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Telemedicine, Nursing and Medical Management: Applications, Case Studies, and Intelligence from RFID

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Abstract The American population continues to age rapidly as more baby boomers reach retirement. Technology is evolving to meet the demands of an aging population that is plagued with chronic illness, the need for health promotion and education, and access to care in rural areas. Physicians and nurses in hospitals are using telemedicine and radio frequency identification (RFID) technology medical management as advanced technologies and continually expanding to develop new modes of medical care delivery. In this paper, concepts about telemedicine and its application, the use of RFID in medical management and telemedicine applications, challenges and technical progress, and several case studies are presented in evidence of the need for global expansion of new technology.

Keywords: *telemedicine, nursing, medical management, RFID, radio frequency identification, health care, rural health*

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1. Introduction

A recent report from the United Nations predicts that the world's population will grow to more than nine billion people by the year 2050 and nearly one in four will be over 60. Technology needs to evolve along with the population trend to cope with the health issues that will inevitably arise. The trend can best be observed in Japan, where more than 20% are elderly and the figure is growing. Japan’s prime minister is set to look at technology that will decrease health costs and improve health services [1]. Millions of Americans in today’s health care arena are being exposed to new technologies. One emerging technology that is fast gaining popularity is telemedicine, which can decrease health costs and improve health services. The American Telemedicine Association (ATA) defines “*telemedicine*” as the use of medical information exchanged from one site to another via electronic communications to improve patients’ health status [2].

Remote diagnosis, information search engines, webcasts, and the easily transported electronic medical record (EMR) invite the imagination to use telemedicine [3]. A remote health monitoring system based on telemedicine technology can offer Global Positioning System (GPS) real-time location of the patient (city, number, street); address and phone number searching of the nearest first-aid stations; simultaneous monitoring of many patients; remote medical consultation service; and creation and management of electronic case sheets accessible on the Internet. The remote monitoring indicators can include: an electrocardiogram (ECG) and heart rate, blood glucose, physical activity (body kinetics), respirations, oxygen saturation, blood pressure, and body temperature [4]. Telemedicine is not only restricted to patient use, medical specialists in off-site locations would be able to provide consulting services to onsite staff [5].

In this paper, an overview of RFID in telemedicine, nursing and medical management will be provided. The application of telemedicine in rural facilities and diabetes will be discussed, and three case studies will be presented. It is important to consider that telemedicine encompasses many avenues of care and only a few are mentioned in this paper.

2. Telemedicine

2.1. Telemedicine Technology

Many telemedicine components consist of a high-definition video monitor and an audio device. In some cases, cell phones have been adapted for telemedicine. Some of the telemedicine technology may be recognized by its trade name: Health Buddy, Commander Home Monitor, TeleAM, HealthHUB, Care Pal, Health Guide, and My Medic Telehealth Monitor to name a few [6]. Images, lab data, vital health records, and other electronic information are sent via the Internet to the central station for the monitoring physicians to use in assessing the patient.

Through a combination of various video and audio technologies, patients and physicians can interact at the bedside while being separated by hundreds of miles. Physicians and nurses in a remote location typically undergo special training for telemedicine applications. After completing the special training, the staff remotely monitors a group of several hundred patients from a central location. High definition cameras and the Internet are used to zoom in for close-ups and detailed assessments. Sensors and monitors directly transmit data such as heart rate, respirations, temperature, and blood pressure to the central control station. Patients and family are able to interact with the physicians and nurses just as if they were at bedside. Figure 1 [7] illustrates the set-up of a room with telemedicine monitors. A physician examines the infant while specialists watch and consult with the bedside physician.

Figure 1. A physician consulting specialists about an infant via telemedicine monitors

2.2. Telemedicine's Applications

Telemedicine is used in a variety of settings, including but not limited to: intensive care units (ICUs), diabetic care, cardiovascular care, emergency and trauma care, caring for children in clinics, and in stroke care. Congestive heart failure patients are increasingly being monitored at home using telemedicine to reduce hospitalizations and monitor fluid retention, heart rate, and oxygen saturation [8]. Programs using trained assistants can reduce hospital and emergency room (ER) admissions by as much as 23% using telemedicine. Programs such as these using telemedicine are in the planning phase for senior centers and assisted living centers in Rochester, New York, USA [9]. This section focuses on applications in diabetes care and rural health care.

