Chapter 48. Patient Safety, Telenursing, and Telehealth

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Background

Tele is a prefix meaning "at a distance," and it is used in terms such as telescope, or telemetry. The prefix *tele,* when combined with the term *scope,* has the single clear following meaning: an instrument to view phenomena at a distance.[1] However, in health care, as in other arenas, the prefix *tele* often takes on several meanings. For example, the term *telemetry* is described as a process,[2] data,[3] and an electronic device[4] related to the task of remote measuring and reporting of information of interest. There is inconsistent and emerging nomenclature related to *tele* in health care.

The inconsistent use of language associated with the delivery and management of health care at a distance has made it even more difficult to distinguish the ontology of terms and describe their related safety and quality issues. Specifically, previous literature has used the terms *telehealth, telemedicine,* and *telenursing* somewhat interchangeably, and the few articles reporting safety concerns were difficult to cluster for further analysis.

Telenursing is the use of "technology to deliver nursing care and conduct nursing practice"[5] (p.558). Although the use of technology changes the delivery medium of nursing care and may necessitate competencies related to its use to deliver nursing care, the nursing process and scope of practice does not differ with telenursing. Nurses engaged in telenursing practice continue to assess, plan, intervene, and evaluate the outcomes of nursing care, but they do so using technologies such as the Internet, computers, telephones, digital assessment tools, and telemonitoring equipment. Bearing in mind that health services now provided via teletechnologies have expanded, the term telehealth is used to capture the breadth of services. For the purposes of this review, the Health Resources and Services Administration defines telehealth as "the use of electronic information and telecommunications technologies to support long-distance clinical health care, patient and professional health-related education, public health and health administration."[6] Telemedicine, the original term, is defined as the practice of health care delivery, diagnosis, consultation, treatment, transfer of medical data, and education using interactive audio, visual, and data communications.[7] The American Nurses Association has defined telenursing as a subset of telehealth in which the focus is on the specific profession's practice (i.e., nursing).[8]

The delivery of telehealth care is not limited to physicians and nurses; it includes other health disciplines such as radiology, pharmacy, and psychology. These disciplines also deliver care using electronic information and telecommunications technologies and are accordingly called *teleradiology, telepharmacy, telepsychology,* and so forth. Although they are not the focus of this review, these disciplines are selectively included here for two reasons: (1) the safety issues associated with care delivered using electronic and telecommunications technologies are more similar than they are different among the various health disciplines, and (2) the dearth of research on safety and quality in the telenursing literature led the authors to include important research in other health disciplines. By including the research findings on safety and quality from varied health disciplines, the body of telenursing knowledge is expected to expand.

Research Evidence

Although the summary for the AHRQ evidence report, *Telemedicine for the Medicare Population*,[9] specifically mentions safety related to telemedicine and how evidence could be presented and researched, it is ironic to note that in all the evidence tables of all the AHRQ reports there are no studies that mention safety or specifically research patient safety in telehealth. Indirect evidence such as monitoring, prevention of acute care events or complications, testing the technology for comparison with in-person care, and outcomes research all allude to safety but do not address it specifically. It is clear that there is a gap in the literature and research evidence for telehealth specifically related to safety. However, telenurses and other health care professionals are continually struggling to increase the safety of their patients, increase the quality of health care, and decrease adverse events, although the evidence of the impact of these concepts is not apparent in the research.

The four themes that emerged upon review of the literature offer insight into the field of telehealth and the practice of telenursing. Although not noted or researched specifically, patient safety is an important part of the diagnosis, monitoring, outcomes, and technical tools used in telehealth practice.

Diagnosis and Teleconsultation

A great deal of research has been done on the use of telehealth for diagnosing disease. It has been shown that diagnosis of disease using telehealth is successful (Evidence Table 1). For example, Schwabb and colleagues[10] found that the remote interpretation and diagnosis with electrocardiogram results was just as good as interpretation in person. Additionally, telehealth has successfully been used as a tool for diagnosing acute leukemia.[11]

In addition to diagnosis, educational sessions for providers, as well as patient education and psychosocial counseling, have been researched. Telehealth has been shown to be a successful endeavor for education and counseling through two-way audio and video technology.[12–14] Providers of care also have seen great benefits from consultations through telehealth equipment. Similar to education and counseling, two-way audio and video technology has been researched and shown to be beneficial for consults between providers.[15] For instance, home health nurses may use telehealth equipment to consult with specialists, or physicians may consult with each other regarding a particular patient.

Monitoring and Surveillance

Compliance and adherence problems are among the many issues that are important to achieving patient safety. After a patient leaves a provider's office or a hospital, the patient is responsible for his or her own health care at home. Patients often do not follow a treatment plan as directed by a physician or provider due to several factors, including: miscommunication or faulty understanding of the treatment plan, lack of access to facilities needed for the treatment plan, and a complex treatment regimen that the patient cannot comprehend without additional guidance.[16] This can cause negative outcomes and creates safety issues for the patient. Therefore, inventive and efficient telehealth-based methods of caring for patients are increasingly being used to improve compliance or adherence to the prescribed regimen of care, as well as for symptom management. Telehealth is one strategy for monitoring and communicating with

patients beyond the acute care setting. It has also had an impact upon health care utilization rates for acute care services (such as decreasing visits to the Emergency Department) in studies with limited sample sizes, although large randomized trials have not yet been reported (Evidence Table 2).

Adding to the problem of adherence in patients is a lack of access to quality health care, specialists, or nurses. With the current trend in outpatient care management, monitoring, and surveillance of patients, additional nurses are needed for the increasing number of home care patients and the increasing acuity of illnesses in these patients.[17] Further, patients who live in rural areas or in medically underserved areas may not be receiving the expert care that is needed.[18, 19] Traveling far distances to a treatment facility, time lost from work for treatment, and other responsibilities also contribute to the compliance issue.

To meet the patients' needs, and with the additional burden on nursing because of the current nursing shortage, many home care agencies are looking for innovative ways to care for a large number of patients. Telehealth technology offers increased productivity for nurses by decreasing travel time to remote areas, thereby increasing the average daily census.[20] Especially in rural areas, where driving time to patients' homes can take up the majority of a nurse's day, new time-saving and patient safety initiatives are imperative, leading to further adoption of telehealth in home care. Audio and video technology can facilitate remote home health monitoring between patients and caregivers.[17, 20] Often, peripheral devices placed in patients' homes—such as thermometers, sphygmomanometers, and stethoscopes—are connected to the telehealth equipment so telenurses can monitor clinical signs remotely. Nurses are able to spend more time on direct patient care rather than indirect care, resulting in better use of their time and education. Hence, telehealth and telenursing address barriers to quality health care that are created by geographic location and costs associated with lost time.

Clinical and Health Services Outcomes

The majority of research completed on outcomes after implementing telehealth has been related to chronic conditions such as diabetes, congestive heart failure (CHF), and chronic obstructive pulmonary disease (COPD). Often, morbidity and mortality are measured outcomes for these patients, and telehealth use shows better outcomes in these areas (Evidence Table 3).

