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Geriatric Telemedicine: Background and Evidence for Telemedicine as a Way to Address the Challenges of Geriatrics

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Objectives: The global population of elderly people is increasing at a remarkable rate, which may be expected to continue for some time. Older patients require more care, and with the current model of care delivery, the costs may be expected to rise, although higher cost is unsustainable. For this reason, a new pattern of practice is needed. Telemedicine will be presented as a highly effective and necessary tool in geriatrics. **Methods:** This review will present some of the background and evidence for telemedicine as a way to address the challenges of geriatrics through geriatric telemedicine. Some of the evidence for the value of telemedicine as a tool for physicians and healthcare systems is presented. **Results:** Telemedicine offers many means to address the problems of geriatric care in creative ways. The use of electronic medicine, telecommunications, and information management has now found its way into the very fabric of health care. The use of telemedicine is a fait accompli in much of the world, and it continues to have an increasing role deeply imbedded in our electronic practices coupled with social media. **Conclusions:** The evidence for successful incorporation of telemedicine into practice is abundant and continues to accrue. This is a great opportunity for medical practice to evolve to new levels of engagement with patients and new levels of attainment in terms of quality care.

Keywords: Telemedicine, Geriatrics, Informatics

I. Introduction

Geriatrics is that specialty of medicine that addresses the health needs of the elderly. Telemedicine is the use of information technology and telecommunications to support healthcare at a distance. In this review, the main issues of ge-

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riatics with regard to scope, disease burden, demographics and challenges will be addressed. Telemedicine will be presented as a highly effective and necessary tool in geriatrics. Geriatrics is a subspecialty of internal medicine and primary care that was named in 1909 by Ignatz Leo Nascher. The specialty was recognized by a certificate of special qualifications under the Internal Medicine board certification by the American Board of Medical Specialties in 1988 [1]. That is of course a very recent date and indicates the late recognition of the care of the aging as a special matter.

Children's hospitals became prominent in the 19th century, but nothing comparable happened at that time in the care of the elderly. The reason is actually simple. There were hardly enough old people to attract attention! In 1900, most newborns could not be expected to live past 50. Now, life expectancy at birth exceeds 80 years in many countries [1], and this demographic trend is continuing. In 2010, there were perhaps 524 million people over 65 years in the world,

whereas in 2050 that number will be 1.5 billion. Interestingly, most of that increase will be in the developing world. In about five more years, people in the world older than 65 years will exceed the number of people under age 5. The fastest growing subset of the elderly is those past 85. The reasons are neither a triumph of medicine nor wholly an accident of sociology. The fertility rate in the world is rapidly declining and life expectancy is climbing. Infectious disease has been generally contained, human immunodeficiency virus (HIV) notwithstanding. Mortality in older populations has been sharply reduced with great inroads in relation to cardiovascular disease, cancer, and diabetes. However, unlike infections, these conditions are not cured; they are curtailed. The implications for healthcare are enormous. At the beginning of the 20th century the principle health threats were infectious diseases. Today the main threats are non-communicable diseases, including heart, stroke, cancer, diabetes, hypertension, and dementia [2]. Hence, geriatrics is a challenging area.

II. Geriatric Issues

Older people present a variety of challenges in healthcare. The previous model of healthcare throughout the world might be termed 'incident care'. In this model, someone became aware of a health problem, sought the advice of a physician, received a diagnosis, and usually some treatment converted the condition into a short-term illness. However, among older patients, 92% have at least one chronic disease, and 77% suffer from at least two [3]. In other words, there has been a huge increase in older people who are always sick rather than intermittently sick. The likelihood of actually healing one of these chronic disorders is small. The objective of care and management is to reduce the morbidity and slow the progression. Thus, longitudinal management of progressive disease and anticipation of complications are the hallmarks of successful geriatric practice.

