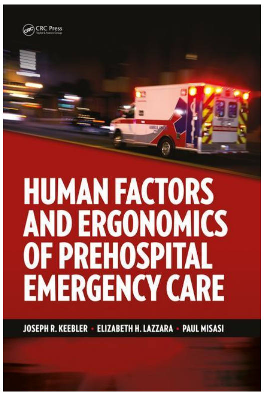

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10 Exploring Telemedicine in Emergency Medical Services

Guidance in Implementation for Practitioners

Elizabeth H. Lazzara and Lauren E. Benishek

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INTRODUCTION

Due to the growing specialties, evolving technologies, and disease complexities, quality care is now contingent upon the synthesis of expertise and seamless coordination of multiple, oftentimes distributed, individuals. EMS exemplify the aforementioned depiction, as it involves crew members serving multiple functions separately (e.g., managing patients and driving ambulances) as well as technology enabling the transmission of information between crews in the field and ED clinicians to foster patient management and preparation for incoming patient admissions.

To integrate seemingly disparate team members and their expertise while addressing patient needs and navigating the challenging clinical care system, the healthcare community has leveraged telemedicine. Currently, half of all US hospitals already use some form of telemedicine according to the American Telemedicine Association, and telemedicine is projected to expand significantly with the number of patients using telemedical services rising to seven million (Roashan, 2014). Also demonstrating this proliferation, previously valued at $14.2 billion, telemedicine is projected to swell at a compound annual growth rate of 18.5% (Wells Fargo Insurance Services, 2014).

Considering the proposed exponential growth of telemedicine as well as the inherent nature of EMS being distributed and relying on technology to facilitate care, telemedicine is rife with opportunity. Consequently, the purpose of this chapter is to elucidate telemedicine and how it is applied within EMS. With that being said, this chapter will proceed by first defining telemedicine, then describing the components and purposes of telemedicine, following with a discussion of the applications of telemedicine within EMS, and concluding with ideas for research.

WHAT IS TELEMEDICINE?

The term actually originates from the Greek word *tele*, which means at a distance, and the Latin word *mederi*, which is defined as healing. Thus, the literal translation means healing at a distance. The term *telemedicine*, however, was coined by Thomas Bird in the 1970s and has been defined as "the use of electronic information and communications technologies to provide and support health care when distance separates participants" (Field, 1996, p. 16). Similar to other complex concepts, telemedicine too has several definitions, such as "the practice of medicine without the usual physician–patient confrontation via an interactive audio-video communication system" (Bashshur et al., 2000, p. 614), "medical applications that use interactive video, typically for specialty or subspecialty physician consultants" (Field & Grigsby, 2002, p. 423), and "use of telecommunications technology for medical diagnostic monitoring and therapeutic purposes when distance and/or time separates the participants" (Hersh et al., 2006a, p. 3), to name a few.

Undoubtedly, these definitions have slight variations, yet it is evident that there are two common and defining characteristics of telemedicine. First, telemedicine inherently assumes distance or separation between two or more parties, and second, it utilizes telecommunication or information transmission technology (e.g., telephone, video, modem) to relay health information to foster clinical care (Bashshur et al., 2000). It should be noted, though, that participants no longer explicitly apply to physician and patient interactions as Bird initially suggested; that is, the participants refer to the original relationship of clinician and patient as well as multiple clinicians or even a combination of clinicians and a patient.

Due to the evolution and expansion of telemedicine, two types have emerged—asynchronous and synchronous (Smith, 2007). The first category, asynchronous applications, does not occur in real time but rather is known more commonly as "store and forward." Traditionally, information and medical data (e.g., images, audio, and text) in store-and-forward tools are captured, stored, and subsequently transmitted for later use (Hersh et al., 2006b). In fact, asynchronous applications do not rely on real-time discussion at all, but rather, they depend on interpretations and diagnosis to be conducted later. Additionally, store and forwards are predominantly personal computer based (Güler & Ubeyli, 2002); however, there are capabilities to be mobile and portable. Regardless if the technology is stationary or portable, the medical data that are transmitted at the receiving end is typically optimal quality such that it is generally equivalent to the sending end (Sable et al., 2009). Subsequently, they are extremely common in certain medical contexts, such as dermatology and radiology, with one review revealing that almost 50% of asynchronous studies were conducted within the field of dermatology (Deshpande et al., 2009). The popularization of such store-and-forward technology is attributed to evidence demonstrating improvements in patient management (Hersh et al., 2001), diagnostic accuracy, and patient satisfaction (Deshpande et al., 2009).

