Telepharmacy and Access to Pharmaceutical Services in Rural Areas

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Abstract

Access to pharmaceutical services in rural areas has been affected by a national shortage of pharmacists. Telepharmacy, a subspecialty of telemedicine, has involved the utilization of telecommunications to deliver pharmaceutical services to consumers located at a distance. The number of telepharmacy programs in the United States and worldwide has been progressively increasing. The purpose of this research project was to examine the effect of the utilization of telepharmacy on rural hospitals' access to pharmaceutical services. The methodology of this qualitative study was a literature review. Four electronic databases were employed to retrieve peer-reviewed journal articles, and three websites were accessed for pertinent information. Sixy-six articles were utilized as references. The findings demonstrate that telepharmacy networks have provided some benefits through which pharmaceutical access to rural areas has been enhanced. Networks have hastened medication order entry and order processing, increased on-call consultations and after-hours orders, and reconciled medications. Various states have reported promising results after implementing these networks. Moreover, networks have also permitted thorough checking of orders in both urban and rural pharmacies, thereby limiting medication errors. Overall, telepharmacy has had a positive effect on access to pharmaceutical services in rural areas. Such networks could diminish the problem of rural pharmacist understaffing, especially after hours and during vacations. Telepharmacy could also aid in reducing medication errors, which have increased as a result of the inability to recruit and retain pharmacists in rural areas. Telepharmacy should be utilized as a tool to maintain the pharmacist-consumer relationship.

Keywords: access, hospital, medication error, regulations, rural, telepharmacy

Introduction

Technology plays a significant role in the lives of people all over the world and has improved access to medical care in rural areas.[1] Telemedicine has been defined as medical or other health services given to a patient via a communication system, such as a computer, phone, or television, by a healthcare provider who is located at a significant distance from the patient.[2] In many healthcare systems worldwide, telecare, which may include telemedicine, has become a means of providing healthcare that is centered on information and communication technology.[3] A distinction between telehealth and telemedicine is warranted. The World Health Organization has classified telehealth as the use of computer-assisted telecommunications to support management, surveillance, and access to literature and medical knowledge, while telemedicine utilizes similar telecommunications solely to diagnose conditions and treat patients.[4]

As a subspecialty of telemedicine, the practice of telepharmacy has been defined by the National Association of Boards of Pharmacy as the provision of pharmacist care by registered pharmacies and pharmacists through the use of telecommunications to patients located at a distance.[5] The worldwide scope of telepharmacy has been steadily rising; the scope of telepharmacy has been similarly intensifying in the United States, and many state pharmacy boards have enthusiastically instituted provisions for telepharmacy as a viable medium for pharmaceutical care.[6]

Because this research study reviewed access to telepharmaceutical services in rural areas, it was imperative to distinguish between urban and rural areas. According to the US Census Bureau's classification of urban and rural areas, urban areas represent densely developed territory and encompass residential, commercial, and other nonresidential urban land (areas with more than 50,000 people and clusters with 2,500 to 50,000 people), whereas rural areas encompass all housing, population, and territory not included within an urban area.[7]

National pharmacist shortages have made it burdensome for hospitals located in rural areas to employ pharmacists.[8] In addition, 924 independently owned rural pharmacies in the United States were lost from March 2003 to December 2013, with most of the closures occurring between 2007 and 2009.[9] Therefore, telepharmacists have suggested that providing remote pharmaceutical care can help to resolve this situation.[10]

The Food and Drug Administration has defined a medication error as any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the healthcare professional, patient, or consumer.[11] Each year, medication errors contribute to 250,000 nonfatal injuries and 7,000 deaths.[12] In rural areas, medications have been being provided without a pharmacist's intervention because of the shortage of pharmaceutical services in hospitals, clinics, and medical centers in rural areas.[13] A lesser response rate by small and rural hospitals has been observed in the American Society of Health-System Pharmacists (ASHP) survey of pharmacy practice in hospitals and the Institute for Safe Medication Practices hospital medication safety self-assessment surveys.[14] It has been reported that small hospitals in rural areas have increased the number of part-time pharmacists. Critical-access hospitals have a median of only 20 on-site pharmacist hours per week, and 63 percent have an on-site pharmacist for less than 40 hours per week. A pharmacist shortage in Illinois has resulted in decreased time for providing clinical pharmacy services and a rise in pharmacy-related medication errors.[15]

The purpose of this research project was to examine the effect of the utilization of telepharmacy on rural hospitals' access to pharmaceutical services.

Methodology

The research framework for this review conformed with the steps and research framework used by Yao, Chu, and Li (2010).[16] The framework elucidates the course of telepharmacy adoption to address the problem of limited access to pharmaceutical services in rural hospitals. To determine whether adoption of a telepharmacy network improves access to pharmaceutical services for hospitals in rural areas, an assessment of the effectiveness of telepharmacy networks must first be made. As seen with any project, the process of technology adoption follows a cyclic path. It begins when issues within the current system call for a review of needs, followed by formulation and implementation of a solution. The solution here is the adoption of a telepharmacy network. Prior to implementation of this solution, an evaluation of the benefits of and barriers to the adoption of a telepharmacy network is necessary. After its institution, needs are reassessed and the cycle continues. (See Figure 1.) Because the focus of this review is the process of application of new technology in healthcare settings, this research framework is suitable for the current study. Furthermore, the effective reproduction of this approach in previous studies supports its internal validity.[17–20]

The primary hypothesis of this research project was that telepharmacy programs enhanced access to pharmaceutical services for hospitals in rural areas that do not offer 24-hour pharmaceutical services. The methodology for this study was an extensive and thorough literature review. The literature that was

utilized in this study encompassed primary and secondary sources. Because the term *telepharmacy* is relatively new and not widely known, peer-reviewed literature on this topic has been limited. Studies in the existing literature have typically described telepharmaceutical activities in a single hospital or a small number of hospitals in an area.