There are some sociological considerations in the aging of the world. In traditional society there were not so many old people. Each had several offspring and an even larger number of grandchildren. They retired rather early and tended to live in an extended family setting. Today, with declining birth rates, the elderly may have one or no children. They may have only one grandchild; thus, the pool of family members to care for them is limited. Furthermore, they tend to live so long that the intimacy of family may have passed. As an offset, men are gaining in the longevity statistics and may survive with their spouses for mutual support.

For many reasons the elderly do not necessarily want to live with their families. Preference for independent living

is growing as children seem to have more career demands with both man and wife employed. For older patients, their independence is fragile to say the least. The chronic diseases they carry may progress at varying rates, and the possibility of a devastating stroke, cardiac decompensation, or diabetic complications may suddenly take away the possibility of independent living. In the United States, an older person has a fall every 15 seconds requiring a hospital visit, and every 28 minutes there is a fatal fall. Then there is the terrible problem of dementia. In a study among the countries of the Organization for Economic Cooperation and Development, the disease burden of Alzheimer disease/dementia was some 30 million. The prevalence at 65 years is about 3% and then doubles every five years. These devastating numbers seem to have no mitigating medical intervention. We just know that a typical chronically ill person has a limited network of family for care, tries to live independently, and is subject to dementia that will eventually make them incompetent for independent living [2].

In summary, geriatrics is a medical specialty which with primary care is struggling with an ever increasing population of chronically ill patients who may live a long time with care but are subject to myriad complications. The objective of longitudinal care is to limit disease progress, diagnose problems such as cancer early, look for early signs of deterioration, and support healthy lifestyles. Rather like parents in the case of children, the care of older patients often involves family members as caregivers. From the standpoint of social planning, the paramount ethical issue is patient autonomy. The paramount fiscal issue is the huge increase in the cost of patients who will require frequent interventions, long-term hospital care, and institutional care. Patients may perceive the desperation of the situation in that the largest incidence for suicide in the United States is among men past age 85. The current mode of health care involving visits to clinics at rare intervals is an overwhelming challenge of expense and personnel, and there is no resource in sight for meeting the demand. The crucial expectation is for medical care to anticipate the crises, avoid them, limit office visits, limit emergency visits, anticipate mental decline, intervene only when needed, and support the social net.

However, the ability of the health community to respond to this huge challenge is not apparent or sufficient. In the United States, there are 784,633 physicians in practice for a population of some 320 million [4,5]. In the 1981 Work Force (Graduate Medical Education National Advisory Committee) report, an excess of physicians was perceived and medical education was limited. By 2000, it was clear that something in the calculation was wrong [6]. With no in-

crease in physician output in 20 years, the physician shortage was said to be staggering. The shortfall for older patients is said to be 70,000. In the United States, the steady-state output of physicians was only 16,000 per year for a population that had increased to 320 million. If all medical graduates committed to geriatrics, it would take many years to train enough of them for the task. In fact, the number of trainees in geriatrics is declining [7], and in 2013 there were only 259 new fellows in the entire country.

One possibility is that any adult primary care physician could fill the gap; however, primary care is not doing very well in the United States either. The Association of American Medical Colleges has recommended a 30% increase in the number of enrollees and an additional 30 medical schools [8]. Yet despite the need for increased care of geriatric patients, the American Geriatric Society has only 6,000 members [9]. Thus, the number of physicians in the world is not going to remotely meet the geriatric need.

Home healthcare is marvelous and terribly important. However, if the shortage of physicians is deep in the developed world, the shortage of nurses for home health is hopeless. We cannot send out an army of health professionals to meet with patients often enough to avert health crises. In the United States, a 17% expenditure of the GDP [10] on healthcare simply is not going to expand by say 25% to account for our current expectations for delivery of care to the elderly. Any proposed increase in health costs to the nation will be roundly rejected. Our aim has been to reduce healthcare expenditures; however, demographics are contrary to that expectation. Furthermore, as patients become more and more frail, they are less able to come on their own to intermittent care visits. Unfortunately, when they are in nursing facilities, access to specialist care is further confounded by transportation challenges.