More specifically, telehealth technology has been shown to be a successful method of telehealth intervention, inducing communication that has helped patients' HbA1c levels to decrease, as well as offering assistance to traumatic brain injury patients in transitioning from the hospital to the community.[16, 21]

In addition to the more widely used telehealth technologies, there are a number of devices and applications with specific functionalities that are making a difference in patient health care and safety as related to health outcomes. Glucoboy and Digiscope are two examples of these new technologies. The former is a diabetic tool in a video game cartridge format. The cartridge is inserted into Nintendo's Game Boy and has been shown to help children with the management of type 1 diabetes mellitus.[22] The Digiscope is a telehealth technology that allows for screening of diabetic retinopathy in a primary care physician's office rather than under the specialized care of an ophthalmologist.[23] These telehealth technologies have been shown to be practical alternatives to traditional care.

Technical Issues

Telehealth technology differs in every situation and can range from telephone calls postoperatively to preventing diabetic complications in children by using a popular video game system, to live, interactive voice and video patient education, to downloadable data devices used by patients with data interpreted by telenurses. Studies report various technology approaches used by various types of providers in different settings with diverse disease entities (Evidence Table 4).

For instance, telephone technology has traditionally been used as a telehealth mechanism. While using a technology that is already in place in many patients' homes, this technology can be used to deliver important aspects of health care, including education,[21] psychosocial therapy,[16] and emotional support.

One of the most common technology configurations for telehealth applications uses two-way audio and video, or teleconferencing equipment. This technology allows patients and caregivers to communicate effectively, while allowing caregivers the benefit of seeing the patient. Other technologies can be incorporated into the main audio and video equipment to transmit specific health care data such as blood pressure and heart rate. These technologies makes telenursing possible because data to support patient safety in home care can be retrieved from home telehealth devices if proper terminology and data standards are employed.[24]

One innovative technology that has recently begun to be studied would allow patients to be monitored remotely with even less of a time burden placed on the nurse and the patient. Infrared technology offers perhaps the most continuous method of telehealth monitoring equipment. Infrared scanners have been shown to be effective in reporting deviations from a daily routine.[25] With this technology, the monitoring of elderly or dependent patients is done from a remote location; patients can be monitored at home, in a nursing home, or in the hospital. Safety of the patient can be assessed without the patient purposely getting in front of a camera or logging on to speak to a nurse.

Evidence-Based Practice Implications

The research related to telehealth and telenursing practice has shown great benefits related to diagnosis and consultations, monitoring and surveillance of patients, clinical and health services outcomes, and technology advancement. Each of these areas have important patient safety concerns, and while not studied as a unique entity, patient safety themes have emerged throughout the literature. Telehealth is a unique field that uses innovative technologies to improve patient care and thereby improve safety. These technologies range from the telephone to ubiquitous computing and only promise more in the future. Special concerns related to patient safety emerge with each of these methods of health care delivery.

Technologies have evolved to offer more and broader capability for telehealth/telenursing practice. With telehealth technologies, patient adherence to care increases, access to care is improved, providers can network with each other, and the safety of patients can be monitored more closely in homes and alternative living facilities.

With telephone-based telehealth, there is relatively no cost to the patient and no technical setup required for a telehealth interaction. Most patients already have a phone in the home that can be used for sessions. However, telephone discussions are usually limited to education and counseling because there are no visual cues for the provider/telenurse.

Two-way audio and video increases the functionality of telehealth by allowing the telenurse/health care provider to see the patient. In addition, peripheral monitoring devices can be used by the patient to transmit clinical information to the remote provider. More patient education is required initially for the use of the equipment with this type of technology, and the initial investment costs for the telehealth equipment can be large. Further, the patient must have Internet access or transmission lines to accommodate the video equipment.

Products such as the Glucoboy are innovative technologies that have been researched and shown to be effective in helping diabetic children maintain a healthy lifestyle.[22] The new product has taken a monotonous, sometimes painful task and made it into a game for children. However, the cost of this technology and who bears the cost remain to be seen.

Finally, infrared technology and sensor technology promise to deliver remote monitoring capabilities into the hands of providers. This has implications for caregivers and even family members of a person who lives at a distance. Falls, injuries, or illness will be easy to detect using such a system, offering immediate care to patients. However, the continuous monitoring nature of these devices may prove to be an infringement of patients' rights to privacy, and therefore an ethical issue for health care providers to consider.

With telehealth, confidentiality also remains a concern and must always be considered. While technology is becoming more sophisticated, telehealth sessions remain as a confidential interaction between a provider and a patient. Enclosed rooms without traffic or others present are imperative to maintain privacy. Health care providers need to be conscious of who is in attendance for the session and respect privacy and confidentiality of the patient. Further, as the numbers of new and innovative technologies emerge, researchers and developers must remember the security of patient information, regardless of how it is transmitted. In the researched technologies, data are transmitted over secure lines. However, new wireless technologies, increased use of e-mail by providers, and the continual threat of computer viruses increase the need for security and confidentiality of patient data to remain in the forefront of telehealth.

The different platforms for telehealth are diverse, yet all increase the ability of telenurses to communicate with and receive data about their patients. Regardless of the specific telehealth technology utilized, the reliability and validity of data transmission is essential to the safety of patients. Further, accepted and proven nursing practice must not be compromised. It is imperative for nurses to see the telehealth technology as a medium for care, and not a tool to replace high-quality nursing practice. Patient safety will be maintained with telenurses who are able to focus on patient care and not the technology itself.

Research Implications

The possibilities for telehealth technology abound, although pitfalls are also a potential. Telehealth has evolved throughout the years, from the first telephone interventions to the present-day use of sensors and remote monitoring devices. Much research has been completed on telehealth technology; however, it can be expanded upon exponentially—and should be expanded to include safety as a variable in all studies.

New wireless technologies have introduced new options for telehealth, which include nanotechnology and artificial intelligence.[26] Both of these offer great possibilities for diagnosis and treatment. However, researchers have only begun studying the potential of these technologies that offer promises for future health care.

In the shorter term, increasingly sensitive and accurate peripheral devices are needed for clinical monitoring. While the technologies currently exist, many can be improved upon to ensure valid clinical results. Peripheral device use can also be expanded. Ubiquitous computing is an option that will allow for clinical monitoring at home or in the community without being intrusive to the patient.[26] There is a greater chance of adherence in patients with this type of technology; however, research will need to be conducted to confirm the expectations.

Telehealth technologies will continue to evolve, as technology has in other business sectors. Health care needs to commit to this progress in order to provide up-to-date technology and safe devices for patients. The majority of studies that were reviewed compared telehealth care vs. in-person care and involved patient monitoring. Overall there were some positive outcomes indicating the benefits of telehealth. However, patient safety issues were not the main focus of these studies. Only one article was found that directly focused on safety issues: That article provided important information on the safety of wireless technologies; however, it was not a research article. Further, in a recent conference funded by the Agency for Healthcare Research and Quality, telehealth nursing experts were brought together to create a national agenda for telenursing research.[27] Themes for future research included cost effectiveness, clearly identified populations, standard outcomes, and standard methodologies to support telenursing. Specific research agenda topics identified were chronic disease management, patient empowerment, and enhanced self-care. While patient safety is a faction of all of these topics, it was not included specifically as a research agenda topic for telenursing. Therefore, the review of the current literature as well as decisions for future research goals indicate a gap of information and future direction regarding patient safety issues related to the use of telehealth in clinical practice.