Step 1: Literature Identification and Collection

When executing the search, we employed the following keywords: "telepharmacy" AND "access" OR "hospital" OR "medication error" OR "regulations" OR "rural." These keywords were the inclusion criteria for this study. PubMed, EBSCOhost, ProQuest, and Academic Search Premier were the electronic databases utilized to retrieve academic peer-reviewed literature. The literature was chosen after a review of the abstracts was conducted. Reputable websites of the Centers for Medicare and Medicaid Services, the U.S. Census Bureau, and the Food and Drug Administration were also studied for pertinent information.

Step 2: Establishment of Inclusion Criteria and Literature Analysis

The literature review included 66 references in which information relevant to the purpose of this study was scrutinized; these references met the inclusion criterion. Because of the technological and pharmaceutical orientation of the present study, the literature was based on a variety of key areas, which included the following: improved access to pharmaceutical services in rural areas in various states of the United States, varying state regulations and policies regarding telepharmacy networks, pharmacist shortages in rural areas, and the need for medication safety in rural areas. All the articles that were analyzed in this study were written in English. To obtain current research, references published from 2007 to 2017 were included in this study. Four of the authors (B.M., C.S., H.S., and R.S.) conducted the literature search, which was validated by another author (A.C.), who acted as the second reader and double-checked to ensure that references met the inclusion criteria.

Step 3: Literature Categorization

The relevant articles were then categorized according to the research framework. The main categories that emerged from the literature were as follows: adoption and implementation (increased access and decreased time, regulations of telepharmacy), benefits (quality of care); and need for telepharmacy networks (shortage of pharmacists). These categories are detailed in the subsections of the Results section.

Results

Increased Access and Decreased Time

Telepharmacy has been shown to enhance access to pharmaceutical services to hospitals in rural areas that do not offer 24-hour pharmaceutical services.[21–24] A prospective cohort study was performed wherein a telepharmacy system was established between seven rural hospitals and a central hospital; the authors of the study concluded that the time required for medication order entry into the system drastically decreased (from 26.8 minutes to just 14 minutes per patient), since the rural pharmacies had to send patient information to just one central pharmacy, which stored all the information in its database.[25]

A longitudinal study was conducted in three rural community hospitals in California, and it evaluated a newly installed telepharmacy system that linked these three hospitals with a central pharmacy.[26] The results of the study indicated that after the network was established, the number of on-call consultations jumped from 15 to 98 within only the first month of utilization. Boon (2007) indicated that the time that rural pharmacists spent locating medications (with respect to the patient's diagnosis) and processing orders was reduced to 60 minutes,[27] while Witkowski (2007) revealed that instituting a telepharmacy network "decentralized" the pharmaceutical system and enhanced the turnaround time on patient order entries and checks on medications by 2 to 3 minutes.[28] A pilot study demonstrated that a telepharmacy network assisted in resolving unreconciled medication orders that accounted for approximately 31 percent of total order entries and prospective order reviews; more importantly, the study suggested that a

telepharmacy network could reduce the turnaround time for the medication reconciliation process down to one hour.[29]

Poulson, Nissen, and Coombes (2010) conducted a feasibility study in Queensland, Australia, to ascertain if a telepharmacy network (between one main hospital and two rural hospitals) was a viable medium through which access to rural inpatient facilities could be improved.[30] The researchers indicated that improvements in the medication supply system and enhanced documentation of medications were achieved; moreover, underdosing of drugs (that had been prescribed for patients) was reduced from 7 percent to 3 percent, patient counseling sessions increased from 2 percent to 4 percent, and erroneous patient medication histories were reduced from 26 percent to 22 percent.

Regulations in Telepharmacy

In the United States, state regulations and policies have been crucial in enhancing access to pharmaceutical services in rural populations; several states have implemented robust telepharmacy networks linking central pharmacies with rural pharmacies.[31] North Dakota has been a pioneer state in establishing and implementing telepharmacy networks throughout various rural regions of the state since 2001.[32] In 2003, additional specific regulations were incorporated that focused on service agreements between central and rural pharmacies.[33] Moreover, the North Dakota Board of Pharmacy has a provision for a licensure subclass for hospital telepharmacies.[34] A study published in 2008 reported that after telepharmacy networks were established in the state, the networks reduced discrepancies in dispensing orders to less than 1 percent (as compared to the national average of 2 percent), since orders were checked and double-checked at both the rural and central pharmacies.[35]