In conclusion, there is a growing crisis in providing proper longitudinal health care to the elderly in our current practice modes. What are the alternatives? Here is the story for health informatics and telemedicine.

III. Telemedicine in General

Telemedicine was given its name by Kenneth Bird in 1975, and the American Telemedicine Association was established in 1994. The name changes regularly. E-health, telehealth, telecare, and other terms are in reality synonyms. Modifiers for mobility like m-health are not alien. The use of telecommunications to support healthcare came first with videoconference access to specialty care. Specialists could be called and provided advice to generalists in remote areas. The no-

tion of using telecommunications for medicine has a history as long as any form of distant communication. However, analog television communication was terribly expensive.

The introduction of satellite connectivity in 1962 made the distance less prohibitive but the cost exploded. The practicality of telemedicine shares a history with the transistor, which was commercialized by Bell Laboratories and was the subject of the Nobel Prize in Physics awarded to Shockley, Bardeen, and Hoes in 1956 [11]. The semiconductor made the digital rendering of data possible, including medical data. The vast composite of the human condition could be stored and transmitted in digital form across any telecommunication medium. The application of transistors to personal computing has a long history, but for the purpose of timelines, the introduction of the Apple computer in 1976 was seminal [12]. Thereafter, management of data in small, compact, highly effective modules became an everyday practice.

The use of digital imaging became cheap, approachable, and ubiquitous. Today, the storage of huge amounts of patient data, including images and live transmission is a simple and cheap process. The combination of telecommunications and information management constitutes a tool inviting the imagination of practitioners and attacking the very basic issues of cost and access. Any practitioner can work from a desk to any point of need and can provide coherent and definitive diagnosis and management expertise. The mantra of telemedicine is simple: *whatever, wherever, whenever*. The growth of telemedicine has been greatly accelerated by wireless communication for devices, cellular telephony, fiberoptic connectivity, and digital records.

The US American Recovery and Reinvestment Act of 2009 had many components to stimulate the economy after the great recession crisis. Among these were the Broadband Initiative, which was intended to bring great bandwidth to almost every village and school in the country. Also, the act included the Health Information Technology for Economic and Clinical Health (HITECH) provisions, requiring the staged expansion of electronic medical records, which were effective, and through such a system, healthcare providers could communicate with one another throughout the US in meaningful ways. This has not yet been fully realized [13]. In fact, the current surge of telemedicine would not have happened without the ubiquity of the Internet, which came into large-scale use in 1994 [14]. The rapid expansion of Internet Protocol version 6 since 2008 means that there are enough Internet Protocol unique addresses for every person and device on the planet with ample room for growth. Thus, we have the Internet of things, and this makes telemedicine so much more feasible. The Internet is not exactly free, but it

is certainly cheap. The drop in cost from required but fabulously expensive satellite connectivity to Internet connectivity is simply astounding.

These innovations and applications come at a time when the costs of medical care are soaring and the geriatric challenge is upon us. Please note that the increase of healthcare costs is upward and exponential while the cost of telecommunication and electronic support is declining in the opposite direction. This is perhaps the most felicitous coincidence in the history of human health. There is no better match in healthcare for improvement and cost saving through telemedicine than the care of the elderly. The population has a huge disease burden, which is not sustainable with the cost constraints of traditional incidental care. The need for creative solutions is urgent and they are available.

IV. Geriatric Telemedicine

The provision of telemedicine services for the elderly is not particularly different from any other medical matters. There is a common belief that high-end electronics and telecommunications cannot be used by the elderly because they have limited computer and technology skills. In the developed world, the current rapid growth in the aging population has occurred as a result of what has been dubbed the baby boom. This spike in births in the United States spanned from 1946 to 1964. The first of that group turned 65 years in 2010. The people entering the ranks of the elderly now are not the same as those very elderly who were born before the Second World War. The upcoming group demanded the Internet in 1994. They created the market for the cell phone when it was introduced in 1973. They all seem to have smartphones now. They created the demand for the personal computer in the late 1970s. They suffered thorough the technical frustrations of floppy disks and every iteration of Windows software. This group followed and cheered the magic of the space program and invented the information age. Perhaps they are not actively interested in every nuance of innovation, but in general, they are technically competent and savvy about applications they perceive as having value for them. Unless they have cognitive difficulties, the upcoming elderly will be the vanguard of electronic medicine in geriatrics if we invite them and listen to them without prejudice.