2.2.1. Telemedicine, Nursing and Diabetes Care

Patients with diabetes are at a high risk for both microvascular and macrovascular events such as heart attacks, stroke, peripheral vascular disease, kidney disease, and hypertension. It is important for diabetic patients to be regulated and monitored closely, depending upon the severity of their disease, and medications and treatment adjusted according to an ongoing plan of care. To allow for easy monitoring of patients with diabetes, telemedicine programs have been developed by some hospitals and clinics to provide an added level of patient care and service. These telemedicine programs are unique in that monitoring is done in the home and on a case-by-case basis. Tight glycemic control can prevent the unwanted sequelae of diabetes and prolong life. Telemedicine programs improve glycemic control and allow for flexibility in patient care plans with consistent physician and patient monitoring of glucose and other vital information [10]. Figure 2 [11] shows an elderly lady being monitored at home using telemedicine. The nurse monitors vital physiological functions that are transmitted via phone lines or Universal Serial Bus (USB) cables.

Figure 2. A woman is being monitored at home by nurses via telemedicine

Tri-Hospital General Hospital Diabetes Center implemented a telemedicine program for patients. Each patient was injecting insulin based on a prescribed regimen. A physician adjusted insulin dosages based on data uploaded by USB cable over the Internet through glucometer readings and other physiological devices. Patients enrolled in the telemedicine program improved glycemic control and reduced hospitalizations and emergency room visits over the course of one year [10]. Telemedicine programs for diabetic patients can reduce the need for repeated hospitalizations and frequent clinic visits, reducing cost to not only the patient but the health care system as well.

2.2.2. The Rural Health Care Industry and Telemedicine

The economic benefit of telemedicine in rural health and community services is essential for the justification of using telemedicine applications for patient care. Economically, a reduction in the number of hospital admissions and clinic visits and an improvement in the overall health of an individual meet national goals for a healthier America. Using telemedicine applications to supplement primary care and bring tertiary care expertise to a small rural community is essential to cost-savings and improving care among rural facilities. Using telemedicine in home applications is vital for improving services such as home health and other services to monitor and observe patients in rural communities with limited access to physician care. These applications can not only save money and lives, but improve the quality of life of the patient and bring hi-tech care to a poor community that otherwise without telemedicine would be unable to enjoy such services and expertise. Not only do patients benefit, but physicians in rural communities benefit as well, knowing backup is available and a second opinion is only a video consultation away. The benefits then to physicians and the community include improved physician satisfaction and improved physician recruitment to rural areas [12]. Lowering transportation costs to a tertiary care facility is also important for many rural patients. Many patients, especially the elderly and handicapped, have difficulty finding transportation and ways to make appointments at tertiary care facilities long distances away. In a study by Wootton, Bahaadinbeigy, & Hailey (2011), travel was reduced by 43% by patients using facilities with telemedicine [13]. When a patient has to travel for medical care, that patient may be off work for an extended time and the company loses profitability. Not only do corporations and small businesses feel the crunch when patients have to travel for health care, the patient themselves may be out an unexpected amount of money based on how far they travel and the tests and treatment they receive. Telemedicine allows patients to enjoy the freedom of reduced travel and decreased time missed from work because a specialist is already at the bedside and able to offer suggestions. The benefit of hospitals seeking telemedicine applications in rural communities also includes approval for tax funding and other financial benefits such as grants [12].

In some rural hospitals, cost-savings included being able to run units without a physician on site. For example, in the radiology department, X-rays were sent directly to a physician who had marketed his services to the hospital and this eliminated the need for an in-house radiologist. In another case, physiatrists were unnecessary as telemedicine provided a route for an expert, tertiary care physiatrist to be onsite via telemonitors and audio equipment for each patient [12]. In some cases, rural emergency rooms (ERs) were run by nurse practitioners, not physicians, eliminating the need to recruit costly physicians to cover the ER. Telemedicine applications allowed the nurse practitioners access to video and audio monitoring at bedside for any patient with a complaint or trauma.

