standards, and taking efforts to eliminate current opposition in this respect. Better adaptation will be achieved through learning, financial and social support, and a variety of good coping techniques. The Table 10 shows a module for short course and training sessions related medical education about maternity support and neonatal care.

Table 10. Short course and training - Module 5

Module	Training Strategies	Outcomes
Module 5 Short course and training 3 Months Prerequisite: None	Maternity support: 15 Days - Anatomy and physiology of adults and newborns, as well as some elements of child development - Pregnancy, labor, and puerperium physiology - Feeding an infant - Basic life support for newborns - Obstetric crises that are relevant - Prenatal and postnatal care - Health promotion - Mental health of mothers Neonatal Care: 15 days - The usual infant's care - feeding a baby (artificially and natural feeding). - Preterm, post-term, and small-for-dates newborns. - Care of Babies that are hypothermic or jaundiced. - Taking care of babies born to diabetic mothers. - Care of babies, who have received oral or intravenous antibiotics, as well as those who have had birth trauma. - Babys born with a congenital defect, such as Down's Syndrome Nursing care in maternity setting: 2 Months - Anatomy and physiology of bodily system changes and adaptations throughout pregnancy, delivery, and the postnatal period. - Physiological guidelines for pregnant women. - A look at medical conditions and how they affect childbearing. - Urgent obstetric treatment and referral - Women's pre-and post-operative nursing care, including anesthetic recovery and pain management - Thermoregulation of the baby, as well as newborn care. - Women's nursing care throughout the postpartum period and recuperation after childbirth. - Bereavement and pregnancy loss - Ethical, legal, and professional issues surrounding care - Interprofessional and team working - IT and information retrieval skills	On completion of the unit participants will be able to: - handle the changing needs and difficulties of health care delivery in both the public and private sectors - enhanced knowledge and practical abilities relevant to the professional area - improved understanding of health care, as well as analytical and academic abilities

C. Training Health Workers

The vaccination workers, sometimes known as frontline health workers or lady health workers in Pakistan, deliver the vaccination doses, usually polio vaccinations, door to door. They approach each family to deliver necessary vaccines, for instance, polio vaccine to ensure vaccination of the target groups. The broad objective of lady health workers (LHWs) programme in Pakistan is to increase the access to required primary health care services at the household and community levels especially in rural areas. Developing strategies to train these workers about how to utilize the technological solutions to perform their job effectively is a need of time. Moreover, SAFE-Rural-Health is an idea to modernize the health services using the latest technologies and sensors data stream for the provision of sustainable health care services remotely. To Utilize advanced systems and modern equipment comprehensive training is required. In order to make the training effective and sustainable, it is developed in such a way that the training process evolves over time and its effectiveness increase on each iteration. The training system is divided into three modules followed by an evaluation session. The aim of the training is to help the health workers to understand the effectiveness of the new technologies and smoothly utilization of remote services. The Remote health worker has a key role in remote health service provision therefore sufficient training would be a prerequisite to get the optimal results.

Health workers are to be trained so that they can get appropriate data from patients for the medical specialists to prescribe necessary medication. Along with the basic remote health system training, it is necessary to educate the health worker that how they will cater to the other challenges during fieldwork. There are numerous challenges that health workers required to overcome that include language barrier, custom taboos, and illiteracy of patients. In addition to these social issues, the health workers need to know the procedure of proper handling of the patient in case of emergency using remote health monitoring system. In order to attain the effectiveness of the system, appropriate technical training is crucial so that health workers can use the devices correctly to get the vital signs of patients. Working in rural areas is challenging for health workers as the environment and cultural differences make it worst. The lack of awareness and illiteracy add more to the difficulty level. Normally the health worker should belong to the same community to minimize the language and cultural barriers.