Therefore, there is a need for telemedicine in the elderly, and they are competent to participate in the abundant technology available. Is telemedicine useful? Telemedicine has been assessed in many ways, but a brief review might be helpful. The American Telemedicine Association has issued 14 practice guidelines for telemedicine in a variety of ap-

plications from pathology to dermatology to diabetes. The guidelines in many cases are identical with guidelines issued by the special organizations [15]. The early reports on telemedicine were often anecdotal with an emphasis on the technology. Now, publications are heavily weighted to randomized controlled trials and telemedicine can be studied as a matter of meta-analysis in the Cochrane Database [16]. In the early days of telemedicine, the cynical view was that a telemedicine program would close when the grant was spent. As a corollary, telemedicine would not have any inherent value until someone finally paid for it.

Here is the news. Telemedicine in the United States is a 5 billion dollar per year business. The Veterans Health System has 70,000 telemedicine visits per year and they declare how much it saves money in the largest health system in the United States. Medicare insurance for the elderly pays for telemedicine services. The same is true for the Medicaid program for the poor. More than half the states now have laws requiring private insurers to pay for telemedicine for its subscribers. Why is telemedicine now being paid for? Its worth has been demonstrated, and the payers are convinced.

Telemedicine was initially considered a solution to access problems. Demonstrations were carried out in remote parts of the world, and its relevance to highly developed communities was not clear. However, in the past 15 years, telemedicine has been used in all manner of healthcare delivery, and has been integrated into the fabric of overall healthcare. When telemedicine was a desperate measure for access, equivalence to standard office care was not an issue. Currently, equivalence is of the utmost importance, and demonstration of at least non-inferiority has been crucial to acceptance by patients, physicians, regulators, and payers.

Videoconference encounters have been shown in every way to be comparable to face-to-face in terms of diagnostic accuracy, interrater variation, patient acceptance, and cost. The best survey in this regard is in the definitive textbook by Bashshur and Shannon [17]. With regard to image transfer standards, radiology can demand the highest DICOM standard from transmission technology and is not compromised. Images produced by smartphone videoconferencing, microscopy, dermatology, and pathology are completely satisfactory. These facts are really technical matters and are not the subject of this clinical review.

V. Clinical Matters in Geriatric Telemedicine

1. Chronic Disease

Since the elderly have an excess burden of chronic disease, what is the evidence that longitudinal management by tele-

medicine is helpful? An extensive review by Bashshur et al. [18] has been used by US Congressional Committees in policy decisions. The data clearly indicates that the use of telemedicine is superior to office visits in terms of emergency visits, hospitalizations, complications, and quality of life for diabetes [19], hypertension, pain [20], congestive heart failure [21], cancer care, rehabilitation after stroke [22], and dementia [23].

2. Home Care

The best place for older people to live is where they want to live, and that is almost always at home. Yet when they are frail and forgetful, and have limited mobility, home may be a very dangerous place. Extending the practice of their medical team to the home is a great strategy for retention of independence and early recognition of problems. Simple monitoring devices can assess gait, pace, activity in general, and adherence to a medical regimen. Sleep, falls and body functions. Monitoring of blood pressure, pulse, oxygen saturation, and weight can be done with non-invasive sensors, and the data can be transferred wirelessly to a computer for transmission to a health management office. The management site can look for alerts and trends with a response that is anywhere from a call to a summon of emergency personnel to the home, to making a small change in medication with a message back to the patient.