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Rural communities are benefiting in unique ways due to telemedicine. Not only are intensive care units (ICUs) in small hospitals able to provide a higher level of care, but ERs are also able to utilize the technology to provide high quality patient care to emergency patients and trauma cases in rural community hospitals where nurse practitioners operate under the watchful eyes of a tertiary care center physician group. This higher quality of care means more small community hospitals can keep their doors open and provide needed services to the communities they serve, providing key emergency and critical care medicine to patients in outlying areas.

3. RFID in Nursing and Medical Management

RFID has been used in identifying laboratory specimens, linking patient with key drugs and personnel, monitoring patients, tracking medical devices and potentially hazardous materials, and detecting medically significant events. RFID integrated with either sensors or network, or both, can monitor the temperature of blood products; send the physiological status of a patient; enable continuous monitoring and patient identification; and identify patients' locations in case of emergency. Based on the Electronic Product Code (EPC) and the EPCglobal Network, RFID can perform traceability of products and track all transactions from the beginning to the end of the supply chain in the pharmaceutical industry, which can combat counterfeit products and protect product brands [14].

RFID is an automated data-capture technology that can store patient information electronically contained on RFID wristband. RFID encoded wristband data can be read through bed linens, while patients are sleeping without disturbing them [15]. RFID with sensors provides real-time information on patient health indicators, monitor patients; and alert for patient status changes [16]. In addition, RFID has the functions of tracking and verification or identification.

Verification or identification is used to reduce incidents harmful to patients (such as medication errors—wrong drug, dose, or time, or procedures) and infant authentication in hospitals to prevent misidentification [16]. Doctors, nurses, and patients have RFID tags attached for identification and location purposes. In the tags only identification (ID) is stored to reduce security and privacy attacks. The unique ID is associated with a database record saved in a server connected to RFID readers. In the database the record of a patient may include, for example, the patient's name, date of birth, gender, and a medical record number, billing, medical insurance, pharmacy, and so on. RFID readers can be fixed in each room or mobile [17].

Tracking can be real-time position tracking (for patient flow monitoring or improving workflow) or tracking of motion. Tracking includes: specimen, blood product, and records tracking; assets tracking and inventory location tracking; and materials tracking to prevent left-ins during surgery [16]. For patients with RFID tags, their location can be tracked continuously [18]. An active RFID system was implemented for two-dimensional positioning service for home health care. The proposed system uses four active tags for the reference addresses and an object equipped with an active tag. The system uses the information from the reader to compute the geometric relation between the reference tags and the object and determine the location of the object by the positioning algorithm. The Global Positioning System (GPS) is widely used in outdoor positioning and its position error is acceptable within 15 meters. However, a position error of a few meters could be unbearable for indoor positioning. GPS does not work well inside buildings. The wireless technology of RFID was adopted to develop a high-accuracy indoor positioning system [19].

A real-time location system (RTLS) can help hospitals track their equipment and patients and display important patient and asset location data in real time. With the RTLS, hospital personnel can tag patients during registration by giving them either a tagged badge or wristband to track patient movement. High-value assets, such as infusion pumps, are also tagged so that nurses can locate them quickly. RTLS can help hospitals execute a coordinated response during a disaster. Several commonly used RTLS technologies are shown Table 1 [20]. The different technologies offer different implementation options and levels of precision. Ultra high-frequency (UHF) sensors and Wi-Fi access points provide broad coverage by tracking tags over longer distances. Because their precision is affected by the absorptive and reflective properties of radio frequencies in the surrounding environment, they are best used for zone-level precision and not for room level or bed level precision [20].

Table 1. A Comparison of Commonly Used RTLS Technologies

Ultra high-frequency	Wi-Fi	ZigBee	Ultrawide band	Ultrasound	Infrared
Zone-to-room-level precision		Room-to-bed-level precision		Bed-level precision	

Analysis of activities of doctors and nurses can be performed, especially in emergency rooms, to measure the flow of doctors and nurses, including the time periods they spend on some patients or wait for some conditions. Patient flow can be measured, which includes the time periods of patients spending on each stage of their treatment such as registration, waiting in the room, and waiting in the bed, for example [17]. An RFID real-time tracking system was developed to monitor patients at the room level and implement an automatic workflow management. The RFID system integrated with the hospital information system increased workflow efficiency by shortening the mean waiting time during the workflow process and provides valuable real-time data for physicians and staff regarding workflow efficiency. The RFID system also sent an alarm signal if a patient did not move for some time [21].