Clearly, research has provided evidence that asynchronous technologies have efficacious results in critical outcomes, which can possibly be connected to the advantages embedded or associated with such applications. For example, due to the nature of store-and-forward applications, they can function on a narrower bandwidth; therefore, they become easier to implement due to less complicated technological and systematic requirements (Perednia & Allen, 1995). Also, inherent in many asynchronous tools is the ability to annotate medical data (Allely, 1995), which too can be extremely informative and valuable in particular instances, especially for teleconsultations. To illustrate, a radiologist seeking another opinion can provide notations on a set of film for another colleague, which could possibly guide or alter the consultative process. Finally, another primary additive benefit of asynchronous uses is that they do not require the coordination of multiple individuals to be present at the same time (Hersh et al., 2006b). Consequently, asynchronous technologies afford for flexibility in the recipient's schedule by enabling the individual to examine the received patient data at his/her own convenience (Allely, 1995; Grigsby & Sanders, 1998). Given the workload and time commitments of clinicians as well as the reduction in hours for residents, the lack of person coordination is potentially a seriously underestimated asset.

Although store-and-forward techniques have positive characteristics, such as minimal people demands (i.e., they do not require multiple people at once), there are also detriments to utilizing these tools. For instance, asynchronous technologies demand better interface designs; interfaces must compensate for any deficits in design since store-and-forward tools do not have another human to interact with and address clinical requests in real time (Allely, 1995). Also, such technology is vulnerable to confidentiality issues; that is, store-and-forward applications are susceptible to breaches in security or improper patient disclosure (i.e., patient data sent to incorrect individuals; Grigsby & Sanders, 1998).

The second category, synchronous applications, includes real-time interactions between two or more parties. Synchronous technology is most notably used for videoconferencing, telementoring, and distance education, and evidence repeatedly seems reassuring. Systematic reviews suggest that these tools are associated with maintaining the same level of care compared to traditional face-to-face interventions (Barak et al., 2008; Currell et al., 2010) and even enhanced outcomes, such as diagnosis (Hersh et al., 2002), patient satisfaction, and reduced length of stay (Hersh et al., 2001).

Unquestionably, one of the primary advantages of synchronous applications is that they afford real-time, natural discussion and interactions (Loane et al., 2000), which enables requests to be addressed immediately and facilitate increased contact with other clinical experts. These real-time interactions are imperative for specific contexts that necessitate urgent yet accurate decision-making and procedural skills, such as videoconferencing in emergencies and surgical telementoring, which is characterized by a more prolific surgeon providing expertise to a colleague performing surgery at a separate location. Real-time interactions, embedded within synchronous technologies, are also useful for building rapport between physicians and patients and family members. The physician–patient relationship is integral considering that the interactions that comprise these relationships are negatively associated with "doctor shopping" (the act of finding an alternative caregiver; Kaplan et al., 1989) and positively related to medical information comprehension and recall (Ong et al., 1995), patient satisfaction, and compliance to treatment plans (Kaplan et al., 1989). Moreover, synchronous applications offer the capability of viewing live images (Smith et al., 2005), and for patient indicators such as heart rate or oxygen saturation levels, having a real-time assessment of such indicators can be pivotal for diagnosis and patient management. In addition, synchronous telemedicine provides more opportunities for education (Grigsby & Sanders, 1998) by fostering relationships between senior and junior colleagues, enabling regional locations to collaborate and discuss difficult patient cases, and providing individually focused learning (Sable et al., 2009).

On the other hand, synchronous telemedicine is not without its drawbacks. For instance, it relies on real-time interactions; thus, scheduling multiple individuals can be difficult and cumbersome. Moreover, real-time interactive feed eliminates the ability to obtain and save hard copies of medical data. Although saved medical data may not be necessary for all contexts, they can become a worthwhile referent, especially for complex cases. Also, such applications require greater technological and bandwidth requirements to be capable of producing a sufficient level of technical quality; in turn, visual images or auditory discussions may be reduced to merely acceptable levels (and potentially subpar) as opposed to optimal (Sable et al., 2009).