Cheap sensors, either passive or interactive, can capture the essence of a health situation at home and the managing physician can embrace that home with much of the immediate care available otherwise only in the office or hospital. Instead of a visit on demand from time to time or regularly every month, surveillance can inform and empower the physician about the situation and allow timely and effective intervention. A smart home with sensors and alerts can assess the environment for such subtleties as a running tub, the temperature of the water, the age of materials in the refrigerator, the consumption of food, water, and medications as well as the urgent situations indicated by the presence of smoke, carbon monoxide, or excess heat. Mobile phones can provide information support and alerts to the home bound in ways that were hard to imagine five years ago.

There are thousands of medial apps for the smartphones that can be incorporated into comprehensive plans for home health by a managing physician with the fullest consent of the patient. Home healthcare performed in person by skilled nursing teams is certainly well established and broadly practiced. However, that intervention cannot be provided hourly or after hours. Telemedicine interventions in home health are provided around the clock. Furthermore, the home

health nurse alone when confronted by a worrisome change can only order transfer to definitive diagnosis and care or communicate by phone with the managing physician. Instead, telemedicine as an augmentation to the physical visit, can be used by nurses to transfer images to evaluate skin lesions or gait, to discuss telemetry data, and receive new instructions which otherwise would only be possible after a visit by the patient to the physician's office.

Another use of telemedicine in home healthcare is the critical support of home caregivers who are subject to exhaustion, terrible stress, and a strong urge at times to give up and send the house-bound patient to a facility. Telemedicine creates a virtual team that can include the home caregiver and dispel the sense of isolation. Home is best as long as possible. The alternative of travel to a fixed health facility is tedious, labor intensive, perhaps painful, and expensive.

3. Health Maintenance

Smartphone programs are excellent for behavior modification in terms of weight, diet, smoking cessation, alcohol abuse, medication, and exercise. The impact, according to published reports, has largely been confined to teenagers, caregivers, and veterans suffering from post traumatic stress disorder. However, the applicability to the elderly has no apparent barrier, and there are examples of success in the elderly [24]. Increasingly, medical practices are using social media to enrich medical practice through enhanced communication and reminders to reinforce a regimen. This is surely applicable to the elderly as to all ages.

The loss of memory and neural plasticity is perhaps the most difficult matter in the care of the elderly. Considerable research is ongoing to find the basis of Alzheimer disease and dementia in general. There are numerous devices and programs available on hand held devices to exercise the memory and perhaps slow the progress of dementia. The value is yet to be determined; however, it is likely that such programs will be integral to health maintenance in the future.

4. Nursing Home Care

In a typical nursing home, the population is generally elderly, and nursing care is of paramount importance. It is carefully monitored by a physician, and outcomes are carefully analyzed by authorities. However, there is usually no physician present, and if there is any medical question, the first resort is transfer to an emergency medical facility. The same is true for all adult-living facilities. The regular use of telemedicine to bring the center into close contact with a medical unit can reduce visits dramatically [25].

VI. Impact on Practice

The traditional practice of medicine is not easily reconfigured to the inclusion of telemedicine. The practitioner must learn new things. The culture of the practice must evolve. The impact on practice has proven far more challenging than the technology or patient acceptance [26]. Why is telemedicine a threat to physicians? In most countries physicians have a very high workload, and the idea of adding any more is just not possible. The cost of introducing telemedicine equipment into the office is formidable.

Also in many venues, the payment for these services is not clear or not adequate. In the ideal situation, without cost or staff concerns, the impact is very positive because the patient care is so much better. In the Veterans Health System in the United States, doctors are all on staff, and their attraction to telemedicine is that it actually takes less time! A well coordinated telemedicine clinic is very efficient with almost no delay between patients. Furthermore, in such a system all records are immediately available by computer. For an office physician who has proper access to technology, the overhead costs of telemedicine visits are in fact negligible compared to maintaining an office, parking, many waiting rooms, staff, etc.