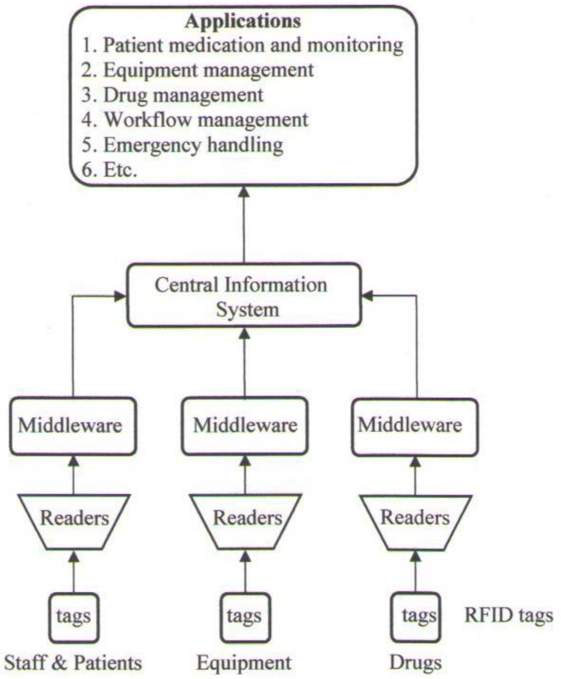

Figure 3. An RFID system for medical management

Figure 3 illustrates RFID applications in medical management. Staff includes physicians, ancillary staff, and nurses. RFID middleware layer enables a quick connectivity with readers, filters raw RFID observations from readers, and lowers the volume of information.

4. RFID-based Telemedicine

RFID tags can be used to monitor patients in a hospital, in an ambulance, in a home, and even in a disaster area. RFID has been applied in telemedicine which employs wired or wireless communications to provide medical information and services [17]. With large-scale wireless networks and mobile computing solutions such as cellular 3G, Wi-Fi mesh, and WiMAX, health care personnel can tap into vital information anywhere and at any time within the healthcare networks. RFID, Bluetooth, ZigBee, and wireless sensor networks further extend the potential for the integration into new mobile health care delivery systems [22].

Physicians or other care-givers can communicate with patients directly by video conference via the Internet. Physicians can remotely assess and diagnose by relying on both video communications with any patient and the patient's physiological data; information is retrieved by a wireless body area network (WBAN) hosted by patients. Remotely monitored information such body temperature, blood pressure, and heart rate convey vital information about a patient's health status to a qualified healthcare practitioner for patients that need to be monitored on a constant basis. This information can be obtained by minute sensors attached to the patient's body (arms, legs, etc.) to form a WBAN. Physicians write diagnostic information, medical methods, and prescription information into the mobile code in the patient's RFID tag [23].

In 2004, the Center for Aging Services Technologies (CAST), USA, used RFID in a telemedicine application. Tags were attached to medicine bottles, teacups, and other objects regularly used in the home. Sensors recorded the elderly patients' activities based on which tagged items were picked up during the day and night. One primary application of RFID in telemedicine is smart sensors [17, 38]. Smart sensors can assist a physician in remotely making an assessment and providing a diagnosis. This system can significantly reduce the need for physicians in rural areas and inner-city urban areas designated an underserved health care area. Using remote technology and telemedicine can produce a network of supporting physicians and nurses for a small community hospital with limited resources or a home-based organization to reduce rehospitalizations. In an ambulance, this technology can prove useful by making pre-hospital diagnosis possible so that advanced treatment can be provided in the field, saving both lives and money. Data is transmitted via secure wireless a local area network (LAN) or cellular network [17]. RFID with sensors can collect patient data and transmitting it to doctors remotely; track the movements of different body parts in an effort to monitor activity levels, help physicians monitor at-home patients remotely, reducing costs and improving care [24].