Two years later, another study scrutinized Montana's telepharmacy system, which established its definition of telepharmacy in 2001 and in 2006 established specific regulations regarding the utilization of telepharmacy and remote medication-dispensing machine sites.[36] This study also noted that for a remote telepharmacy site to obtain a practicing license, the site had to be located beyond a 10-mile radius from a central pharmacy and must undergo unscheduled visits from a central pharmacist. A cross-sectional pilot study indicated that after telepharmacy networks were established in Montana, the number of after-hours orders and subsequent follow-ups of these orders increased by 32.1 percent because telepharmacy networks could always provide an on-call pharmacist who did not have to be physically present at the rural hospital.[37]

Shortage of Pharmacists

The states of Utah, Oklahoma, Washington, Arkansas, and Minnesota have offered telepharmacy services only on a case-by-case basis; depending on the emergency of the situation, such as a severe pharmacist workflow shortage in a rural pharmacy, rural hospitals could electronically transmit medication orders to a central pharmacy, where orders were analyzed and reviewed.[38] This study also revealed that after telepharmacy networks were implemented in Minnesota, more than 700 patient drug regimens were documented in the network via clinical messages within solely the first 20 months of network utilization.

Studies in this arena have revealed that access to pharmaceutical services does not have to be limited to a single state.[39] Pharmacists who are engaged in a telepharmacy network in a particular state have been licensed in that state, and some states have permitted the use of remote services of pharmacists from other states. For example, in North Dakota, pharmacists engaged in a telepharmacy network had to have a license within either the state or any contiguous state, and in South Dakota, pharmacists located in any adjacent state could provide services if the hospital facility in the state was a component of the telepharmacy network system in the adjacent state.[40]

The importance of providing 24-hour pharmaceutical services has been supported by the fact that reductions in pharmacist personnel in rural areas have had a high correlation with medication errors, which include inaccurate dosages dispensed, increased unauthorized drug errors, and prescription errors; in other words, quality of care and medication safety have been adversely affected when unresolved pharmacist-related work issues were present.[41]

Quality of Care

Some studies involving various scenarios (e.g., emergency departments) and procedures (e.g., chemotherapeutic drug preparations, patient medication regimens) have reported a reduction in medication errors with telepharmacy.[42–50] (See Table 1.) In one study in which barcode technology was used with telepharmacy, medication error rates decreased from 1 percent to 0.2 percent.[51] In another study, the implementation of a telepharmacy network increased to about 97.7 percent the use of barcode technology that improved accuracy in preparing chemotherapeutic drugs.[52] A retrospective cross-sectional study from 2008 to 2010 showed an increase in quality management with the aid of a telepharmacy network, with the use of medication action, medication therapy review, and medication monitoring interventions accounting for 67 percent, 33 percent, and 4 percent, respectively.[53] (See Table 1.)

Discussion

The purpose of this research project was to examine the effect of utilization of telepharmacy on rural hospitals' access to pharmaceutical services. Results of the literature review demonstrated that telepharmacy networks have enhanced pharmaceutical access to hospitals in rural areas that do not offer 24-hour pharmaceutical services.

The literature review revealed several facts regarding the enhancement of access to pharmaceutical services in rural areas. Via telepharmacy, the time for entering medication order entries into the system decreased, the number of remote on-call consultations for rural inhabitants increased, and transit of patient order entries was made quicker. Moreover, the time spent locating medications within the system decreased (because the central pharmacy categorized medications by each rural patient), and errors in the consumer's pharmaceutical history were curtailed. Telepharmacy has also substantially ameliorated the national predicament of pharmacist shortages since telepharmacy networks have linked central pharmacists with pharmaceutical technicians at rural pharmacies.[54] A telepharmacy network could also improve stressful situations, such as evening, night, and weekend hours; it could also resolve problems in which pharmacists are unavailable during sick leave, vacations, or professional conferences as well as alleviate pharmacists' workload.[55]

Medication errors have many sources and contributing factors—of which a pharmacist shortage may be one. Reduction of medication errors has been a benefit of enhanced rural access to pharmaceutical services, and the literature review revealed several facts concerning these mistakes. Telepharmacy networks have substantially decreased the rate of such errors because multiple checks have to be performed at both the central pharmacy and the rural pharmacy; one report noted that the number of medication orders processed increased along with the accuracy of the processing system.[56] Moreover, peripheral interventions, such as the establishment of drug regimen protocols, ultimately mitigate errors because these functions institute protocols that both central and rural pharmacists have to abide by.

The utilization of telepharmacy has improved the quality of care by increasing medication accuracy and decreasing errors. The literature review revealed that medication safety has been enhanced by the tracking of error rates internally using barcode technology. The use of telepharmacy has improved the quality of care by monitoring other activities, such as accuracy of order entry, the number of after-hours orders, follow-up on after-hours orders, and productivity of pharmacy staff.

Hospitals in rural areas have had to confront demographic and financial constraints that have made them vulnerable to medication errors.[57] These areas have encountered difficulties in recruiting, attracting, and retaining pharmacists.[58] More often than not, many rural pharmacies have been inclined to employ only a handful of pharmacists, because of financial cutbacks. As a result, the chance of medication errors has increased because worker shortages prevent pharmacists from double-checking orders.[59] Moreover, rural hospitals have had to deal with an insufficiency of pharmaceutical innovations (that are available to their urban counterparts) necessary to boost pharmaceutical efficiency and prescription accuracy.[60] These factors have resulted in medication errors, especially in rural settings.