Telemedicine must be integrated into the workflow of physicians and staff in such a way as to make it an improvement and not an add-on. If telemedicine is left to the singular efforts of a physician, the task is very difficult. In the United States, there is a strong movement for telemedicine to be freestanding and not managed by the personal physician. This can certainly be seen as a threat to the sanctity of physician-patient relations. However, the attraction of this innovation to patients is undeniable, and the success is such that there are considerable efforts to accredit the freestanding activities also the best practice standards possible. The American Telemedicine Association is active in this area. Should personal physicians be left behind? Certainly not!

The notion that some electronic beast is taking away our patients is a bleak one and contrary to the best traditions of medicine. Telemedicine is inevitable according to all economic trends and public opinion. The approach for concerned and conscientious physicians is to learn about the matter, to become leaders rather than followers, and to bring this tool into the daily practice of medicine rather than having a disruptive technology eroding our basic bond of patient care [27].

The question regularly arises as to whether or not telemedicine is in fact a medical specialty. That is not an ideal outcome. Telemedicine is a tool, not a specialty. The chal-

lenge for biomedical engineers, software engineers, and the telecommunications community is to make the technology as transparent as possible such that the average physician and patient will not find it intimidating. The challenge to physicians is to acquire sufficient facility with the technology as to be a competent user not subject to a profound reliance on technical personnel. Also, the physician should know enough to tell the engineers what is needed. Finally, the physician should know enough to be a prudent user of new technology. Telemedicine like any other tool in medicine can be poorly used, and people can be hurt, or certainly, they can be poorly served. The good practitioner will understand the tools, their application, safeguards and nuances for best practice. There are many courses available and a little time to become comfortable is time well invested in the future of practice.

VII. Conclusion

This brief review has shown that our current practice of care for the elderly is simply not going to succeed as the numbers of elderly patients continues to grow. A new pattern of practice is needed. Some of the evidence for the value of telemedicine as a tool for physicians and healthcare systems was presented. The use of telemedicine is a fait accompli in much of the world, and it continues to have an increasing role that is deeply imbedded in our electronic practices coupled with social media. This is a great opportunity for medical practice to evolve to new levels of engagement with our patients and new levels of attainment in terms of quality care.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

References

1. Brubaker JK. The birth of a new specialty: geriatrics. *J Lanc Gen Hosp* 2008;3(3):105-7.
2. World Health Organization; National Institute on Aging. Global health and aging [Internet]. Geneva, Switzerland: World Health Organization; 2011 [cited at 2015 Oct 1]. Available from: www.who.int/ageing/publications/global_health/en/.
3. National Council on Aging. Health aging facts [Internet]. Arlington (VA): National Council on Aging; c2015 [cited at 2015 Oct 1]. Available from: <https://www.ncoa.org/news/resources-for-reporters/get-the-facts/healthy->