A real-time patient monitoring system was proposed, which can use smart sensors to collect patients' vital signs so that medical specialists can perform remote diagnosis anywhere and at any time [17]. Wireless sensor networks (WSNs) have been used in health status monitoring. The integration of WSNs and RFID systems has also opened up new opportunities in health care systems and wireless telemedicine [25]. A multi-hop WSN composed of many wearable sensors and a central workstation and database was developed to remotely supervise the medication intake of nursing home patients via an RFID monitoring device to accurately transmit the patient's electrocardiogram (EKG) [26].

Researchers at the Georgia Institute of Technology, USA for instance, have created a passive ultrahigh-frequency (UHF) tag so thin it can be sewn into a medical gown, removing the need for patients to be hardwired to equipment. There is still much work to be done in the area of research for tags that will deliver high quality information remotely and cost effectively for applications in telemedicine. It is important for patients to have freedom of movement and be at ease while being remotely monitored [24].

5. Telemedicine Case Studies

5.1. Case Study: Telemedicine Applications in Rural Health

Rural health has many applications for telemedicine. Research is ongoing for ways to improve telemedicine programs and integrate services with new technology such as RFID to bring high quality care to rural communities. One area that has gained popularity in telemedicine is the emergency medicine programs at small rural hospitals. With physician recruitment down, and economic and geographical factors making it hard to recruit local physicians, smaller community hospitals in rural areas have turned to a program that allows specially trained nurse practitioners staff the ER while consulting physicians are hundreds of miles away in a tertiary care facility central monitoring station waiting to conference with them about a patient via high definition cameras and audio. Images, lab data, and other pertinent patient information needed for diagnosis is available to the telemedicine physician to make an assessment and diagnosis. One such facility has used this technology for over five years and reductions in the number of physicians needed to staff the facility's ER and the cost effectiveness of the program have been determined to be well worth the program's initiation.

Mississippi (MS), USA as a state is a rural state, with many areas underserved by both physicians and nurses. There is one tertiary care facility in the central portion of the state for residents, and many would have to drive hours to receive the same level of care found at this facility. However, the University Medical Center (UMC) in Jackson, MS, USA, in cooperation with smaller community hospitals such as Marks Hospital and Ruleville Hospital, has developed a telemedicine program to staff the ERs with qualified nurse practitioners who undergo special training at the University Medical Center School of Medicine. According to John Sandifer, MD, one of the attending telemedicine physicians working at UMC, nurses and nurse practitioners in the community hospitals enjoy the support of the telemedicine physician, and physicians in the telemedicine program enjoy providing the support to the smaller hospitals. Patients are admitted to the ER of the community hospital, evaluated by the nurse practitioner, and if a consultation is necessary, high-definition television monitors and audio are available so that the consulting physician can make a detailed assessment of the patient and interact with the patient and family just as if the physician were at bedside. The physician then advises the nurse practitioner on a course of action and both the health care facility and patient benefit.

According to Sandifer, high-definition television and audio allow a detailed assessment, but a shortcoming is having no physiological data input from the patient. Nurses or the nurse practitioner must manually enter the data into the computer. RFID sensors worn by the patient would eliminate the need for the cumbersome and time-consuming task of manually entering data and allow direct transmission of data to the physician. However, Sandifer did not say if UMC has decided to upgrade to an RFID-based system at this time or not.

Sandifer also said that the community benefits from the telemedicine program because they get a board certified emergency medicine physician right at the bedside. The disadvantage to the system, according to Sandifer, is that the physician is not looking at the patient directly. Patients perceive the technology as important to their community as a whole because not only do they get a specially trained emergency nurse practitioner, able to perform advanced care treatment, they get a board certified emergency medicine physician consulting on cases as well and get to interact with the physician via the television and audio equipment.