One of the most significant positive aspects of telepharmacy networks is that they require only software and videoconferencing capabilities to operate.[61] This utility has made widespread utilization possible. Another benefit proposed by this analysis is that because remote pharmacists have been

involved in telepharmaceutical networks (in terms of double-checking prescriptions, confirming providers' orders, and more), on-site pharmacists in rural areas could utilize the extra time to engage in concrete clinical services face-to-face with patients, thereby distributing the workload to enhance clinical care.[62] In this way, this technology could permit rural regions to pool their limited resources to recruit and retain on-site pharmacists in these areas. Finally, these networks could contribute to the overall economic development in rural areas; the North Dakota Telepharmacy Project has brought about $12 million to the rural region where the network was implemented, as well as 80 to 100 additional jobs.[63]

Telepharmacy has had a few negative aspects as well. On the basis of two studies conducted in the economic arena, we can extrapolate and surmise that telepharmacy networks in rural areas could hamper the business of traditional pharmacies located in adjacent cities because these companies would inevitably encounter reduced medication prescription volume.[64, 65]

Opponents have also voiced concerns about the increased responsibility that inevitably falls on pharmaceutical technicians posted in rural areas, who represent the pharmacist in these areas; an underlying concern related to utilizing technicians has been that a variety of situations could require enhanced pharmaceutical expertise.[66] Finally, it has been difficult to ascertain the entire scope of benefits that could be realized with telepharmacy because of the absence of a uniform telepharmaceutical system across the United States.

Limitations of the literature review were due to restrictions in the literature search strategy because of the following reasons. Peer-reviewed literature on telepharmacy was limited because only four electronic databases were utilized. Additional databases were searched; however, these databases provided the same journal articles that were obtained from these four databases. Moreover, researcher and publication bias, which could have limited the availability and the quality of the research identified for this review, cannot be ruled out.

A practical implication for the utilization of telepharmacy to enhance access to pharmaceutical services in rural areas ultimately involves the consumer's interpretation of this technology. In the US healthcare system, it is imperative to maintain the foundational importance of pharmacist-consumer relationships; to this effect, telepharmacy should be utilized as merely a medium to facilitate and consolidate that relationship. However, there is an underlying fear that giant pharmaceutical chains could employ a large number of pharmacists in call centers to interact with rural consumers via videoconferencing. Such a scenario could certainly undermine the importance of the pharmacist's role and provide the impression that pharmacy has evolved into a commercial business venture solely to boost sales and profit margins that could ultimately result in higher insurance premiums for consumers. Instead of viewing telepharmacists as caring healthcare specialists, consumers may become wary of telepharmacists and consider them agents of a pharmaceutical corporation.

A tangential aspect of this practical implication is that if a rural consumer requires only a prescription refill and has prior comprehensive knowledge of the medication to be refilled, the consumer may believe that the pharmacist's role is redundant and not as significant; as a result, the rural consumer might not feel the need for the services of a telepharmacist. In this case, a simple refill for a drug already prescribed might suffice. However, it is imperative for state boards of pharmacy to institute a policy that enforces some amount of interaction at least for those medications that consumers will ingest for the first time; in this manner, telepharmacy can aid in consolidating a relationship between the urban pharmacist and the rural consumer.

Future research should examine the results attributable to the adoption of telepharmacy. A systematic review or a meta-analysis should be performed to obtain a more precise measurement of the effects (i.e., access and decreased time) of the implementation of telepharmacy in rural areas.

Conclusion

Telepharmacy may have significant potential to transform the delivery of pharmaceutical services. The literature review in this study has suggested that telepharmacy may enhance access to pharmaceutical services for hospitals in rural areas that do not offer 24-hour pharmaceutical services.