Conclusion

The scarcity of research evidence focused primarily on patient safety in telehealth may in part be due to a lack of understanding about the emerging safety issues associated with telehealth and telenursing. The safety issues identified for telehealth and telenursing extend beyond the limited view of the precision of the information.[28] Telehealth encompasses a wide range of applications, including teleconsultations, telediagnosis, telepharmacy, e-health via the Web, telephone triage/telephone advice, tele-emergency support, disease management, and telehomecare. The safety issues associated with telehealth are, in turn, more complex and include not only apprehension about malfunctioning equipment, but also concerns regarding potential adverse effects on patient management decisions through delayed or missing information, misunderstood advice, or inaccurate findings due to patient or caregiver error.[29] Further research is clearly needed in the arena of patient safety as it is directly related to telehealth practice.

Search Strategy

The majority of research studies to date have focused upon teleradiology, telepathology, telepsychiatry, and other medical uses of telemedicine technology for medical care and diagnosis. These studies were purposely not included in this review. The purpose of this literature review was to focus upon the safety issues associated with care delivered by and relating to telenursing. The search strategy and distillation process of the literature consisted of three primary activities: (1) identification of meaningful MeSH® search terms and searching in

PubMed®, (2) an alternative process for locating articles, and (3) identification and validation of safety and quality related themes.

Identification of Meaningful MeSH® Search Terms and Searching in PubMed®

The U.S. National Library of Medicine developed MeSH®, a controlled vocabulary for indexing articles, which is located in the MEDLINE®/PubMed® databases. It took several iterations of MeSH® terminology to produce references that reflect the scope of safety and quality issues inherent in telehealth. For example, a search using the MeSH® terms "safety" and "telehealth" produced 12 articles, only 5 of which dealt specifically with monitoring equipment safety issues related to telehealth. Furthermore, the details of the MeSH search indicated that it could not find the term "telehealth" or "telemedicine" and instead suggested terms like "equipment safety" and "health care technology." A further search of the PubMed® database yielded zero results for "telehealth" and seven journal titles for the term "telemedicine."

Alternative Process for Locating Articles

Two of the seven journals identified through PubMed were *Journal of Telemedicine and Telecare* and *Telemedicine and e-Health.* Volumes of these journals were hand culled to locate any articles related to telehealth and its related safety concerns. As these articles were located, the reference list of each was also reviewed and relevant articles flagged for further searching. Additionally, professional organization sites such as the American Telemedicine Association and the Telehealth Information Exchange were searched to locate references to telehealth and safety.

Identification and Validation of Safety/Quality Themes

One author conducted the search and located all of the articles included in this review. A total of 41 articles were found to have some relevance to telehealth and safety. After an initial appraisal of the articles, they were examined for semantic similarities and differences. Four themes emerged among the 41 articles: (1) diagnosis and teleconsultations, (2) monitoring and surveillance, (3) clinical and health services outcomes, and (4) technical/ethical issues. The articles were then distributed among the authors, and the themes were validated. Where appropriate, articles were redistributed from their initial category to a more appropriate category. The included safety and quality topics are described in Table 1, below.

Table 1. Safety and Quality Topics as Related to Telehealth

Number of Articles	Category	Included Topics
2	Diagnosis and teleconsultation	The use of EKG leads in diagnosis and Web-based decision support in the care of leukemia patients.
11	Monitoring and surveillance	Adherence issues among patients using telehealth technologies to manage asthma, medication regimen, and CHF.
19	Clinical and health services outcomes	The use of telehealth applications and telenursing for managing CHF and diabetes at home. The use of telehealth technologies for consults such as dermatology, cardiology, intensive care, and emergency care/trauma.
19	Technical and ethical issues	Questions surrounding interoperability of equipment, algorithms for applying telehealth development, and issues in developing various technologies.

It became clear to the authors that issues such as measuring return on investment are often tied to clinical outcomes; thus these studies were included in the review. Additionally, articles that addressed disparities to access in health care and the potential benefits of telehealth are included, as these articles address the prevention of safety problems.

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Evidence Tables

Evidence Table 1. Diagnosis and Consultations Using Telehealth

Source	Safety Issue Related to Clinical Practice	Design Type	Study Design & Study Outcome Measure(s)	Study Setting & Study Population	Study Intervention	Key Finding(s)	Category of Telehealth Article O = Outcomes M = Monitoring D = Diagnosis/ Consultation T = Technical/ Ethical
Belachel 2005[11]	Web-based clinical decision support tool	Changing practice projects/ research	Observational study with controls (Level 3) Other measurable variables with an indirect or unestablished connection to the target safety outcome (Level 3)	191 Acute leukemia cases from the database of Cliniques Universitaires Saint-Luc Brussels, Belgium	Web-based clinical decision support tool to virtually diagnose and support secure and timely electronic data exchange regarding acute leukemia.	The percentage of correct classification in this experimental testing was consistent with the proposed prototype. 96.4% of acute leukemia cases were correctly classified, proving that Web integration can be a promising tool for dissemination of computerized decision support system tools. The system is robust and capable of deployment for referring physicians.	D

Source	Safety Issue Related to Clinical Practice	Design Type	Study Design & Study Outcome Measure(s)	Study Setting & Study Population	Study Intervention	Key Finding(s)	Category of Telehealth Article O = Outcomes M = Monitoring D = Diagnosis/ Consultation T = Technical/ Ethical
Schwaab 2005[10]	The study compared the accuracy of a 12-lead electrocardiogram (ECG) recorded by patients and transmitted to a cardiology call center via telephone (tele-ECG) with standard 12-lead ECGs.	Non-randomized trials	Nonrandomized control trials (Level 2) Surrogate outcomes (Level 2)	158 post myocardial infarction cardiac patients living at home with the capacity to communicate the tele-ECG via telephone.	Tele-ECGs were compared with standard ECGs by two cardiologists and one internist, independently and blindly.	In 155 of 158 patients (98%), the quality of the tele-electrocardiogram (tele-ECG) was adequate for diagnosis. Reliability coefficients ® for PQ, QRS, and QT intervals between tele- and standard ECG. Additionally, negative T-waves and ST segment detection was very good. Residual signs of myocardial infarction could be detected by tele-ECG, with very good agreement for anterior as well as for posterior localizations. The tele-ECG technique seems a promising approach to reducing pre- and in-hospital time delays to the initiation of thrombolytic therapy.	D

Evidence Table 2. Monitoring and Surveillance Related to Telehealth and Telenursing Practice

Source	Safety Issue Related to Clinical Practice	Design Type	Study Design & Study Outcome Measure(s)	Study Setting & Study Population	Study Intervention	Key Finding(s)	Category of Telehealth Article O = Outcomes M = Monitoring D = Diagnosis/ Consultation T = Technical/ Ethical
Chan 2003[30]	Test the use of an Internet-based store-and-forward video home telehealth system to manage asthma in children	Prospective cohort study	Observational studies with controls (Level 3) Surrogate outcomes (Level 2)	Pediatric patients ages 6–17 years with persistent asthma were recruited from among the population of patients with asthma in pediatric clinic at Tripler Army Base, Honolulu.	The use of an Internet-based store-and-forward video monitoring system for patients with asthma, and followup with virtual visits via the Internet in comparison to in-person office visits.	No overall change in quality of life reported by patients. However, the caregivers in the virtual followup group reported an increase in the patients' quality-of-life survey scores. Emergency department visits and hospital admissions for asthma were avoided. Rescue therapy was infrequent. A high rate of satisfaction with home telemonitoring was reported. Internet-based, store-and-forward video assessment of children's use of asthma medications and monitoring tools in their homes appeared effective and well accepted.	M