5.2. Case Study: Telemedicine Applications in the Management of Stroke

An estimated seven million Americans 20 or older have had a stroke. Overall stroke prevalence from 2007 to 2008 is an estimated 3.0%. According to data from the 2010 Behavioral Risk Factor Surveillance System (BRFSS) (CDC), 2.6% of men and 2.6% of women 18 or older have had a history of stroke; 2.4% of whites, 4.0% of blacks, 1.4% of Asian/Pacific Islanders, 2.5% of Hispanics (of any race), 5.8% of American Indian/Alaska Natives, and 4.1% of other races or multiracial people had a history of stroke. The prevalence of silent stroke ranges from 6% to 28% and increases with age. The prevalence of stroke-related symptoms is relatively higher in the general population free of a prior diagnosis of stroke or transient ischemic attack (TIA). On the basis of data from 18,462 participants enrolled in a national cohort study, 17.8% of the population over 45 reported at least one stroke symptom. Stroke symptoms were more likely among blacks than whites, among those with lower income and lower educational achievement, and among those with fair to poor perceived health status. Symptoms were also more likely in participants with higher Framingham stroke risk scores. Projections show that by 2030, an additional four million people will have had a stroke, a 24.9% increase in prevalence from 2010. On average, every 40 seconds, someone in the USA has a stroke. A review of published studies and data from clinical trials found that hospital admissions for intracerebral hemorrhage have increased by 18% in the past 10 years, probably because of increases in the number of elderly people, many of who lack adequate blood pressure control, as well as the increasing use of anticoagulants, thrombolytics, and antiplatelet agents [27].

With stroke becoming such a prevalent complication of many diseases such as hypertension, diabetes, and heart disease, the need for advanced treatment is essential to good stroke care and the prevention of disability. It is a small window of opportunity for a stroke victim to receive life-saving thrombolytics to prevent severe disability. There is only a three hour window of opportunity to save lives and prevent complications associated with stroke [28]. Telemedicine is rapidly advancing in the area of stroke care so that advanced and timely treatment can not only be given, but that assessment and a plan of care can be documented sometimes before the patient arrives. Mississippi, USA, has a new system being installed statewide to assist pre-hospital responders in identifying stroke victims [29]. Figure 4 [30] demonstrates the concept of emergency pre-hospital care using telemedicine.

Figure 4. Emergency medical services (EMS) using telemedicine to provide high-quality pre-hospital treatment in stroke treatment

Large amounts of data and images can be transferred through cell phone and high bandwith broadband to allow physicians at incoming hospitals to view patients prior to arrival and make a stroke assessment based on the National Institutes of Health Stroke Scale (NIHSS), a systematic assessment tool that provides a quantitative measure of stroke-related neurologic deficit [29,31]. The NIHSS can be used as a clinical stroke assessment tool to evaluate and document neurological status in acute stroke patients. The stroke scale is valid for predicting lesion size and can serve as a measure of stroke severity. The NIHSS has been shown to be a predictor of both short and long term outcome of stroke patients [31].

With these facts in mind, Massachusetts General Hospital and Brigham and Women's Hospital in Boston, Massachusetts (MA), USA, has developed a telemedicine program to treat stroke in smaller outlying facilities, bringing tertiary care expertise and stroke specialist care to many smaller facilities that would otherwise have to transfer patients, delaying treatment too long. Juan Estrada, Program Manager for Partners Telestroke program at Massachusetts General Hospital indicated there is a great need for many more telestroke programs in the USA. Estrada's program serves 32 hospitals in the Massachusetts, Maine, and New Hampshire, USA region. When there is a stroke patient in any of these 32 facilities, consulting physicians at Partners use high-definition video and audio to make detailed assessments and talk directly to the patient and family to determine such things as when the symptoms started and a medical history. After reviewing labs, imaging data, and other electronic patient data, telestroke physicians then consult with the admitting emergency medicine physicians on the appropriate course of treatment. Although Estrada said the program uses hardwire technology currently, the plan is to move toward technologies like RFID and wireless transmitters to allow more flexibility and reliability in the transmission of data as well as allowing the patients more freedom.

Diagnosis made with video monitors by consulting stroke physicians compare favorably with diagnoses made on site [32]. Estrada said that many physicians can get close enough with cameras to perform the closest exams. Nurses are especially trained as well as the physicians in cooperating emergency rooms. Most enjoy the technology and rely on the expertise and knowledge of the telestroke physicians in supporting diagnoses made for treatment. According to Estrada, patients and families call the technology a "stroke of genius" and are very glad to have the knowledge and capabilities of stroke specialists at their smaller community hospitals.