Both asynchronous and synchronous telemedicine can be used for a variety of purposes. Aiming to better understand and organize the expansive field of telemedicine, researchers have created taxonomies. Leveraging previous work, Tulu et al. (2005) proposed a taxonomy including two primary purposes of telemedicine: clinical and nonclinical. Expanding upon this taxonomy, Smith et al. (2005) further delineated the dominant purposes of telemedicine into three overarching categories: clinical, educational, and administrative. Within the clinical arena, telemedicine is used to supplement patient care, such as diagnostics and surgery. Meanwhile, for educational purposes, telemedicine is used to augment lectures, conferences, workshops, and grand rounds. Finally, for administrative applications, it is used to arrange interviews, meetings, and correspondence between regional facilities. See Table 10.1 for a summary of the advantages and disadvantages of asynchronous and synchronous telemedicine.

TABLE 10.1
Comparison of Asynchronous versus Synchronous Telemedicine

Type	Advantages	Disadvantages
Asynchronous	• Functions on narrower bandwidth • Mandates less complicated technological and systematic requirements • Easier to implement • Affords annotation • Offers flexibility in terms of scheduling users	• Demands better interface designs • Inability to address requests in real time • Vulnerable to confidentiality issues
Synchronous	• Affords real-time, natural discussion and interactions • Addresses feedback immediately • Builds rapport between users • Offers real-time assessment of fluctuating indicators (e.g., heart rate) and images • Facilitates education and collaboration between colleagues	• Demands coordinating schedules • Adds complexity to saving hard copies of images • Requires greater bandwidth

PURPOSES AND APPLICATIONS OF TELEMEDICINE IN EMS

Although we have primarily discussed telemedicine in general, it is not new to EMS settings. Despite being limited by technology capabilities, telemedicine has been utilized in some form or another for almost three decades, beginning with the transmission of EKGs via cellular phones in the late 1980s (Garza, 1998). We now live in a digital age defined by rapid technological advancements and the ubiquitous presence of devices needed to make modern work and life possible. Naturally, telemedicine is not exempt from the proliferation of new technologies (e.g., Google Glass; Carenzo et al., 2014), which have the capability of revolutionizing the field and making sci-fi-esque devices a reality. As a result, EMS telemedical systems vary widely in how they are designed and applied. Typical applications within this context range from mostly asynchronous, such as sending EKGs, still images, or video clips, to more synchronous, such as the sending and/or receiving of live feed audio and video (Bashford, 2011). While the potential applications of EMS telemedicine are as diverse as the technologies available, they may serve three common purposes: (1) documentation, (2) education, and (3) teleconsultation.

In principle, documentation is the most basic application of telemedicine within EMS as it does not require interaction between two or more providers. Documentation refers to materials that provide official information or evidence and serve as a record. There are a number of ways that EMS information can be documented using telemedicine. As already discussed, early applications of EMS telemedicine involved the transmission of EKGs from ambulance to hospital (Garza, 1998). This is one example of patient status in the prehospital setting. Another may be to take pictures or video of the patient upon arrival (Bergrath et al., 2013b) or record treatment refusals (Bashford, 2011).

The second purpose of EMS telemedicine is education. The information collected and transmitted using telemedicine can be used in the education and training of healthcare providers and emergency medical professionals (Bergrath et al., 2013a), either in real time or by using case studies in classroom-based instruction. For example, Haney et al. (2012) compared conventional lectures and tele-education lectures in managing wound care and found that both groups had similar knowledge acquisition and performance, indicating that tele-education is at least as effective as conventional education.

Finally, the arguably purest purpose of telemedicine is for consultation, coined *teleconsultation* or *telepresence*. Teleconsultation is potentially more inclusive of both asynchronous and synchronous technologies, whereas telepresence is restricted primarily to synchronous applications. Teleconsultation can potentially involve assessment and/or assistance. Assessment activities involve the evaluation of a patient prior to their arrival at the treatment facility. They include but are not restricted to initial diagnosis (Yperzeele et al., 2014), treatment decisions (Demaerschalk et al., 2010), and triage (i.e., assessment of the degree or urgency of wounds and illness; Brunetti et al., 2014). These activities have the potential benefit of cost reduction. For example, costs were reduced in a Spanish sample because fewer transport resources were used when telemedicine (i.e., transmission of EKGs and images) was utilized (Cabrera et al., 2002).