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Notes

1. Singh, Ranjit, Michael I. Lichter, Andrew Danzo, John Taylor, and Thomas Rosenthal. "The Adoption and Use of Health Information Technology in Rural Areas: Results of a National Survey." *Journal of Rural Health* 28, no. 1 (2012): 16–27.
2. Centers for Medicare & Medicaid Services. "Glossary." 2016. Available at https://www.medicare.gov/glossary/t.html (accessed February 5, 2017).
3. Solli, Hilde, Ida Torunn Bjørk, Sigrun Hvalvik, and Ragnhild Hellesø. "Principle-based Analysis of the Concept of Telecare." *Journal of Advanced Nursing* 68, no. 12 (2012): 2802–15.
4. Principi, Beth. "The Difference Between Telehealth and Telemedicine." *American Well*. May 11, 2015. Available at https://www.americanwell.com/the-difference-between-telehealth-and-telemedicine/ (accessed February 5, 2017).
5. Win, Aung Z. "Telepharmacy: Time to Pick Up the Line." *Research in Social and Administrative Pharmacy* 13, no. 4 (2017): 882–83.
6. AlFaar, Ahmed S., Sherif Kamal, Sherif AbouElnaga, William M. Greene, Yuri Quintana, Raul C. Ribeiro, and Ibrahim A. Qaddoumi. "International Telepharmacy Education: Another Venue to Improve Cancer Care in the Developing World." *Telemedicine and eHealth* 18, no. 6 (2012): 470–74.
7. US Census Bureau. "Urban and Rural." 2016. Available at https://www.census.gov/geo/reference/urban-rural.html (accessed February 5, 2017).
8. MacDowell, M., M. Glasser, M. Fitts, K. Nielsen, and M. Hunsaker. "A National View of Rural Health Workforce Issues in the USA." *Rural Remote Health* 10, no. 3 (2010): 1–16.
9. Martin, Sarah L., Robert P. Baker, and Brian J. Piper. "Evaluation of Urban-Rural Differences in Pharmacy Practice Needs in Maine with the MaPPNA." *Pharmacy Practice* 13, no. 4 (2015): 1–8.
10. Steckler, Taylor. "Telepharmacy: Controversy and Promise." *Journal of Pharmacy Technology* 32, no. 6 (2016): 227–29.
11. US Food and Drug Administration. "Medication Errors Related to Drugs." 2016. Available at http://www.fda.gov/drugs/drugsafety/medicationerrors/ (accessed February 2, 2017).
12. Win, Aung Z. "Telepharmacy: Time to Pick Up the Line."
13. Traynor, K. "Remote Technician Supervision Up and Running in Kansas." *American Journal of Health Systems Pharmacy* 69, no. 4 (2012): 273–74.
14. Pedersen, C. A., P. J. Schneider, and D. J. Scheckelhoff. "ASHP National Survey of Pharmacy Practice in Hospital Settings: Prescribing and Transcribing—2004." *American Journal of Health-System Pharmacy* 62, no. 4 (2005): 378–90.
15. Casey, M. M., I. S. Moscovice, and G. Davidson. "Pharmacist Staffing, Technology Use, and Implementation of Medication Safety Practices in Rural Hospitals." *Journal of Rural Health* 22, no. 4 (2006): 321–30.
16. Yao, W., C. H. Chu, and Z. Li. "The Use of RFID in Healthcare: Benefits and Barriers." *Proceedings of the 2010 IEEE International Conference on RFID Technology and Applications (RFID-TA)* (2010): 128–34.
17. Coustasse, A., S. Tomblin, and C. Slack. "Impact of Radio-Frequency Identification (RFID) Technologies on the Hospital Supply Chain: A Literature Review." *Perspectives in Health Information Management* (Fall 2013).
18. Deslich, S., and A. Coustasse. "Expanding Technology in the ICU." *Telemedicine and e-Health* 20, no. 5 (2014): 485–92.
19. Porterfield, A., K. Engelbert, and A. Coustasse. "Electronic Prescribing: Improving the Efficiency and Accuracy of Prescribing in the Ambulatory Care Setting." *Perspectives in Health Information Management* (Spring 2014).
20. Bhardwaj, Niharika N., Bezawit Wodajo, Keerthi Gochipathala, David P. Paul III, and Alberto Coustasse. "Can mHealth Revolutionize the Way We Manage Adult Obesity?" *Perspectives in Health Information Management* (Spring 2017).
21. Collins, Brian, Tyrone F. Borders, Kristen Tebrink, and Ke Tom Xu. "Utilization of Prescription Medications and Ancillary Pharmacy Services among Rural Elders in West Texas: Distance Barriers