Any moment of delay in an emergency such as ambulance dispatch, ambulance diversion and clinical handover communication can significantly reduce a patient's chance of survival. A new type of RFID application named 2G-RFID-Sys was proposed and applied to the medical emergency system. It is efficient without the disadvantage of centralized management. It is suitable for the tagged ambulance dispatch management in a huge range [44].

5.3. Case Study: Telemedicine and eICUs

Critical care medicine is essential in this current health care climate where many elderly patients have multiple chronic illnesses and suffer from exacerbations and complications related to their primary and secondary diseases. Not all hospitals are equipped to handle a critical care patient; many smaller community hospitals lack the physician support necessary to operate a critical care unit. Telemedicine and eICUs (intensive care units with telemonitoring), a concept that is rapidly gaining popularity, is one way many smaller hospitals are combating the need for highly trained staff while still being able to treat sicker patients.

At Banner Desert Medical Center in Mesa, Arizona, USA, the eICU oversees 500 critical care beds, 100 medical-surgical beds, and about 24 pediatric intensive care beds. According to Dee Gleadall, RN, Nurse Manager of the eICU, Desert Medical Center has an average census of anywhere from 450 to 200 beds per day depending on the time of year. The eICU is an added level of care for many smaller hospitals. Nurses and physicians in the eICU interact over television and audio devices with patients and nurses in the hospitals where they monitor patients. Nurses may manage "bundle compliance" for a patient on a ventilator to prevent a hospital acquired infection from setting in, while physicians may be asked to assess the patient to give a back-up diagnosis and support to the on-site physician.

Gleadall said while they are currently using hardwire technology at present in the eICU and telemetry monitors for the mobile medical-surgical patients, the medical center is considering moving toward RFID technology in the future to allow better capture of data and patients more flexibility. Mobile cardiac sensors (EKG) have an error rate of about 2-10%. However, they allow greater flexibility for patient movement. SkyeTek's M1-Mini that is advertised as 'the world's smallest, self-contained multi-protocol 13.56 MHz' low-power RFID reader supports a radius of a mere 12.7 mm [26]. Gleadall said that diagnosis and treatment of patients in the eICU is no different than on-site diagnosis, and the technology is an added level of care that prevents the patient from having to leave his or her community to receive a higher level of care.

Nurses and physicians like the technology because not only do they have the support of their colleagues from a tertiary care facility, they have a back-up plan in case of problems with the patient [33]. Gleadall said that patients enjoy the knowledge that their level of care in their own community is now higher thanks to the telemedicine application. All nurses are specially trained who work in the eICU and have at least five years of critical care experience, most have many more years than that so floor nurses and outlying facility nurses have a ready source of experienced colleagues on hand to discuss issues and problems that may come up with the patient. Sometimes, however, Gleadall said, teamwork is a little awkward between floor nurses and the eICU nurses. Although the eICU nurse may see something happening, communication may become a key issue in solving the problem. Gleadall said that is an issue she is working on.

Situations in the middle of the night are easily handled by nurses in the outlying facility. A button is directly connected to the medical center's eICU and nurses are there and available to answer questions, do exams, review patient data, and help with physician handling. At the same time, physicians also have the same advantage as physicians in the eICU are available as a team and can be consulted at any time, day or night. Gleadall said there is a lot the eICU nurses can do for the patient.

6. Challenges and Technical Progress

Although telemedicine brings many advantages to providing health care to the disadvantaged, there are multiple ethical and legal implications to consider in using the technology. Among the most common concerns for telemedicine is patient privacy and maintaining patient confidentiality among the telenetwork. Current research into this area is vital to safeguard information being transmitted over unsecure video and audio frequencies and should focus on improving technology to prevent hackers and breaches in confidentiality.

Nurses who work with telemedicine perceive the technology in various ways. There are many nurses who feel the technology brings an added level of care while more than a few nurses feel the telemedicine technology is just more than an interruption in their daily work cycle [33]. For the staff that works with this technology, providing comprehensive training and an educational program that encompasses the complete role of telemedicine in health care should be offered to offset some of the negative attitudes.