Teleconsultation may also be used to provide assistance to EMS providers in a variety of situations requiring varying levels of patient care and has been shown to be logistically feasible (Rortgen et al., 2013). Because EMS providers operate under a limited scope of practice, they are not always qualified to provide necessary care to patients. In more critical cases, teleconsultation may enable a remote physician to guide an EMS provider through life-saving treatment that an EMS provider would not be able to provide otherwise. Additionally, teleconsultation can allow for "treat and release" practices in which an EMS provider delivers the necessary care to a patient under the guidance of a remote physician (Widmer & Muller, 2014). Such practices may circumvent the unnecessary transport of patients to the emergency room (ER) (Haskins et al., 2002), thus reducing care costs and hospital staff workload.

We have highlighted some of the more common approaches to EMS telemedicine described in the published literature. However, there certainly exist more reasons and ways to implement telemedicine for EMS settings than those addressed here. EMS systems themselves can be diverse in nature in order to accommodate the laws and regulations set forth by the countries, states, and counties in which they operate and the demographics of the populations that they serve. As such, the needs and available resources of EMS systems will vary and consequently affect the adoption and implementation of telemedicine within each. Therefore, in the next section, we aim to describe some general guidance for researchers and practitioners considering EMS telemedicine applications.

GUIDANCE FOR RESEARCHERS AND PRACTITIONERS

When embarking on plans to implement or evaluate a telemedicine EMS system, there are a number of factors that both researchers and practitioners should consider in order to help prepare for the undertaking. These include (1) needs and objectives, (2) stakeholder buy-in, (3) resource availability, (4) privacy and confidentiality issues, and (5) use and maintenance policies. We next elaborate on each of these factors and offer a summary of tips for managing each in Table 10.2.

All decisions regarding EMS telemedicine should be related to a known need. Telemedicine implementation can be a complex and expensive process. The likelihood

TABLE 10.2
Success Factors and Tips for Implementing a Telemedicine EMS System

Success Factor	Implementation Tips
Needs and objectives	• Conduct a thorough need analysis prior to choosing or implementing a telemedicine EMS system • Match the telemedicine EMS system to the known need(s) to avoid resource waste and optimize success
Stakeholder buy-in	• Present compelling evidence (e.g., pilot testing, case studies of similar facilities) favoring the use of EMS telemedicine • Solicit stakeholder opinions about the telemedicine system • Address concerns and suspicions surrounding telemedicine prior to implementation • Include stakeholders in decision-making meetings and show that their contributions are valued
Resource availability	• Consider available resources (funds, time, labor, and space) prior to implementation • Identify ways in which EMS telemedicine might be a source of revenue, save resources, or prevent resource waste • Partner with another entity or department to pool resources • Utilize technologies that allow providers to perform normal duties while working with the telemedicine system to avoid needing additional personnel
Privacy and confidentiality	• Use products made to comply with HIPAA and other federal security and privacy requirements • Use advanced encryption to protect data • Store data on password-protected hard drives and servers • Keep telemedical equipment away from unauthorized visitors or staff
Use and maintenance	• Evaluate the telemedicine EMS system regularly and improve on weaknesses • Establish formal policies, procedures, and rules to establish proper-use practices • Share success stories associated with telemedicine • Build a cadre of staff champions to promote the use of EMS telemedicine • Make use fun: consider hosting contests to encourage buy-in and promote awareness of the telemedicine EMS system

of success is increased if plans are carefully constructed to make sure that the system was best able to meet user needs. As such, we recommend beginning with a requirement (i.e., needs) analysis, which will elucidate areas for improvement within the EMS system. Beginning with knowledge of what could be done better allows for more informed decisions about the type(s) of telemedicine that may be most appropriate and beneficial (Czaplik et al., 2014). Some telemedicine systems may sound really exciting, but if they do not meet a need within the organization or service area, then they are a waste of resources.

If it is decided that a certain telemedicine system is needed to address a specific gap, it will become necessary to obtain stakeholder buy-in. Stakeholders will include clinicians (from both prehospital and hospital settings) as well as organizational leadership (Bashford, 2011). Telemedicine can create suspicion in clinicians who might question how telemedicine will impact them personally. Clinicians who fear punitive action, for instance, might be resistant to the installation of an audio and video recording device onboard an ambulance. Although the purpose may be to document patient status prior to arrival in the ER, clinicians may have concerns that the video might be used to take punitive action against them. To encourage buy-in includes clinicians in the planning stages and addresses their concerns up front. Staff members are more likely to adopt new practices when they have been included in the planning and when their opinions have been considered.