The first step when a patient approaches the health care centre is to take general history and complaints of the patient. Health workers should be trained enough to get this verbal information from the patient easily. On the technical side, they should know the use of computers and the health management software in which each patient is registered with all particulars and initial history. Secondly, health workers should be trained enough to use the sensing devices. They should know how to connect a device with the patient and get readings. The life cycle of the training and complete process of the training modules is shown in Figure 1. The first module composed of basic training of

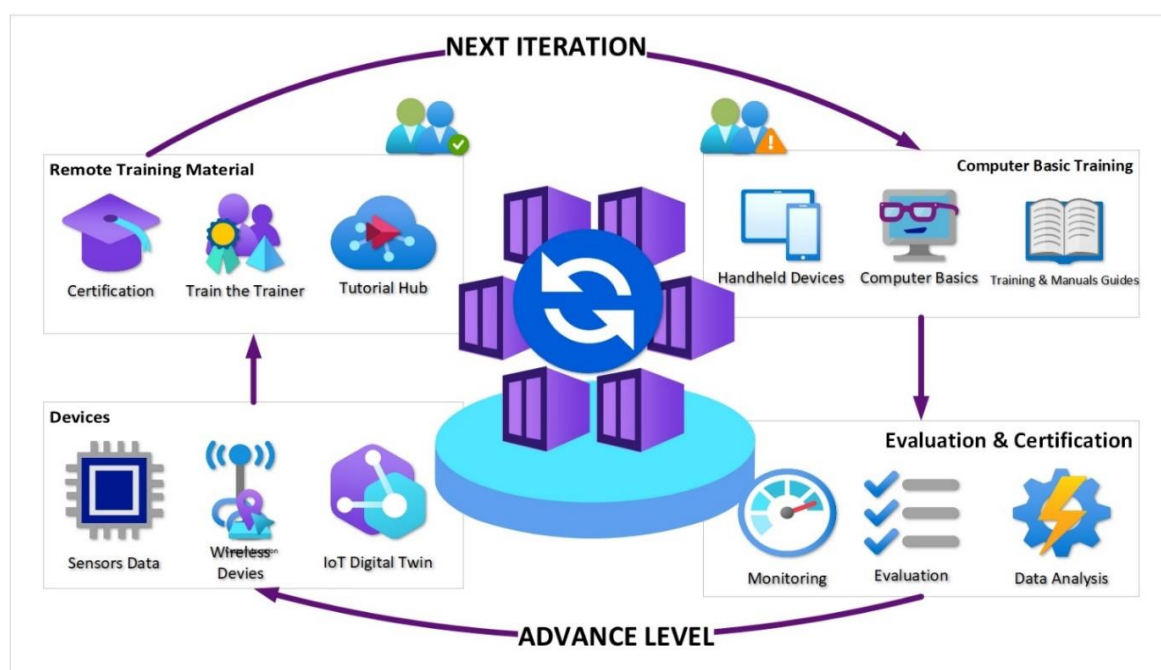


Figure 1. Training process of the SAFE-RH system for remote health workers and patients

the computers and electronic gadgets that are part of a system. It includes of labs, manuals, and videos lectures based material. After the first module evaluation would be carried out, on analysis and determining the learning outcomes next module will be offered to trainees that is about the devices and sensors and its working model. After evaluation and satisfactory results trainees will be enrolled into the third module which includes the system advance training, data collection and utilization of training material, and further training process followed by certification and complete access to the help resources. The training process continues with new trainers and follows the same steps of training.

i. Mode of Training

Training is a continuous process, evaluation led training improves the quality of the training and feedback the gaps. In order to conduct effective training for health workers, the different modes can be chosen according to the situation of the training site. The physical training session would be suitable for small groups of workers being easily available on site, however, due to the long distances, it would be difficult for workers to approach the cities, in this situation online training can be carried out through a convenient online platform. The operating manual of all devices that are used at the remote end with practical demonstration should be used to train the health workers. However, with the practice and passage of time they learn and get more experience. It is also possible to make short demonstration videos for them to learn the use of devices.