Source	Safety Issue Related to Clinical Practice	Design Type	Study Design & Study Outcome Measure(s)	Study Setting & Study Population	Study Intervention	Key Finding(s)	Category of Telehealth Article O = Outcomes M = Monitoring D = Diagnosis/ Consultation T = Technical/ Ethical
Fragou 2005[31]	Adherence to medication regimen	Randomized controlled trial	Randomized controlled trial (Level 1) Clinical outcomes (Level 3)	108 diagnosed schizophrenic outpatients, part of the South London and Maudsley NHS.	Telementoring using a new platform called @HOME, which offered clinicians early warnings about impending nonadherence as well as information about the pattern of medication taking.	In comparison to the other two groups, patients using @HOME showed improvement in the Global Clinical Impression Scale and a significant reduction in emergency visits and medical appointments.	M
Gilbert and Sutton 2006[32]	N/A	Randomized controlled trial (Level 1)	No outcome relevant to decreasing medical errors/ adverse events.	1,457 callers to Quitline (smoking cessation program) were randomly allocated to a control group to receive usual care or to a repeated contact group to be offered abstinence 6 & 12 months after recruitment, quit attempts and 24 hours of periods of abstinence in nonquitters.		Proactive telephone counseling did not significantly decrease abstinence from smoking rate.	M

Source	Safety Issue Related to Clinical Practice	Design Type	Study Design & Study Outcome Measure(s)	Study Setting & Study Population	Study Intervention	Key Finding(s)	Category of Telehealth Article O = Outcomes M = Monitoring D = Diagnosis/ Consultation T = Technical/ Ethical
Lamothe 2006[17]	Increased need for home care services	Non-comparative studies	Observational studies without controls (Level 4) No outcomes relevant to decreasing medical errors and/or adverse events (Level 4)	Patient homes in Quebec and Manitoba, Canada; patients with chronic illness.	Telehomecare monitoring, including disease measurements.	Positive impacts on patients and health crisis prevention.	M
Manfredi 2005[33]	N/A	Observations	No outcome relevant to decreasing medical errors/ adverse events	15 inmates were assess & treated in 37 consultations. Subjects were young white males.	Interactive two-way audio-video communication between the psychiatrists & inmates.	Services were readily accepted by inmates and staff. Telepsychiatric examinations & treatment appear to be a feasible method to increase access to mental health care in rural jails.	M
Marinella 2006[34]	Use of telemedicine to monitor patients and deliver care.	Observation, convenience sample	No outcome relevant to decreasing medical errors/ adverse events.	14 Spinal cord injury (SCI**)** patients at home after discharge from James Peteres VA Medical Center.	Monitoring patients for safety, home accessibility, exercise by messaging device or videophone on weekly basis.	Office visits increased, hospitalization and length of stay decreased. Poor reliability of monitoring device was identified as an obstacle.	M

Source	Safety Issue Related to Clinical Practice	Design Type	Study Design & Study Outcome Measure(s)	Study Setting & Study Population	Study Intervention	Key Finding(s)	Category of Telehealth Article O = Outcomes M = Monitoring D = Diagnosis/ Consultation T = Technical/ Ethical
Prince 2005[35]	Seniors will be able to safely age in place with use of telehealth	Literature reviews/ narrative	Design (Level 4) Outcomes: telehealth technology and services (Level 4)	Review of previous research and reports of safer and longer aging in place for seniors when using telehealth technology and services.	Telehealth can delay nursing home care, support aging in place at home, and provide in-home monitoring and health care services.	Telehealth has been successfully used in hospital specialty areas to provide health care services. Research points to benefit of seniors use of telehealth in a systematic fashion to acquire services and information so they may age in place in their homes safely and with a good quality of life.	M
Rogers 2001[36]		Randomized controlled trial (Level 1)		121 adults with essential hypertension.	A home service consisting of automatic transmission of blood pressure data over telephone lines, computerized conversion of the info into report forms, & weekly transmission of the report forms to physicians and patients.	Telecommunication service was efficacious in reducing the mean arterial pressure of patients with established essential hypertension.	M

Source	Safety Issue Related to Clinical Practice	Design Type	Study Design & Study Outcome Measure(s)	Study Setting & Study Population	Study Intervention	Key Finding(s)	Category of Telehealth Article O = Outcomes M = Monitoring D = Diagnosis/ Consultation T = Technical/ Ethical
Rotondi 2005[37]	Descriptive study of provision of Web -based support services/ information to families of patients with traumatic brain injury (TBI) to improve their patient outcomes, to include safety	Nonrandomized trial	Observational study without controls (Level 4) Self-reports of satisfaction and Web utilization (Level 3)	17 female caregivers of patients with TBI were provided access to Web site for support/services from home.	Study evaluated use of WeCare Web site for information, answers to questions, and support group with other caregivers for those with TBI.	Caregivers used support group as the most frequent function on the Web site. There is strong correlation between caregiver capability and patient outcomes for TBI patients, to include safety outcomes of TBI patients who may have gait or motion dysfunction as a result of their injury.	M
Savard 2003[38]	No outcome relevant to decreasing errors/ adverse events	Case observations, two rehabilitation centers, convenience sample	No outcome relevant to decreasing medical errors/ adverse events.	117 teleconferences with 75 patients ages 9m–-86 yrs. (38 of the visit were with neurological diagnoses.)	High-speed video conferencing with real-time audio-video communication.	Care of individuals with neurological issues can be supported.	M
Smith 2006[14]	Adherence with sleep apnea treatment—Continuous Positive Airway Pressure (CPAP)	Randomized controlled trial	Randomized controlled trial (Level 1) Surrogate outcomes (Level 2)	In-home patients with nonadherence to CPAP regimen.	Telehealth educational sessions.	Increased use of CPAP in the group with the telehealth education sessions regarding CPAP.	M

Source	Safety Issue Related to Clinical Practice	Design Type	Study Design & Study Outcome Measure(s)	Study Setting & Study Population	Study Intervention	Key Finding(s)	Category of Telehealth Article O = Outcomes M = Monitoring D = Diagnosis/ Consultation T = Technical/ Ethical
Wang 2005[39]	A feasibility study on an Internet-based compliance system to provide personalized care for patients suffering from chronic diseases.	Changing practice project/research	Observational studies with controls (Level 3) Other measurable variables with an indirect or unestablished connection to the target.	The study monitored the chronic disease management of oral anticoagulation treatment in Spain, asthma care in the United Kingdom, and morbid obesity care in Greece in 25 patients residing at home with access to a personal computer and an Internet connection.	The C-Monitor System consisting of an integrated service aimed at monitoring patients' adherence to therapy at home via the Internet.	Health care providers credited the C-Monitor in helping with the adherence in disease management as determined by the system's ability to create personalized therapeutic schemes, provide an efficient communication channel between providers and patients, and offer satisfactory monitoring of patients' adherence with treatment and their physical status. The performance of the system was assessed by all participants. Most of the patients and physicians agreed that C-Monitor system provided a more valuable service than the traditional ambulatory system and would like to use the C-Monitor service in the future for disease management. Suggestions for improvement of the system were offered by both types of participants.	M