The adoption of telemedicine has been slow. Since its introduction in the 1980s, few facilities have made great strides in improving and updating the technology. Five reasons for the lack of response to telemedicine can be identified as: relative advantage, compatibility, trialability, observability, and complexity. Relative advantage is how well the technology is perceived in response to existing technologies and is perhaps the most important factor in developing new technology. The most common barriers to the adoption of telemedicine are cost and regulatory restrictions [34]. One barrier to implementing RFID in most telemedicine units has also been cost, however new low-cost sensor tags are now being developed to reduce cost and improve the technology [35].

A 2007 national public opinion survey concerning the desirability of several mobile healthcare technologies based on RFID. The survey revealed high levels of interest in emergency intervention services, but much less so in health information and monitoring services [36]. Security and privacy are important issues in RFID systems. Tags are vulnerable to eavesdropping, spoofing, or denial of service. Unauthorized readers may access tags [17]. Greater read ranges and stronger signal penetration capability pose a significantly higher threat to personal privacy in an RFID-enabled system. Consequently, it is important to minimize the tag and reader distance by choosing the standard that has the smallest read range sufficient for a particular application [37]. The primary concern of RFID use in telemedicine has been and is currently the temptation for illegal use of patient information or breaches of patient confidentiality [17,38]. To combat these issues, several possibilities exist for support. A randomized hash lock for security can be proposed for secure data transmission. The tag can be locked and opened with a key. Re-encrypting data using a security key can also be used to prevent data hijacking [17]. A novel mutual authentication protocol was proposed to solve the tradeoff between location privacy and scalability in healthcare environments. The authentication scheme would be able to increase confidence in the implementations of RFID systems in healthcare environments with personal and medical data in RFID tags [45]. A biometrics-based user authentication scheme was proposed to ensure uniqueness and anonymity because biometrics (such as iris, face, voiceprint, fingerprint and so on) is unique, easy to be verified, and hard to be copied [46].

A number of environmental conditions can impede the read range of a tag and degrade the quality of tag and reader communication. Ambient radio noise, radio-reflective objects (metals) nearby, and radio-absorbing objects (liquids) can greatly reduce the read range. Since the human body consists primarily of liquids, it may reduce the read range of UHF tags if the radio signal has to travel through it. The electromagnetic interference (EMI) caused by RFID with medical devices among hospitals must be appropriately handled [37].

There are a lot of metal items and liquids in the medical environment; some technical challenges of RFID are from metals and liquids. Some progress has been made in overcoming the challenges. Water interferes with radio waves and affects the readability of liquid items. It was recommended that tags be slightly offset from items containing the liquid [39]. Metal interferes with the radio waves and affects read rates. For tagging metallic objects, any of the following approaches [40,41,42,43] can improve readability:

- Use antennas, such as patch antennas, that require a ground plane to operate. This type of antenna will not be affected much when attached to metallic objects. Some examples are tags made of patch antennas and planar inverted-F antennas.
- Leave a gap between tag antenna and metallic object. A Teflon mounting bracket was constructed to hold a tag and the bracket is attached to the metal. The Teflon provides enough isolation from the metal to eliminate the interference.
- Using an adhesive resin to position the tag can provide a barrier layer between the tag and the metal surface, which would allow for the data to be read without any interference.

A new RFID system (UHF band, 953 MHz) were tested in a hospital and demonstrated that the electric fields produced by the new RFID system did not significantly affect medical devices and was safe and useful for tracking people and medical equipments. The new RFID technologies may enhance patient safety, and wellness, and reduce staff workloads in a hospital [47].

7. Conclusion

Telemedicine has many applications useful in today's health care arena. The many cost-savings aspects of telemedicine as well as the increased level of care that smaller hospitals are able to provide improves the USA health care system for all patients. In rural areas, patients have reduced travel times and access to the same health care available at larger, tertiary care facilities. The need for more home applications in telemedicine is pressing. While diabetes is a severe disease and can be limiting in its complications, there are other home applications such as for chronic obstructive pulmonary disease (COPD) patients, heart failure patients, and hypertensive patients. Monitoring of the elderly so that medication compliance and accurate dosing is achieved is another important reason to continue research into telemedicine applications and nursing. The need for more telestroke programs and eICUs dominate the country. It is important for these programs to have the best available technology which includes RFID-based systems in telemedicine and nursing. Challenges to telemedicine applications and the use of RFID-based systems are an ongoing struggle to develop better solutions to current problems.

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