Evaluation is a valuable indicator to measure the effectiveness of the training efforts, therefore, assessment at every stage of the training would be a prerequisite to the next module for the training. At later stages, the evaluation will provide input for measuring the effectiveness of training and help to point out the weak areas of the training. Due to limited resources and a lower knowledge base of the remote areas of the country, it is necessary to devise an evaluation mechanism such that it fits with end-users. The Evaluation model provides an overview of the evaluation mechanism.

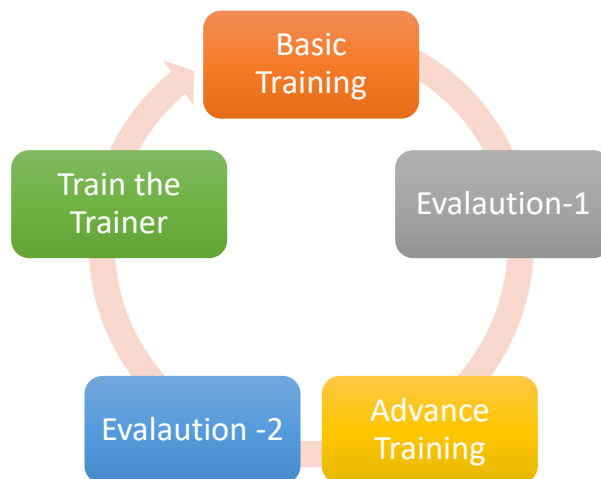


Figure 2. An overview of evaluation led training steps for remote health workers

ii. Evaluation Model

Training Evaluation is the feedback process which depicts the effectiveness of the process and helps to identify the training gaps and improvement areas. For the purposes of evaluation questionnaire based evaluation form is to be used to take the necessary feedback on provided training in the form of a different set of multiple graphically illustrated questions, signs, and verbal conversation. The feedback would enable the system to improve the training process and provide a mechanism to improve the quality of the training content and process.

The evaluation model consists of the four-stage process with two evaluation campaigns as shown in Figure 2. Each assessment provides feedback of the trainee for readiness to the next stage of the training. After the second evaluation trainee will gain enough knowledge of the system so that he can train other fellow workers. In the following section a detailed curriculum is being presented for the training of the remote health workers and the patients.

iii. Modules for Training Health Workers

The Whole system training is divided into three modules. The First module consists of basic level knowledge of computing while the second and third modules are specific to the use of electronic gadgets and online systems respectively. Each module is followed by an evaluation of the trainee. Based on evaluation results analysis provides the necessary data to be utilized for the effectiveness of the training, to improve the process of the training, and make it more effective.

Module I – Introduction to Computers and Information Technology

Basic training of the information technology equipment and services i.e., computer, email, smartphone, etc. would be delivered. The training will consist of video lectures and a printed user manual for a better understanding of the user. Details are presented in Table 11.

Module II – Equipment demonstration and training

Remote sensing devices are the backbone of the SAFE-RH system, effective utilization and understanding will result in accurate diagnostic and prescription on later stages. Equipment handling and practical aspects would be delivered in this module as per the following syllabus. Steps in detail are presented in Table 12.

Table 11. Curriculum for remote health workers Module - I

Module 1	Major role	Training Strategies	Resources
Introduction to Computer and Information Technology 3 hours Pre-requisite: None	After the Completion of session participants will be able to understand: 1) Basic computers technology such as typing a document, sending email, web browsing 2) How to effectively use mobile devices in providing medical support to the patient locating at a distant place for example collection of community and clinical healthcare data, delivery of healthcare information to practitioners, and real-time monitoring of patient vital signs 3) How to use Internet-based computing (cloud computing), where different services like servers, storage, and applications are shared which results in the effective and optimized use of software and hardware resources	Verbal information: 1 hour 1) What is a computer and how the mobile device can be used as an alternative to a computer? 2) Introduction to MS word 3) How to use browser, email and web services on computer and mobile devices. 4) Introduction to audio video conferencing Practical Activities: 1) How to type a word document. 2) How to compose and send an email on computers as well as on mobile devices. 3) How to join audio-video conferencing 4) How to monitor vital signs on smart devices 5) How to use a cloud computing such as Dropbox or any other	1) PowerPoint slides 2) Projector 3) Internet access 4) Video lectures presented on PowerPoint in CDs 5) User manual