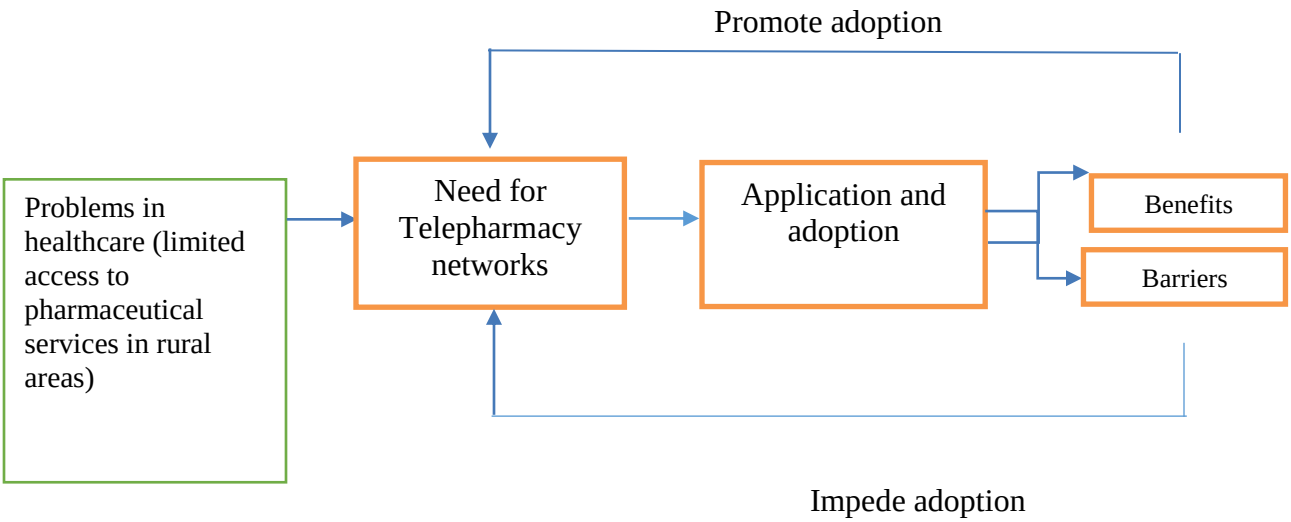
and Implications for Telepharmacy." *Journal of Health and Human Services Administration* 30, no. 1 (2007): 75–97.
22. Khan, Shamima, Herbert W. Snyder, Ann M. Rathke, David M. Scott, and Charles D. Peterson. "Is There a Successful Business Case for Telepharmacy?" *Telemedicine and e-Health* 14, no. 3 (2008): 235–44.
23. Rose, Joseph L. "Improved and Expanded Pharmacy Care in Rural Alaska through Telepharmacy and Alternative Methods Demonstration Project." *International Journal of Circumpolar Health* 66, no. 1 (2007): 14–22.
24. Sherman, Justin. "Telepharmacy—a Promising Alternative for Rural Communities." *Pharmacy Times* 73 no. 2 (2007): 65–86.
25. Garrelts, James C., Mark Gagnon, Charles Eisenberg, Janell Moerer, and Joe Carrithers. "Impact of Telepharmacy in a Multihospital Health System." *American Journal of Health-System Pharmacy* 67, no. 17 (2010): 1456–62.
26. Schneider, Philip J. "Evaluating the Impact of Telepharmacy." *American Journal of Health-System Pharmacy* 70, no. 23 (2013): 2130–35.
27. Boon, Adam D. "Telepharmacy at a Critical Access Hospital." *American Journal of Health-System Pharmacy* 64, no. 3 (2007): 242–44.
28. Witkowski, Paul. "Case Study: Novel Ways Automation Enhances Medication Safety. *American Journal of Health-System Pharmacy* 64, no. 9 (2007): S21–S23.
29. Keeys, Christopher, Bamidele Kalejaiye, Michelle Skinner, Mandana Eimen, JoAnn Neufer, Gisele Sidbury, Norman Buster, and Joan Vincent. "Pharmacist-managed Inpatient Discharge Medication Reconciliation: A Combined Onsite and Telepharmacy Model." *American Journal of Health-System Pharmacy* 71, no. 24 (2014): 2159–66.
30. Poulson, Louise, Lisa Nissen, and Ian Coombes. "Pharmaceutical Review Using Telemedicine—a Before and After Feasibility Study." *Journal of Telemedicine and Telecare* 16, no. 2 (2010): 95–99.
31. Casey, Michelle, Walter Elias, Alana Knudson, and Walter Gregg. *Implementation of Telepharmacy in Rural Hospitals: Potential for Improving Medication Safety* (Upper Midwest Rural Health Research Center Final Report 8). 2008. Available at http://rhrc.umn.edu/wp-content/files_mf/telepharmacy.pdf.
32. Gilman, Matlin, and Jeff Stensland. "Telehealth and Medicare: Payment Policy, Current Use, and Prospects for Growth." *Medicare and Medicaid Research Review* 3, no. 4 (2013): E1–E14.
33. McCarthy, Douglas, Rachel Nuzum, Stephanie Mika, Jennifer Wrenn, and Mary Wakefield. "The North Dakota Experience: Achieving High-Performance Health Care through Rural Innovation and Cooperation." The Commonwealth Fund, May 2008. Available at http://www.commonwealthfund.org/usr_doc/1130_McCarthy_North_Dakota_experience.pdf?section=4039.
34. Casey, Michelle, Walter Elias, Alana Knudson, and Walter Gregg. *Implementation of Telepharmacy in Rural Hospitals: Potential for Improving Medication Safety.*
35. McCarthy, Douglas, Rachel Nuzum, Stephanie Mika, Jennifer Wrenn, and Mary Wakefield. "The North Dakota Experience: Achieving High-Performance Health Care through Rural Innovation and Cooperation."
36. Casey, Michelle M., Todd D. Sorensen, Walter Elias, Alana Knudson, and Walter Gregg. "Current Practices and State Regulations Regarding Telepharmacy in Rural Hospitals." *American Journal of Health-System Pharmacy* 67, no. 13 (2010): 1085–92.
37. Scott, David M., Daniel L. Friesner, Ann M. Rathke, Charles D. Peterson, and Howard C. Anderson. "Differences in Medication Errors between Central and Remote Site Telepharmacies." *Journal of the American Pharmacists Association* 52, no. 5 (2012): e97–e104.
38. Stratton, Timothy P., Marcia M. Worley, Mark Schmidt, and Michael Dudzik. "Implementing After-Hours Pharmacy Coverage for Critical Access Hospitals in Northeast Minnesota." *American Journal of Health-System Pharmacy* 65, no. 18 (2008): 1727–34.
39. Friesner, Daniel L., David M. Scott, Ann M. Rathke, Charles D. Peterson, and Howard C. Anderson. "Do Remote Community Telepharmacies Have Higher Medication Error Rates Than Traditional Community Pharmacies? Evidence from the North Dakota Telepharmacy Project." *Journal of the American Pharmacists Association* 51, no. 4, (2011): 48–58.