In today's competitive environment, many organizations are trying to do more with less. It will be important to consider available resources in order to determine whether telemedicine is an appropriate and affordable solution. Buy-in from organizational leadership may be necessary to procure the needed resources (e.g., money) to implement telemedicine. It clearly communicates why telemedicine is needed and articulates the expected organizational benefits and explains other alternatives and what makes telemedicine the best option. Of course, resources are not restricted to funds. They also include the time, space, and workforce needed to support the telemedicine system. Remember to consider whether telemedicine can be implemented and sustained with the available workforce and space.

In healthcare, confidentiality and privacy issues are major concerns. Fortunately, Health Insurance Portability and Accountability Act (HIPAA) compliance can be achieved with advanced encryption to protect electronic information. However, encryption protects only the transmission of data. Additional consideration will be needed to ensure that data are protected once they have arrived. For instance, data will need to be kept in a space where they cannot be accessed by unauthorized visitors or staff (Bashford, 2011). Managing HIPAA compliance will depend on the type of telemedicine application adopted and the resources available, but both practitioners and researchers must consider these concerns and find workable solutions.

Finally, adoption of telemedicine will require policies regarding how the system is to be used, tested, and maintained (Bashford, 2011). Once again, these policies and procedures will vary in accordance with the type of telemedicine application selected. They may evolve with use and trial and error, but researchers and practitioners should make initial plans for use and maintenance prior to implementation of telemedicine. These plans should include details for ongoing assessment and evaluation of a system's efficacy and utility.

Much of the research surrounding telemedicine in EMS is dedicated to determining the feasibility of implementing it within a given context, hospital, or EMS system (e.g., Wu et al., 2014). Although such studies are indeed important as an initial first step in determining whether telemedicine can be used to solve a known or perceived deficit in patient care, it is also necessary to conduct research with the purpose of elucidating the benefits that telemedicine in EMS holds for patients, providers, organizations, and communities in terms of care quality, safety, and costs. These types of evaluative studies can inform development and implementation of telemedicine in EMS and help to determine their value to the system. Initial evidence is positive but far from conclusive about the positive implications of telemedicine. Moreover, because there are so many different combinations of applications and purposes of EMS telemedicine, it is especially important to share results, findings, and lessons learned from adoption of telemedicine. Doing so allows others for triangulation of information.

CONCLUSIONS

EMS is characterized by distributed providers who must seamlessly integrate and coordinate to deliver quality patient care. Telemedicine is one mechanism to facilitate the synthesis of this distributed care. Realizing the potential of telemedicine, EMS has utilized such technology primarily for three purposes: documentation, education, and teleconsultation. As established, there is some evidence to demonstrate the promise of telemedicine within EMS (e.g., Bolle et al., 2009); however, most studies are dedicated toward establishing feasibility (Bergrath et al., 2013a; Yperzeele et al., 2014). Given that telemedicine is gaining acceptance within EMS and the production of innovative technology is rapid, the possibilities will broaden mandating the need for future research. For example, how does technology change the provision of patient care? What advantages or disadvantages do patients experience from specific telemedical hardware and software? How is taskwork and teamwork altered with the addition of telemedicine? How do multiteam systems adapt to the presence of telemedicine? Does telemedicine enable organizations to reduce resource waste and cost by better equipping clinicians? What detriments or benefits can communities experience with the addition of telemedicine?

Although these examples simply scratch the surface of the unanswered questions, we encourage researchers and practitioners to collaborate to better navigate these unexplored domains. These questions and others are undoubtedly difficult and complex; however, patients deserve answers to these questions. Evidence should drive change in care; change should not be accelerated exclusively by flashy technology.

REFERENCES

Allely, E.B. (1995). Synchronous and asynchronous telemedicine. *Journal of Medical Systems*, *19*, 207–212.

Barak, A., Hen, L., Boniel-Nissim, M. & Shapira, N. (2008). A comprehensive review and a meta-analysis of the effectiveness of Internet-based psychotherapeutic interventions. *Journal of Technology in Human Services*, *26*, 109–160.