Module III – Patient dealing using e-prescribing

To operate the online SAFE-remote-health system collection of data from the patient and feeding it into the system is an important step. The system would work effectively only when it is thoroughly understood, and the process of the e-prescription is fully followed. For awareness of system and process of information, the data collection would provide a comprehensive training guide composed of the following syllabus. Complete picture is presented in Table 13.

iv. Conclusion

Like other systems, effectiveness of the SAFE-RH system is dependent on the training of the health workers as well as patients in the subsequent levels. A comprehensive practical led training program consists of the three modules followed by evaluation provides hands-on training to the remote health workers. The training evolution model enables the system to improve the quality of the training and point out weak areas of the training framework, in this way system will adopt changes as per the requirement of the end-user, the training mechanism also provides leverage to the trained workers to independently train the newcomers on the system.

Table 12. Curriculum for remote health workers Module - II

Module 2	Major Role	Training Strategies	Resources
Equipment Training/Demonstration	After the completion of this phase participant will be able to understand: The equipment used for vital sign monitoring such as how to monitor fetal heart rate, BP, diabetes level etc.. using sensors or the complete the system proposed by SAFE R-H	It will be finalized after completion of architecture which SAFE RH will use.	1) Lab and Workshop 2) Multimedia Projector 3) Internet access 4) Video lectures presented on PowerPoint in CDs 5) User Manual

Table 13. Curriculum for remote health workers Module - III

Module 3	Major Role	Training Strategies	Learning Material
Patient Dealing, use of online system and E-prescribing	The health care workers will be able to: 1) Deal with patients using smart technology. 2) Will be able to motivate and train their patients to use smart devices. 3) Able to Manage patient medication and history 4) Health care workers will be able to deal with the patients using architecture proposed by SAFE R-H	1) Provide understanding of the patient audio, visual signs. 2) How to operate smart devices and sensors. 3) How to train the patients to use the smart gadgets on their own for continuous monitoring of vital signs.	1) PowerPoint slides 2) Projector 3) Video lectures presented on PowerPoint in CDs. 4) User manual

D. Training Students

The medical students are the doctors of tomorrow who need to be trained to cope with the complexities of the future healthcare. They must be trained with the nature of the data in the electronic health records, the management of the contents that includes all administrative functions such as storing, indexing, and cataloguing. The workshops and symposiums should be organized in the academic institutions to provide necessary training to students. A feedback from these students would allow the exploration of new challenges and solutions that comes in the way of integrating technologies in healthcare infrastructure.

Adaptive learning is a technology-based learning which employs different teaching systems in order to better meet the learning needs of students and allow them to develop the knowledge and skills with the help of lecturers, tutors, learning support tools and technological resources. The period of

the Covid-19 pandemic has shown the importance of such systems and further emphasized the need to help educators, in their permanent quest of rethinking and revising the learning design of their courses, with the unique goal to provide more meaningful learning experiences for their students [30]. Students also play an active role in the learning process using these technologies by providing their feedbacks at a regular basis and especially by pointing out on what did not work that well in the presented adaptive learning content. Nowadays, the most used learning systems include Blackboard, Moodle, Web CT and Canvas. The advantages of utilizing such learning systems include constant availability and accessibility of course materials, additional cost savings, enhanced collaboration amongst students and lecturers, improved learning performance, feedback from users and effective communication. On the other hand, various issues are also reported in adaptive learning systems, such as heterogeneity in ways the learning process takes place, different profiles and backgrounds of students leading to different engagements and motivations, personalized learning, and high teachers overload.