40. Gilman, Matlin, and Jeff Stensland. “Telehealth and Medicare: Payment Policy, Current Use, and Prospects for Growth.”
41. Scott, David M., Daniel L. Friesner, Ann M. Rathke, and Shelly Doherty-Johnsen. “Medication Error Reporting in Rural Critical Access Hospitals in the North Dakota Telepharmacy Project.” *American Journal of Health-System Pharmacy* 71, no. 1 (2014): 58–67.
42. Bubalo, Joseph, Bruce A. Warden, Joshua J. Wiegel, Tess Nishida, Evelyn Handel, Leanne Svoboda, Lam Nguyen, and P. Neil Edillo. “Does Applying Technology Throughout the Medication Use Process Improve Patient Safety with Antineoplastics?” *Journal of Oncology Pharmacy Practice* 20, no. 6 (2014): 445–60.
43. Kimber, Michael B. “The Application of Telepharmacy as an Enabling Technology to Facilitate the Provision of Quality Pharmaceutical Services to Rural and Remote Areas of Australia.” Unpublished doctoral dissertation, James Cook University, Australia, 2007.
44. Erickson, Amy K. “Smilow Expands the Universe of Cancer Care with Telepharmacy.” *PharmacyToday* 21, no. 8 (2015): 2–3.
45. Figge, Helen L. “Reducing Medication Errors Using Technological Innovations.” *U.S. Pharmacist* 34, no. 3 (2009): HS-15–HS-16.
46. O’Neal, Brian, John C. Worden, and Rick J. Couldry. “Telepharmacy and Bar-code Technology in an I.V. Chemotherapy Admixture Area.” *American Journal of Health-System Pharmacy* 66, no. 13 (2009): 1211–17.
47. Cole, Stacey L., John H. Grubbs, Cathy Din, and Thomas S. Nesbitt. “Rural Inpatient Telepharmacy Consultation Demonstration for After-Hours Medication Review.” *Telemedicine and e-Health* 18, no. 7 (2012): 530–37.
48. Sankaranarayanan Jayashri, Lori J. Murante, and Lisa M. Moffett. “A Retrospective Evaluation of Remote Pharmacist Interventions in a Telepharmacy Service Model Using a Conceptual Framework.” *Telemedicine and e-Health* 20, no. 10 (2014): 893–901.
49. Benizri, Frédéric, Benoit Dalifard, Christophe Zemmour, Maxime Henriquet, Emmanuelle Fougereau, and Benoit Le Franc. “Drugcam®—an Intelligent Video Camera System to Make Safe Cytotoxic Drug Preparations.” *International Journal of Pharmaceutics* 502, no. 1–2 (2016): 198–207.
50. Campbell, M. J., M. P. Phelan, E. J. Wells, F. M. Hustey, D. Tietz, R. Balmat, and E. Sokn. “Telepharmacy Services and Emergency Medicine Pharmacist Interventions in Freestanding Emergency Departments.” *Annals of Emergency Medicine* 68, no. 4S (2016): S5–S6.
51. Kimber, Michael B. “The Application of Telepharmacy as an Enabling Technology to Facilitate the Provision of Quality Pharmaceutical Services to Rural and Remote Areas of Australia.”
52. Erickson, Amy K. “Smilow Expands the Universe of Cancer Care with Telepharmacy.”
53. Sankaranarayanan Jayashri, Lori J. Murante, and Lisa M. Moffett. “A Retrospective Evaluation of Remote Pharmacist Interventions in a Telepharmacy Service Model Using a Conceptual Framework.”
54. McDonald, Kevin. “Practice Spotlight: A Telepharmacy Model of Care for Hospitals.” *California Journal of Health-System Pharmacists* 62, no. 6 (2009): 510–11.
55. Blanchet, Kevin D. “Innovative Programs in Telemedicine Northwest TeleHealth.” *Telemedicine and e-Health* 14, no. 4 (2008): 318–22.
56. Erickson, Amy K. “Smilow Expands the Universe of Cancer Care with Telepharmacy.”
57. Scott, David M. “Assessment of Pharmacists’ Perception of Patient Care Competence and Need for Training in Rural and Urban Areas in North Dakota.” *Journal of Rural Health* 26, no. 1 (2010): 90–96.
58. Poudel, Arjun, and Lisa Nissen. “Telepharmacy: A Pharmacist’s Perspective on the Clinical Benefits and Challenges.” *Integrated Pharmacy Research and Practice* 5 (2016): 75–82.
59. Wakefield, Douglas S., Marcia M. Ward, Jean L. Loes, John O’Brien, and Leevon Sperry. “Implementation of a Telepharmacy Service to Provide Round-the-clock Medication Order Review by Pharmacists.” *American Journal of Health-System Pharmacy* 67, no. 23 (2010): 2052–57.
60. Peterson, Charles D., David M. Scott, Ann Rathke, Patricia Killingsworth, and George Hill. “Establishing a Central Order Entry System for Delivering Telepharmacy Services to Remote Rural Hospitals.” *Journal of Pharmacy Technology* 26, no. 4 (2010): 179–86.

61. Newsome, Jonathan. "Virtual Medication Therapy Management: The Cornerstone to a Pharmacy Renaissance." *Journal of the American Pharmacists Association* 53, no. 2 (2013): 159–62.
62. Lam, Annie Y., and Dave Rose. "Telepharmacy Services in an Urban Community Health Clinic System." *Journal of the American Pharmacists Association* 49, no. 5 (2009): 652–59.
63. Peterson, Charles D., Ann Rathke, John Skwiera, and Howard C. Anderson. "Hospital Telepharmacy Network: Delivering Pharmacy Services to Rural Hospitals." *Journal of Pharmacy Technology* 23, no. 3 (2007): 158–65.
64. Traynor, Andrew P., Todd D. Sorensen, and Tom Larson. "The Main Street Pharmacy—Becoming an Endangered Species." *Rural Minnesota Journal* 2, no. 1 (2007): 82–100.
65. Todd, Kelli, Fred Ullrich, and Keith Mueller. "Rural Pharmacy Closures: Implications for Rural Communities." *Rural Policy Brief* 2012, no. 5 (2013): 1–5.
66. Meidi, Tracy M., Thomas W. Woller, Arlene M. Iglar, and Dennis G. Brierton. "Implementation of Pharmacy Services in a Telemedicine Intensive Care Unit." *American Journal of Health-System Pharmacy* 65, no. 1 (2008): 1464–69.