Bashford, C. (2011). *Thinking about EMS telemedicine?* Retrieved from http://www.general-devices.com/files/learning_pdf/EMS_World_Article.pdf.

Bashshur, R.L., Reardon, T.G. & Shannon, G.W. (2000). Telemedicine: A new health care delivery system. *Annual Review of Public Health*, *21*, 613–637.

Bergrath, S., Czaplik, M., Rossiant, R., Hirsch, F., Beckers, S.F., Valentin, B. et al. (2013a). Implementation phase of a multicenter prehospital telemedicine system to support paramedics: Feasibility and possible limitations. *Scandinavian Journal of Trauma, Resuscitation, and Emergency Medicine*, *21*, 1–10.

Bergrath, S., Rossaint, R., Lenssen, N., Fitzner, C. & Skorning, M. (2013b). Prehospital digital photography and automated image transmission in an emergency medical service: An ancillary retrospective analysis of a prospective controlled trial. *Scandinavian Journal of Trauma, Resuscitation* & *Emergency Medicine*, *21*, 1–9.

Bolle, S.R., Larsen, F., Hagen, O. & Gilbert, M. (2009). Video conferencing versus telephone calls for team work across hospitals: A qualitative study on simulated on simulated emergencies. *Biomed Central Emergency Medicine*, *9*, 22.

Brunetti, N.D., Dellegrottaglie, G., Lopriore, C., Di Giuseppe, G., de Gennaro, L., Lanzone, S. et al. (2014). Prehospital telemedicine electrocardiogram triage for a regional public emergency medical service: Is it worth it? A preliminary cost analysis. *Clinical Cardiology*, *37*, 140–145.

Cabrera, M.F., Arredondo, M.T. & Quiroga, J. (2002). Integration of telemedicine into emergency medical services. *Journal of Telemedicine and Telecare*, *8*, 12–14.

Carenzo, L., Barra, F.L., Ingrassia, L., Colombo, D., Costa, Al. & Corte, F.D. (2014). Disaster medicine through Google Glass. *European Journal of Emergency Medicine*, *22*, 222–225.

Currell, R., Urquhart, C., Wainwright, P. & Lewis, R. (2010). Telemedicine versus face to face patient care: Effects on professional practice and health care outcomes. *Cochrane Database of Systematic Reviews*, *2*, 1–35.

Czaplik, M., Bergrath, S., Rossaint, R., Thelen, S. Brodziak, T., Valentin, B. et al. (2014). Employment of telemedicine in emergency medicine. *Methods of Information Medicine*, *53*, 99–107.

Demaerschalk, B.M., Bobrow, B.J., Raman, R., Kiernan, T.J., Aguilar, M.I., Ingall, T.J. et al. (2010). Stroke team remote evaluation using a digital observation camera in Arizona: The initial Mayo Clinic experience trial. *Stroke*, *41*, 1251–1258.

Deshpande, A., Khoja, S., Lorca, J., Mckibbon, A., Rizo, C., Husereau, D. et al. (2009). Asynchronous telehealth: A scoping review of analytic studies. *Open Medicine*, *3*, 69–91.

Field, M.J. (1996). *Telemedicine: A guide to assessing telecommunications in health care*. Washington, DC: National Academies Press.

Field, M.J. & Grigsby, J. (2002). Telemedicine and remote patient monitoring. *Journal of American Medical Association*, *288*, 423–425.

Garza, M.A. (1998). Telemedicine: The key to expanded EMS or an expensive experiment? *JEMS*, *23*, 28–38.

Grigsby, J. & Sanders, J.H. (1998). Telemedicine: Where it is and where it's going. *Annals of Internal Medicine*, *129*, 123–127.

Güler, N.F. & Ubeyli, E.D. (2002). Theory and applications of telemedicine. *Journal of Medical Systems*, *26*, 199–220.

Haney, M., Silvestri, S., Van Dillen, C., Ralls, G., Cohen, E. & Papa, L. (2012). A comparison of tele-education versus conventional lectures in wound care knowledge and skill acquisition. *Journal of Telemedicine and Telecare*, *18*, 79–81.

Haskins, P.A., Ellis, D.G. & Mayrose, J. (2002). Predicted utilization of emergency medical services telemedicine in decreasing ambulance transports. *Prehospital Emergency Care*, *6*, 445–448.