i. Learning Process

The learning process is one of the most common problems faced by students and lecturers in their respective learning environments. Learning process-related challenges include [31]: difficulties to share learning resources, high redundancy of learning materials, learning isolation without direct real-time feedback and inappropriate information load. Syed et al. [31] analysed the enhanced learning based on the use of existing technologies that improve student learning, and proposed a personal learning recommendation systems architecture that aims to support student learning through the use of online learning management system to find relevant educational material.

ii. Background Knowledge and Profile

Another concern is related to the profiles and backgrounds of students. Existing educational systems utilise standardised teaching methods that do not fit the individual characteristics of each student [32]. Several studies have applied AI-enabled learning interventions to address this issue. For instance, a mobile adaptive learning system called the Personal Assistant for Life-Long Learning (PAL3) to prevent knowledge decay was designed and presented in [33]. Similarly, the generation of learning paths that can adapt according to the profiles of students was proposed in [34]. Troussas et al., [35] proposed and presented a framework that recommends collaborative activities to students, considering their needs and preferences.

iii. Engagement and Motivation

Engagement and motivation of students is also an important issue. High levels of demotivation, passive attitudes, boredom, poor engagement and frustration among the students are specifically identified in this category. To mitigate these issues, Maravanyika et al. [36] proposed an adaptive recommender system-based framework for personalized teaching on e-learning platforms. An affective tutoring system was developed to identify when students become frustrated and confused, at which point it offers them the help they needed [37].

iv. Personalized Learning

Personalized learning is a key learning concept in the research community of educational technologies. In fact, some of the students are highly self-motivated and learn by exploring while other students prefer some specific guidance in a structured way [31]. For the learning content in personalized systems, especially in disciplines such as health medical/nursing, social science/studies and so on which need a great deal of domain-specific knowledge and skills, by adapting the student's profile to pedagogical objectives as an optimisation problem the overall learning process will be boosted and better learning results can be expected [34].

Most adaptive learning systems were designed to support teaching several courses which are generally specific to disciplines like mathematics, physics, psychology, nursing, computer literacy and biology. As far as we know, no learning system or platforms addressing multidisciplinary teaching including practical aspects such as remote health monitoring systems have been addressed and proposed in the literature so far. Remote health monitoring systems can be considered from different points of view: hardware/software design of systems for information (health related) processing, which require teaching skills for students in science, technology, engineering (commonly known as STEM students); and utilisation and manipulating of these systems by students and workers in health domain such as future doctors, nurses, etc. Adaptive blended learning is an approach that can greatly benefit to multidisciplinary teaching combining virtual face-to-face instruction using digital technology with online learning of laboratory activities [38]. With the digital transformation of learning organisations, new concepts like digital twin [39] are on the rise and can be transposed to adaptive learning on remote health monitoring systems as they can be modelled from sensors, networks, artificial intelligence, to decision making.



4. Conclusion

This report highlights the challenges of medical staff in Pakistan that are faced in adapting the technological solutions and advances. The different groups of the medical staff have been identified that are needed to be trained in order to achieve the objective of the smart healthcare system. In this regard, the intelligent tutoring systems (ITS) and dialog systems can be designed to effectively train the medical staff in stages. For instance, a small group of medical staff can be trained in first phase and this group can be used to train further members of staff to ensure the fast spread of effective training over the country. Training only the medical staff and the healthcare providers is not enough as it is equally important to train the patients to achieve the fruitful results. The patients should be introduced to the existing results achieved by other countries through these technologies to increase their trust on machines. To ease the initial adoption of these technologies, the e-learning and dialog systems can provide solutions, such as interactive tutoring, which not only train the learners but it can also provide a real time feedback and assessment if the knowledge has been transferred successfully.



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