Evidence Table 3. Outcomes Related to Telehealth and Telenursing Practice

Source	Safety Issue Related to Clinical Practice	Design Type	Study Design & Study Outcome Measure(s)	Study Setting & Study Population	Study Intervention	Key Finding(s)	Category of Telehealth Article O = Outcomes M = Monitoring D = Diagnosis/ Consultation T = Technical/ Ethical
Adkins 2006[16]	Type 1 diabetes adherence	Pre- and post-test	Observational studies without controls (Level 4) Surrogate outcomes (Level 2)	In patients' home: patients ages 7–18, elevated HbA1c levels and/ or DKA within the last year.	Telephone therapist intervention.	HbA1c levels decreased for patients when they received the telephone intervention.	O
Bunn 2005[40]	The effects of telephone consultation and triage on safety, service use, and patient satisfaction was examined.	Systematic literature review	Randomized controlled trials (Level 1A) Clinical outcomes: morbidity, mortality, adverse events (Level 1)	The researchers reviewed randomized controlled trials, controlled studies, controlled before/after studies, and interrupted time series of telephone consultation or triage in a general health care setting; however, the majority of studies were in primary care.	The researchers searched registers such as the National Research Register, Cochrane Central Register of Controlled Trials and searched databases like PubMed, EMBASE, CINAHL, SIGLE. A list of identified studies and review articles was produced and verified by two independent reviewers.	The findings are mixed. There was inconclusive evidence about the frequency of return visits to general practitioners (GPs) and in the reporting of accident and emergency department (ED) visits. Although telephone consultation appears to have the potential to reduce unnecessary visits to the GP or ED, questions remain about its effect on service use. Further rigorous evaluation is needed with emphasis on service use, safety, cost, and patient satisfaction.	O

Source	Safety Issue Related to Clinical Practice	Design Type	Study Design & Study Outcome Measure(s)	Study Setting & Study Population	Study Intervention	Key Finding(s)	Category of Telehealth Article O = Outcomes M = Monitoring D = Diagnosis/ Consultation T = Technical/ Ethical
Dale 2004[41]	The safety of nurses and paramedics offering telephone assessment, triage, and advice as an alternative to immediate ambulance dispatch for emergency ambulance service callers with "nonserious" problems was examined.	Randomized controlled trial	Randomized controlled trial (Level 1) Clinical outcomes (Level 1)	635 patients treated by ambulance services in London and the West Midlands, UK, were the subjects. A multidisciplinary expert clinical panel reviewed data from various ambulance and ED records and call transcripts for patients triaged by nurses and paramedics. Calls were placed into categories that indicated if the dispatch of an ambulance was necessary or not. All cases for which one or more members of the panel rated that an emergency ambulance should have been dispatched were further re-reviewed for an assessment of the "life risk" that might have resulted.	The intervention comprised nurse or paramedic telephone consultation using a computerized decision support system to assess, triage, and advise patients whose calls to the emergency ambulance service had been classified as "nonserious."	From the 239 usable cases, in 237 cases the majority of the panel concurred with the nurses' or paramedics' triage decision. Telephone advice may be a safe method of managing nonemergency (category C) calls. Further study is needed to exclude the possibility of rare adverse events.	O

Source	Safety Issue Related to Clinical Practice	Design Type	Study Design & Study Outcome Measure(s)	Study Setting & Study Population	Study Intervention	Key Finding(s)	Category of Telehealth Article O = Outcomes M = Monitoring D = Diagnosis/ Consultation T = Technical/ Ethical
Dang 2006[42]	Care coordination using telehealth reduces hospitalizations, thereby reducing exposure to medical errors	Pre- and poststudy	Design (Level 2) Outcomes (Level 3)	59 chronically ill VA patients. Outcomes were hospital admissions, bed days of care, number of emergency room visits, number of outpatient visits.	Telecare management via an Internet-based home messaging device and whether it can impact health care utilization rates.	Significant reduction in hospital admission and number of emergency room visits occurred pre- to post-6 months with use of telehealth care management. Significant reductions in acute care utilization rates among chronically ill patients imply a reduction in medical error rates since exposure to acute care is less.	O

Source	Safety Issue Related to Clinical Practice	Design Type	Study Design & Study Outcome Measure(s)	Study Setting & Study Population	Study Intervention	Key Finding(s)	Category of Telehealth Article O = Outcomes M = Monitoring D = Diagnosis/ Consultation T = Technical/ Ethical
Finkelstein 2006[43]	A study that examined patient outcomes and cost when home health care was delivered by telemedicine or by traditional means for patients receiving skilled nursing care at home.	Randomized clinical trial	Randomized controlled trial (Level 1) Clinical outcomes (Level 1)	53 rural Minnesotans participated. Candidates for TeleHomeCare had to be (1) eligible to receive skilled home nursing care for either congestive heart failure (CHF), chronic obstructive pulmonary disorder (COPD), or chronic wound care; (2) able to use the equipment or have a supportive care partner who could do so; (3) live in a technically functional home environment.	There were two separate interventions with two intervention groups. In group a, video intervention and traditional skilled nursing care at home was used, and the second group received traditional skilled nursing care at home, virtual visits using video-conferencing technology, and physiologic monitoring.	There was no difference in mortality between the groups. Morbidity, as evaluated by changes in the knowledge, behavior, and status scales of the Omaha Assessment Tool, showed no differences between groups except for increased scores for activities of daily living at study discharge among the intervention groups. The average visit costs were $48.27 for face-to-face home visits, $22.11 for average virtual visits (video group) and $32.06 and $38.62 for average monitoring group visits for CHF and COPD subjects, respectively. The findings showed that virtual visits between a skilled home health care nurse and chronically ill patients at home can improve patient outcome at lower cost than traditional skilled face-to-face home health care visits.	O

Source	Safety Issue Related to Clinical Practice	Design Type	Study Design & Study Outcome Measure(s)	Study Setting & Study Population	Study Intervention	Key Finding(s)	Category of Telehealth Article O = Outcomes M = Monitoring D = Diagnosis/ Consultation T = Technical/ Ethical
Grady and Melcer 2005[44]	N/A	Retrospective record review. Non-randomized trials	No outcome relevant to decreasing medical errors/ adverse events	Service members & their adult family members of National Naval Medical Center.	Telemental health care via video-conferencing vs. care provided in person.	Telemental health care improved adherence, & shorter times to next followup appointment.	O
Grigsby 2005[45]	A meta-analysis of the home telehealth literature using a systematic application of a health services research (HSR) method for assessing the impact of telemedicine on access, quality, and cost of care.	Meta-analysis	Randomized controlled trial (Level 1A)	The criteria for inclusion included the use of telemedicine as a substitute for home visits by nurses and the use of information technology in the management of chronic conditions in the home environment.	A comprehensive model for the evaluation of telemedicine based on an applied research matrix consisting of: cost of care, quality of care, and access to care as used in HSR.	Despite its limited use in telemedicine, the scope of HSR is broader than that of clinical trials, with a focus on the system of care; its acceptance by the users; and outcomes, costs, and access. The methods of HSR provide a valuable analytical framework for the assessment of telemedicine and to discern the real merit of telemedicine.	O