Hersh, W.R., Helfand, M., Wallace, J.A., Kraemer, D., Patterson, P., Shapiro, S. et al. (2002). A systematic review of the efficacy of telemedicine for making diagnostic and management decisions. *Journal of Telemedicine and Telecare*, *8*, 197–209.

Hersh, W.R., Hickam, D.H., Severance, S.M., Dana, T.L., Krages, K.P. & Helfand, M. (2006a). Diagnosis, access and outcomes: Update of a systematic review of telemedicine services. *Journal of Telemedicine and Telecare*, *12*, 3–31.

Hersh, W.R., Hickam, D.H., Severance, S.M., Dana, T.L., Krages, K.P. & Helfand, M. (2006b). *Telemedicine for the Medicare population: Update*. Rockville, MD: Agency for Healthcare Research and Quality.

Hersh, W.R., Wallace, J.A., Patterson, P.K., Kraemer, D.F., Nichol, W.P., Greenlick, M.R. et al. (2001). *Telemedicine for the Medicare population: Pediatric, obstetric, and clinician-indirect home interventions in telemedicine*. Rockville, MD: Agency for Healthcare Research and Quality.

Kaplan, S.H., Greenfield, S. & Ware, J.E. (1989). Assessing the effects of physician–patient interactions on the outcomes of chronic disease. *Medical Care*, *27*, S110–S127.

Loane, M.A., Bloomer, S.E., Corbett, R., Eedy, D.J., Hicks, N., Lotery, H.E. et al. (2000). A comparison of real-time and store-and-forward teledermatology: A cost–benefit study. *British Journal of Dermatology*, *143*, 1241–1247.

Ong, L.M.L., De Haes, J.C.J.M., Hoos, A.M. & Lammes, F.B. (1995). Doctor–patient communication: A review of the literature. *Social Science & Medicine*, *40*, 903–918.

Perednia, D.A. & Allen, A. (1995). Telemedicine technology and clinical applications. *Journal of American Medical Association*, *273*, 483–488.

Roashan, R. (2014). *A dedicated study on telehealth that provides detailed analysis of the world market*. Englewood, CO: IHS Pressroom.

Rortgen, D., Bergrath, S., Rossaint, R., Beckers, S.K., Fischermann, H., Na, I. et al. (2013). Comparison of physician staffed emergency teams with paramedic teams assisted by telemedicine: A randomized, controlled simulation study. *Resuscitation*, *84*, 85–92.

Sable, C., Reyna, M. & Holbrook, P.R. (2009). Telemedicine applications in pediatrics. In C.U. Lehmann, G.R. Kim & K.B. Johnson (Eds.), *Pediatric informatics: Computer applications in child health* (pp. 279–292). New York, Springer.

Smith, A.C. (2007). Telemedicine: Challenges and opportunities. *Expert Review of Medical Devices*, *4*, 5–7.

Smith, A.C., Bensick, M., Armfield, N., Stillman, J. & Caffery, L. (2005). Telemedicine and rural health care applications. *Journal of Postgraduate Medicine*, *51*, 286–293.

Tulu, B., Chatterjee, S. & Laxminarayan, S. (2005). A taxonomy of telemedicine efforts with respect to applications, infrastructure, delivery tools, type of setting and purpose. *Proceedings of the 38th Hawaii International Conference on System Science*, 1–10.

Wells Fargo Insurance Services (2014). *The growing trend toward telehealth*. Retrieved from https://wfis.wellsfargo.com/insights/whitepapers/Documents/WP_TheGrowingTrendTowardTelehealth.pdf.

Widmer, A. & Mimuller, H. (2014). Using Google Glass to enhance pre-hospital care. *Swiss Medical Informatics*, *30*. Retrieved from http://www.medical-informatics.ch/index.php/smiojs/article/viewFile/316/359.

Wu, T.C., Nguyen, C., Ankrom, C., Yang, J., Persee, D., Vahdiy, F. et al. (2014). Prehospital utility of rapid stroke evaluation using in-ambulance telemedicine: A pilot feasibility study. *Stroke*, *45*, 2342–3247.

Yperzeele, L., Van Hooff, R., De Smedt, A., Espinoza, A.V., Van Dyck, R., Van de Casseye, R. et al. (2014). Feasibility of ambulance-based telemedicine (FACT) study: Safety, feasibility and reliability of third generation in-ambulance telemedicine. *PLoS ONE*, *9*, e110043.