- aging-facts/.
4. Statista. Statistics and facts about U.S. physicians [Internet]. New York (NY): Statista; c2015 [cited at 2015 Oct 1]. Available from: <http://www.statista.com/topics/1244/physicians/>.
 5. World Health Organization. Country statistics: United States of America [Internet]. Geneva, Switzerland: World Health Organization; c2015 [cited at 2015 Oct 1]. Available from: <http://www.who.int/countries/usa/en/>.
 6. Iglehart JK. The woeful neglect of health care workforce issues. *Health Aff* 2002;21(5):7-8.
 7. Span P. Even fewer geriatricians in training [Internet]. New York (NY): The New York Times; 2013 [cited at 2015 Oct 1]. Available from: <http://newoldage.blogs.nytimes.com/2013/01/09/even-fewer-geriatricians-in-training/?module=BlogPost-Title&version=Blog%20Main&action=Click&pgtype=Blogs®ion=Body>.
 8. Association of American Medical Colleges. Workforce data and reports [Internet]. Washington (DC): Association of American Medical Colleges; c2015 [cited at 2015 Oct 1]. Available from: <https://www.aamc.org/data/workforce/reports>.
 9. American Geriatric Society [Internet]. New York (NY): American Geriatric Society; c2015 [cited at 2015 Oct 1]. Available from: <http://www.americangeriatrics.org/>.
 10. Central Intelligence Agency. The world factbook [Internet]. Washington (DC): Central Intelligence Agency; c2015 [cited at 2015 Oct 1]. Available from: <https://www.cia.gov/library/publications/the-world-factbook/>.
 11. Nobel Prize [Internet]. [place unknown]: Nobel Prize; c2015 [cited at 2015 Oct 1]. Available from: <http://www.nobelprize.org/>.
 12. Computer History Museum. Timeline of computer history [Internet]. Mountain View (CA): Computer History Museum; c2015 [cited at 2015 Oct 1]. Available from: <http://www.computerhistory.org/timeline/>.
 13. Public Law 111-5 (February 17, 2009) [Internet]. Washington (DC): Department of Health & Human Services; c2015 [cited at 2015 Oct 1]. Available from: <http://www.hhs.gov/ocr/privacy/hipaa/understanding/coveredentities/hitechact.pdf>.
 14. Leiner BM, Cerf VG, Clark DD, Kahn RE, Kleinrock L, Lynch DC, et al. Brief history of the Internet [Internet]. Reston (VA): Internet Society; c2015 [cited at 2015 Oct 1]. Available from: <http://www.internetsociety.org/brief-history-internet>.
 15. American Telemedicine Association [Internet]. Washington (DC): American Telemedicine Association; c2015 [cited at 2015 Oct 1]. Available from: <http://www.americantelemed.org/>.
 16. Cochrane Community (beta) [Internet]. London: The Cochrane Collaboration; c2015 [cited at 2015 Oct 1]. Available from: <http://community.cochrane.org/>.
 17. Bashshur RL, Shannon GW. History of telemedicine: evolution, context, and transformation. New Rochelle (NY): Mary Ann Liebert; 2009.
 18. Bashshur RL, Shannon GW, Smith BR, Alverson DC, Antoniotti N, Barsan WG, et al. The empirical foundations of telemedicine interventions for chronic disease management. *Telemed J E Health* 2014;20(9):769-800.
 19. Bashshur RL, Shannon GW, Smith BR, Woodward MA. The empirical evidence for the telemedicine intervention in diabetes management. *Telemed J E Health* 2015; 21(5):321-54.
 20. Levine M, Richardson JE, Granieri E, Reid MC. Novel telemedicine technologies in geriatric chronic non-cancer pain: primary care providers' perspectives. *Pain Med* 2014;15(2):206-13.
 21. Lemay G, Azad N, Struthers C. Utilization of home telemonitoring in patients 75 years of age and over with complex heart failure. *J Telemed Telecare* 2013;19(1):18-22.
 22. Chumbler NR, Li X, Quigley P, Morey MC, Rose D, Griffiths P, et al. A randomized controlled trial on stroke telerehabilitation: the effects on falls self-efficacy and satisfaction with care. *J Telemed Telecare* 2015;21(3): 139-43.
 23. Postma-Nilsenova M, Postma E, Tates K. Automatic detection of confusion in elderly users of a web-based health instruction video. *Telemed J E Health* 2015;21(6): 514-9.
 24. Makai P, Perry M, Robben SH, Schers HJ, Heinen MM, Olde Rikkert MG, et al. Evaluation of an eHealth intervention in chronic care for frail older people: why adherence is the first target. *J Med Internet Res* 2014;16(6): e156.
 25. Shah MN, Gillespie SM, Wood N, Wasserman EB, Nelson DL, Dozier A, et al. High-intensity telemedicine-enhanced acute care for older adults: an innovative health-care delivery model. *J Am Geriatr Soc* 2013;61(11):2000-7.
 26. Esterle L, Mathieu-Fritz A. Teleconsultation in geriatrics: impact on professional practice. *Int J Med Inform* 2013;82(8):684-95.
 27. Yellowlees P, Odor A, Patrice K, Parish MB, Nafiz N, Iosif AM, et al. Disruptive innovation: the future of healthcare? *Telemed J E Health* 2011;17(3):231-4.