Source	Safety Issue Related to Clinical Practice	Design Type	Study Design & Study Outcome Measure(s)	Study Setting & Study Population	Study Intervention	Key Finding(s)	Category of Telehealth Article O = Outcomes M = Monitoring D = Diagnosis/ Consultation T = Technical/ Ethical
Heizelman 2005[46]	Comprehensive review and synthesis of the literature concerning clinical outcomes associated with various telemedicine applications.	Systematic literature review	Randomized controlled trials (Level 1A)	Inclusion criteria were based on Donabedian's Medical Care process as defined by clinical care processes (diagnosis, clinical management, and clinical outcomes) and user satisfaction.	Key terms were used in searching the PubMed Web site to identify published studies in peer-reviewed journals that focused on the care process and outcome in telemedicine. Inclusion criteria included (1) published between 1996 and February 2004, (2) contained an abstract, (3) had a control group, and (4) not limited to voice communication only.	There were 356 articles analyzed. 160 studies related to diagnosis, 61 studies related to clinical management and clinical outcomes, and 168 studies dealt with user satis-faction. Most clinical outcomes studies to date have focused on diagnosis and patient satisfaction. A few studies investigated telemedicine's effects on clinical management or patient-oriented clinical outcomes. Diagnostic accuracy seems to be well documented in radiology, dermatology, pathology, and ECG interpretation. Psychiatric diagnosis is promising, but study sizes have been small, and ophthalmology diagnostics require further study. The most evidence for outcome and management appears to be with home/institution-based applications for CHF, diabetes, and blood pressure monitoring. Among clinic- or hospital-based applications, the fields of dermatology, cardiology (i.e., echocardio-graphy), and intensive care and emergency care/trauma have stronger evidence for their benefit. Overall user satisfaction is well demon-strated, especially in the areas of psychiatry, dermatology, and other multispecialty applications.	O

Source	Safety Issue Related to Clinical Practice	Design Type	Study Design & Study Outcome Measure(s)	Study Setting & Study Population	Study Intervention	Key Finding(s)	Category of Telehealth Article O = Outcomes M = Monitoring D = Diagnosis/ Consultation T = Technical/ Ethical
Henault 2002[47]	Communication between care-givers for long-term diabetes management	Case control studies	Nonrandomized controlled trial (Level 2) Surrogate outcomes (Level 2)	VA Boston Healthcare System, male diabetic patients with elevated HbA1c levels.	Using e-mail for communication of recommendations from pharmacist to primary care provider.	Intervention and control groups both had a decrease in HbA1c levels.	O
Hilty 2004[48]	Telepsychiatry clinical and educational videoconferencing applications are equal to or better than in-person and also reduce health care utilization	Meta-analysis	Design (Levels 1 thru 4) Outcomes (Level 3)	Review of telepsychiatry studies from January 1, 1965, to July 31, 2003, containing the terms videoconferencing, telepsychiatry, telemedicine, effectiveness, efficacy, access, outcomes, satisfaction, quality of care, education, empowerment, costs.	All 110 telepsychiatry studies that mentioned videoconferencing were reviewed.	Telepsychiatry is effective and has been successfully used to increase access to care, provide patient and provider satisfaction in general, improve outcomes of care, and empower those using it. Further research on impact on patient outcomes is needed. Reduced hospitalizations and decreased use of acute services are two key findings that point to impact on hospital-based medical errors.	O
Hopp 2006[49]	Clinical outcomes with telehealth use; research for evidence-based practice	Randomized controlled trial	Randomized controlled trials (Level 1) No outcomes relevant to decreasing medical errors and/or adverse events (Level 4)	Veterans Affairs Center home care patients.	Interactive telehealth with voice and video and some peripheral attachments for home care patients.	High level of patient satisfaction and health-related quality of life (HRQOL) scores; trend toward decreased outpatient health visits with the intervention group.	O

Source	Safety Issue Related to Clinical Practice	Design Type	Study Design & Study Outcome Measure(s)	Study Setting & Study Population	Study Intervention	Key Finding(s)	Category of Telehealth Article O = Outcomes M = Monitoring D = Diagnosis/ Consultation T = Technical/ Ethical
James 2001[12]	Obesity in the military, difficulty in long-term program sustainability	Non-randomized trials	Non-randomized controlled trial (Level 2) Clinical outcomes (Level 1)	48 U.S. Navy and Army personnel in Hawaii, with a body mass index of at least 27.	Obesity treatment program through telehealth.	Successful weight management with the use of telehealth.	O

Source	Safety Issue Related to Clinical Practice	Design Type	Study Design & Study Outcome Measure(s)	Study Setting & Study Population	Study Intervention	Key Finding(s)	Category of Telehealth Article O = Outcomes M = Monitoring D = Diagnosis/ Consultation T = Technical/ Ethical
Joseph 2006[50]	The Veterans Health Administration (VHA) evaluated a care coordination program for diabetic, CHF, COPD, and mental health chronically ill patients using technology to promote self-management.	Changing practice projects/ research	Observational studies with controls (Level 3) Surrogate outcomes (Level 2)	Enrollment in the program began by identifying patients with frequent ED visits or frequent admissions. Additionally, patients with hemoglobin A1c greater than 10 were identified. Following identification, collaboration from the primary care provider was obtained and the patient contacted to request their involvement in the program. Patient had to have a standard plain old telephone system (POTS), electrical service to the house, and be agreeable to monitor and transmit data daily.	Patients were asked to answer a series of questions about their health status and habits using a digital messaging unit placed on their phone line. In some instances ancillary monitoring devices (i.e., glucometers) were directly connected to the messaging device or the patient entered the results information. This information was transmitted to the care coordinator, who would note abnormalities and contact the physician and monitor the patient closely for followup care.	Defined clinical and utilization outcomes were defined and compared to the findings for ED visits and bed days (utilization) and hemoglobin A1c measurement for all diabetic patients, low density lipoproteins (LDL) levels on patients followed for hypertension, diabetes, and CHF (clinical). There were no statistically significant findings; however, care coordination efforts have demonstrated improved glycemic control for diabetic patients, improved lipid management, and decreased use of costly resources, such as ED visits and hospitalizations. The authors concluded that substantial gains in both clinical and resource outcomes have been shown.	O

Source	Safety Issue Related to Clinical Practice	Design Type	Study Design & Study Outcome Measure(s)	Study Setting & Study Population	Study Intervention	Key Finding(s)	Category of Telehealth Article O = Outcomes M = Monitoring D = Diagnosis/ Consultation T = Technical/ Ethical
LaFraboise 2003[51]	A pilot study to determine the feasibility of providing a heart failure disease management program through an in-home communication device, Health Buddy.	Randomized clinical trial	Randomized controlled trials (Level 1) Clinical outcomes (Level 1)	90 home care patients capable of living independently who had been discharged from the hospital within 6 months with a primary diagnosis of heart failure.	The intervention, a telecommunication device named Health Buddy, was compared with traditional methods for home management of heart failure, including in-person visits and telephonic case management.	Confidence in managing disease, quality of life index, functional status, and depression were measured in each of the clinical trial groups. Patients who received telephonic case management experienced decreased confidence in managing their disease; all other groups experienced increased confidence. Functional status, depression, and quality of life did not differ among the groups. The findings suggest that using telehealth to manage home care for heart failure is feasible; however, further study is needed to determine differences that might exist between various treatment methods.	O