Figure 1

Research Framework



Source: Adapted from Yao, W., C. H. Chu, and Z. Li. "The Use of RFID in Healthcare: Benefits and Barriers." *Proceedings of the 2010 IEEE International Conference on RFID Technology and Applications (RFID-TA)* (2010): 128–34.

Table 1

Selected Studies of Reduction in Medication Errors

Authors (Year)	**Study Design**	**Outcome**
Bubalo et al. (2013)	Literature review	Barcode technology coupled with a network during antineoplastic drug preparation necessitated pharmaceutical intervention in only 1.1% of erroneous drug orders during one month.
Kimber (2007)	Direct observation-based methodology	Barcode implementation within a network reduced medication error rates from 1% to 0.2%.
Erickson (2015)	Literature review	A network produced an increase to 97.7% utilization of the barcode technology that aided in maintaining accuracy in preparing chemotherapeutic drugs.
Figge (2009)	Literature review	Utilization of the automated process within a network resulted in a 0.075% dispensing error rate.
O'Neal et al. (2009)	Direct observation-based methodology	Telepharmacy and barcoding resulted in the need for pharmaceutical intervention for only 4 of 363 doses in order to confirm the accuracy of chemotherapeutic preparations.
Cole et al. (2012)	Retrospective chart review	Before telepharmacy was incorporated into rural hospital pharmacy systems, the medication error rate was 30%, compared to 19.2% after the incorporation. The total number of medications ordered after the incorporation (2,378) was more than four times the number (500) before incorporation.

Sankaranarayanan et al. (2014)	Retrospective cross-sectional study	With the aid of a telepharmacy network, the use of interventions significantly increased each year (36% in 2009, 55% in 2010, and 7% in 2011) vs. 3% in 2008 (baseline). Of the total number of remote pharmaceutical care interventions, medication action, medication therapy review, and medication monitoring constituted 67%, 33%, and 4% respectively.
Benizri et al. (2016)	Quantitative and qualitative analysis	A video system that utilized automatic verification procedures during critical stages of chemotherapy preparation was shown to identify 2.1% of preparation errors (244 of 11,640).
Campbell et al. (2016)	Retrospective chart review	A network aided in clarifying 12% (266 of 2219) of medication orders in three freestanding emergency departments.

Sources:

Benizri, Frédéric, Benoit Dalifard, Christophe Zemmour, Maxime Henriquet, Emmanuelle Fougereau, and Benoit Le Franc. "Drugcam®—an Intelligent Video Camera System to Make Safe Cytotoxic Drug Preparations. *International Journal of Pharmaceutics* 502, no. 1–2 (2016): 198–207.

Bubalo, Joseph, Bruce A. Warden, Joshua J. Wiegel, Tess Nishida, Evelyn Handel, Leanne Svoboda, Lam Nguyen, and P. Neil Edillo. "Does Applying Technology Throughout the Medication Use Process Improve Patient Safety with Antineoplastics? *Journal of Oncology Pharmacy Practice* 20, no. 6 (2014): 445–60.

Campbell, M. J., M. P. Phelan, E. J. Wells, F. M. Hustey, D. Tietz, R. Balmat, and E. Sokn. "Telepharmacy Services and Emergency Medicine Pharmacist Interventions in Freestanding Emergency Departments." *Annals of Emergency Medicine* 68, no. 4S (2016): S5–S6.

Cole, Stacey L., John H. Grubbs, Cathy Din, and Thomas S. Nesbitt. "Rural Inpatient Telepharmacy Consultation Demonstration for After-Hours Medication Review." *Telemedicine and e-Health* 18, no. 7 (2012): 530–37.

Erickson, Amy K. "Smilow Expands the Universe of Cancer Care with Telepharmacy." *PharmacyToday* 21, no. 8 (2015): 2–3.

Figge, Helen L. "Reducing Medication Errors Using Technological Innovations." *U.S. Pharmacist* 34, no. 3 (2009): HS-15–HS-16.

Kimber, Michael B. "The Application of Telepharmacy as an Enabling Technology to Facilitate the Provision of Quality Pharmaceutical Services to Rural and Remote Areas of Australia." Unpublished doctoral dissertation, James Cook University, Australia, 2007.

O'Neal, Brian, John C. Worden, and Rick J. Couldry. "Telepharmacy and Bar-code Technology in an I.V. Chemotherapy Admixture Area." *American Journal of Health-System Pharmacy* 66, no. 13 (2009): 1211–17.

Sankaranarayanan Jayashri, Lori J. Murante, and Lisa M. Moffett. "A Retrospective Evaluation of Remote Pharmacist Interventions in a Telepharmacy Service Model Using a Conceptual Framework." *Telemedicine and e-Health* 20, no. 10 (2014): 893–901.