Source	Safety Issue Related to Clinical Practice	Design Type	Study Design & Study Outcome Measure(s)	Study Setting & Study Population	Study Intervention	Key Finding(s)	Category of Telehealth Article O = Outcomes M = Monitoring D = Diagnosis/ Consultation T = Technical/ Ethical
McCue and Palsbo 2006[52]	A demonstration of the business case for telemedicine in nonrural areas was shown. The study differed from earlier investigations in that return on investment did not include the variables of provider or patient travel time.	Changing practice project/ research	Observational studies with controls (Level 3) Other measurable variables with an indirect or unestablished connection to the target safety outcome (Level 3)	The case study of poststroke rehabilitation in urban settings in Oklahoma.	Interactive spreadsheet was used to conduct multiple financial analyses under different capital investment, revenue, and expenses for poststroke rehabilitation services to urban patients, including five speech-language pathology (SLP) provided to poststroke patients over videophones or videoconferencing equipment and two physical therapy (PT) codes (individual activities and physical therapy evaluation).	The outcome measures were financial breakeven points and internal rate of return. It was found that a Total of 340 telemedicine visits has the potential to generate a positive net cash flow each year. By the fourth year, this type of service can produce a positive present value return of more than $2,000, and earn rate of return of 20%, which exceeds the hospital's cost of capital. Thus business case was demonstrated. Urban telemedicine programs can be financially self-sustaining without accounting for reductions in travel time by providers or patients.	O

Source	Safety Issue Related to Clinical Practice	Design Type	Study Design & Study Outcome Measure(s)	Study Setting & Study Population	Study Intervention	Key Finding(s)	Category of Telehealth Article O = Outcomes M = Monitoring D = Diagnosis/ Consultation T = Technical/ Ethical
Reardon 2005[53]	A comprehensive review of telemedicine cost research and major issues affecting the yield from this research.	Systematic literature review	Randomized controlled trials (Level 1A)	The criteria for inclusion included studies with major analytic components of health care services cost evaluations, cost analysis decision framework, and methods of inference that affect the quality and productivity of telemedicine cost research.	Keywords evolved from first considering previous studies and then using keyword and database selection strategies to augment the literature. This approach is referred to as iterative triangulation. These terms were used to create a database of keywords, which resulted in overlapping sets of literature. The database of resulting articles consisted of 1,430 telemedicine articles. Sources for the studies were varied and included the NLM Database, CINAHL, Journal of Economic Literature, and AHRQ.	This review supports previous conclusions on the potential net savings to society through specific uses of telemedicine. Most specifically populations in remote areas, in prisons, or on ships may have reduced total cost of care by accessing it through telemedicine. However, these specific reported gains in the cost effectiveness of telemedicine depend on the reduced cost of access to care. Specifically, the greatest potential for cost savings from telemedicine seems to be the production of health or wellness. When study outcomes are measured as health maintenance or wellness, as is usually done in home care, potential savings, especially for high-risk chronically ill patients, are seemingly greater. The review also concludes that the productivity of telemedicine cost studies suffers from an underutilization of appropriate program evaluation and economic methods. Better consensus guidelines and best practices on costs can provide common benefits to cost research and are needed to accurately	O

Source	Safety Issue Related to Clinical Practice	Design Type	Study Design & Study Outcome Measure(s)	Study Setting & Study Population	Study Intervention	Key Finding(s)	Category of Telehealth Article O = Outcomes M = Monitoring D = Diagnosis/ Consultation T = Technical/ Ethical
Slater 2005[22]	Type 1 diabetes noncompliance	Pre- and post-test	Observational studies without controls (Level 4) Surrogate outcomes (Level 2)	In the community, children with type 1 diabetes and their parents.	Use of Glucoboy device for monitoring blood sugar levels.	Testing adherence increased by 200%; HbA1c levels were lowered.	O
Wu 2005[54]	This pilot study evaluated the feasibility and patients' acceptability of using the Internet to communicate with patients with symptomatic heart failure.	Changing practice projects/ research	Observational study with controls (Level 3) Surrogate outcomes: observed error, intermediate outcomes (e.g., laboratory results) (Level 2)	62 home care patients with symptomatic heart failure were enrolled into the program and instructed how to use the Internet communication tool.	The study measured the proportion of patients who used the system regularly for at least 3 months and the safety and maintainability of the tool. Additionally, researchers conducted a content analysis of patient and clinician messages.	The majority of the patients quit using the system; however, 45% of the patients used the system and continued to use it on average for 1.5 years. In a 3-month time period there were over 5,000 entries made by patients. The content analysis of a subset of the patient comments revealed the following major categories of communication: patient information, patient symptoms, patient questions regarding their condition, patient coordinating own care, social responses. The study concluded that an Internet tool is a feasible and safe method of communication in a substantial proportion of patients with heart failure.	O

Evidence Table 4. Technical and Ethical Issues Related to Telehealth/Telenursing

Source	Safety Issue Related to Clinical Practice	Design Type	Study Design & Study Outcome Measure(s)	Study Setting & Study Population	Study Intervention	Key Finding(s)	Category of Telehealth Article O = Outcomes M = Monitoring D = Diagnosis/ Consultation T = Technical/ Ethical
Bell 2004[21]	Traumatic brain injury (TBI) patients and their transition to the community	Changing practice projects/ research	Observational studies without controls (Level 4) No outcomes relevant to decreasing medical errors and/or adverse events (Level 4)	Patients' homes, TBI patients discharged from University of Washington Medicine.	Telephone followup program.	Telephone support is a feasible means for followup of TBI patients in the community.	T
Boye 2006[55]	Risk to patients from use of wireless devices.	Literature review	Possible outcome relevant to adverse events (Level 5)	Review of sources of electromagnetic interferences in hospitals.	A description of wireless communication devices used in the hospitals and the industry standards.	Wireless technologies are deemed suitable for use throughout hospital areas, including ICUs & ORs, given that recommended separation distances from medical devices are observed.	T
Britt 2006[15]	Access to specialist care for high-risk pregnancies	Pretest and post-test	Observational studies without controls (Level 4) Other measurable variables with an indirect or unestablished connection to the target safety outcome	Across the State of Arkansas, high-risk pregnancy patients.	Using the ANGELS telehealth program to facilitate care and provider consultations.	An increase in telemedical and telephone consultations. A slight decrease in transports to the high-risk clinic, with a decrease in the length of stay for patients.	T

Source	Safety Issue Related to Clinical Practice	Design Type	Study Design & Study Outcome Measure(s)	Study Setting & Study Population	Study Intervention	Key Finding(s)	Category of Telehealth Article O = Outcomes M = Monitoring D = Diagnosis/ Consultation T = Technical/ Ethical
Dansky and Ajello 2005[56]	The strategic objectives and marketing strategies for telehealth	Non-comparative studies	Observational studies without controls (Level 4) No outcomes relevant to decreasing medical errors and/or adverse events	29 home health agencies of a Midatlantic State, person at the organization responsible for implementing telehealth.	Qualitative interviews were conducted to discover the reasons for telehealth adoption and the marketing strategies.	Clinical excellence and cost containment were the main reasons for adopting telehealth. Marketing strategies were broad, but included brochures, articles, Web site content, and fact sheets.	T
Ferrante 2005[26]	Wireless capabilities available to telemedicine for patient care	Literature reviews, non-systematic/ narrative	Observational studies without controls (Level 4) No outcomes relevant to decreasing medical errors and/or adverse events (Level 4)		Literature review of current and future technology applications for medicine.	Many applications of new technologies exist for telemedicine.	T
Frey 2005[20]	Nursing shortage having an effect on home health agencies and their patients	Changing practice projects/ research	Observational studies with controls (Level 3) No outcomes relevant to decreasing medical errors and/or adverse events (Level 4)	Home health agencies of a Midatlantic State.	Use of telehealth for home health agency visits vs. traditional visits.	Average daily census of patients seen was increased.	T

Source	Safety Issue Related to Clinical Practice	Design Type	Study Design & Study Outcome Measure(s)	Study Setting & Study Population	Study Intervention	Key Finding(s)	Category of Telehealth Article O = Outcomes M = Monitoring D = Diagnosis/ Consultation T = Technical/ Ethical
Ganguly 2005[57]	The development methodology for interoperable telemedicine systems	Changing practice projects/ research	Observational studies without controls (Level 4) No outcomes relevant to decreasing medical errors and/or adverse events (Level 4)	School of Computer Science and Engineering, The University of New South Wales, Kensington, NSW 2052, Australia.	Development of an ontology-driven, multiagent system for diabetic treatment using diabetes ontology and agent system called Foundations of Intelligent Physical Agents (FIPA) standard-based ontology development.	Yet untested design that focuses on a FIPA-compliant model for interoperable telehealth technologies.	T
Keeys 2002[58]	Overnight pharmacist access in an acute care facility	Quality improvement projects/ research	Observational studies without controls (Level 4) Other measurable variables with an indirect or nonestablished connection to the target safety outcome (Level 3)	A 340-bed acute care community hospital, hospital staff.	Enhancing current after-hours pharmacy on-call coverage with a telepharmacy group.	Successful quality improvement.	T

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Masucci 2006[59]	Descriptive study of patients without computer experience and whether they were able to safely and effectively use telemedicine technology	Non-randomized trial	Observational study (Level 4) Self-reports (Level 3)	44 subjects with little/no computer experience and with hypertension, diabetes, and other cardiovascular risk factors were provided telemedicine systems.	Patients with no or limited computer experience were given a 2-hour class in use of the telemedicine technology system.	Patients utilized the system accurately and safely using IDs and passwords. Prior access to computers and prior computer experience was not a predictor of use of telemedicine systems. Having access to telemedicine systems may reduce risk for cardiovascular disease.	T
McConnochie 2006[18]	Social and economic burden of childhood illness/access to health care	Randomized controlled trial	Randomized controlled trials (Level 1) Surrogate outcomes (Level 2)	University of Rochester Medical Center primary care practice or pediatric ED, pediatric patients.	Three models of telemedicine: basic, simple, and extended.	Approximately 85% of visits offered successful telemedicine intervention.	T

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Miller 2006[60]	The use of telehealth technology in home health care for adult persons with developmental disabilities was examined, and algorithm for delivering telehealth services to developmentally disabled persons developed.	Changing practice projects/ research	Observational study without controls (Level 4) No outcomes relevant to decreasing medical errors and/or adverse events (Level 4)	The researchers examined the utilization of telehealth needed by multidisciplinary clinicians, including physicians, nurses, physical therapist, occupational therapist, and speech language pathologists, etc., to meet the health care needs of rural adults with developmental disabilities.	Following an examination of the utilization of services, the authors developed an algorithm for telehomecare for adults with disabilities.	A practice-based algorithm and model for telehealth care delivery to meet the needs of rural adults with developmental disabilities was developed. The unique consideration regarding the need to determine the risk-management needs for using telehealth technologies with this population is also described.	T
Seren 2005[61]	Postoperative nasal airflow pattern detection for the prevention of hospital visits	Case control studies	Nonrandomized controlled trial (Level 2) Other measurable variables with an indirect or nonestablished connection to the target safety outcome (Level 3)	In-home, 27 patients post septoplasty.	Use of Web technology, Web Add, and Odiosoft-rhino programs to record and transmit sound from nasal passages.	Significant difference in the sounds transmitted between the group with nasal blockage and those without nasal blockage.	T

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Suzuki 2006[25]	Daily health monitoring of elderly	Non-comparative studies	Observational studies without controls (Level 4) Other measurable variables with an indirect or unestablished connection to the target safety outcome (Level 3)	Nursing home, three elderly patients.	Use of infrared scanner sensor output in nursing home patients' rooms, as compared with the reported activities of the patients.	The sensors were able to identify the reported patterns of activity.	T
Tang 2006[62]	Medical errors related to usability and interface design	Quality improvement projects/ research	Observational studies without controls (Level 4) Other measurable variables with an indirect or nonestablished connection to the target safety outcome	Digital emergency medical system interface prototypes.	Heuristic evaluation of interface usability.	Heuristic evaluation serves as a useful technique in designing user interfaces.	T
Thomas 2004[13]	Improved education for surgical patients	Quality improvement projects/research	Observational studies without controls (Level 4) No outcomes relevant to decreasing medical errors and/or adverse events (Level 4)	University of Kentucky Chandler Medical Center/ Kentucky Telehealth Network locations Patients undergoing joint surgery	Use of telehealth for preoperative education in addition to the conventional method of education.	Patient satisfaction was positive with the use of the telehealth model.	T

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Wei 2006[19]	Access to experienced ophthalmo-logists	Changing practice projects/ research	Observational studies without controls (Level 4) Other measurable variables with an indirect or unestablished connection to the target safety outcome (Level 3)	Los Angeles County Department of Health Services, high-risk diabetic patients.	Use of Web-based telemedicine system.	Web-based architecture successful in capturing and transmitting images.	T
Whited 2005[63]	Access to routine eye examinations for diabetics	Quality improvement projects/ research	Observational studies with controls (Level 3) Other measurable variables with an indirect or unestablished connection to the target safety outcome (Level 3)	Indian Health Service, Department of Veterans Affairs, and Department of Defense, diabetic patients.	Monte Carlo simulation, modeling the use of the Joslin Vision Network telehealth model vs. conventional clinic-based ophthalmoscopy.	The Joslin Vision Network is less costly and more effective in detecting diabetic retinopathy than conventional clinic-based methods.	T

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Yoon 2005[64]	The accuracy of a single finger probe using photoplethysm-ography (PPG) was tested as a digital monitoring device for hematocrit, SPO2, respiration, pulse, and blood pressure	Changing practice/ research	Observational studies with controls (Level 3) No outcomes relevant to decreasing medical errors and/or adverse events (Level 4)	Sample size varied for each type of measurement. Hematocrit testing was performed on 549 patients at Samsung Hospital, Seoul, South Korea. Five healthy adults were used to test the predictive power of the PPG waves for the other parameters.	A palm-sized digital health monitor used a finger probe and a light emitting diode (LED) array. The light was measured to obtain PPG signals. Hematocrit, pulse, respiration rate, and saturated oxygen in arterial blood (SpO2) were measured and predictive algorithms developed to measure the clinical accuracy of the PPG diagnostics.	The accuracies were within clinically acceptable errors. This work showed that the method and algorithm for multiple physiological signal measurement based on a single LED sensor are valid.	T
Zimmer-Galler and Zeimer 2006[23]	Adherence in retinopathy screening and treatment	Retro-spective cohort study	Observational studies without controls (Level 4) Other measureable variables with an indirect or unestablished connection to the target safety outcome (Level 3)	Primary care practices throughout 7 States and the District of Columbia. Diabetic patients who are not receiving recommended eye examinations.	Use of DigiScope imaging.	DigiScope implementation is shown to be a practical alternative for patients not receiving routine eye examinations	T