

# Original Research

## The Empirical Foundations of Telemedicine Interventions in Primary Care

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### Abstract

**Introduction:** This article presents the scientific evidence for the merits of telemedicine interventions in primary care. Although there is no uniform and consistent definition of primary care, most agree that it occupies a central role in the healthcare system as first contact for patients seeking care, as well as gatekeeper and coordinator of care. It enables and supports patient-centered care, the medical home, managed care, accountable care, and population health. Increasing concerns about sustainability and the anticipated shortages of primary care physicians have sparked interest in exploring the potential of telemedicine in addressing many of the challenges facing primary care in the United States and the world. **Materials and Methods:** The findings are based on a systematic review of scientific studies published from 2005 through 2015. The initial search yielded 2,308 articles, with 86 meeting the inclusion criteria. Evidence is organized and evaluated according to feasibility/acceptance, intermediate outcomes, health outcomes, and cost. **Results:** The majority of studies support the feasibility/acceptance of telemedicine for use in primary care, although it varies significantly by demographic variables, such as gender, age, and socioeconomic status, and telemedicine has often been found more acceptable by patients than healthcare providers. Outcomes data are limited but overall suggest that telemedicine interventions are generally at least as effective as traditional care. Cost analyses vary, but telemedicine in primary

care is increasingly demonstrated to be cost-effective. **Conclusions:** Telemedicine has significant potential to address many of the challenges facing primary care in today's healthcare environment. Challenges still remain in validating its impact on clinical outcomes with scientific rigor, as well as in standardizing methods to assess cost, but patient and provider acceptance is increasingly making telemedicine a viable and integral component of primary care around the world.

**Key words:** primary care, telemedicine, evidence, outcomes, cost

### Introduction

This is the fifth in a series of articles aimed at assessing the empirical foundations of telemedicine interventions in clinical applications as reported in the scientific literature. The main objective of this article, like the others, is to ascertain the evidence regarding the feasibility, acceptance, and effects of telemedicine interventions—in this case primary care. Whereas the previous articles were focused on well-defined disease entities served by one or more medical specialties and subspecialties, this article focuses on a form of medical care practice provided by a group of physicians that encompasses all aspects of healthcare delivery, but one with a somewhat amorphous content and with imprecise and shifting boundaries. Although the topical areas chosen as the focal points for the previous articles were quite complex in and of themselves, each with various manifestations, it was relatively straightforward to explain what they are and to provide basic information regarding their etiology, epidemiology, and cost. This information was deemed as appropriate context for the review and analysis of the empirical evidence regarding the impact of telemedicine interventions in those domains.

Here, we focus on primary care, an inclusive concept that refers to a more general practice of medicine compared with practice that is more narrowly focused. It has been heralded as “the backbone of the nation's healthcare system.”<sup>1</sup> But, its potential is still largely unrealized.<sup>2,3</sup> Despite several decades of scholarly analysis and advocacy, primary care is still subject to speculation,<sup>4-6</sup> and some view it as facing an uncertain

future.<sup>1,7</sup> Nonetheless, most healthcare scholars who focused on this subject agree that primary care is and will remain a critical component of medical practice in the United States and elsewhere.<sup>8</sup> The anticipated shortage of primary care physicians and services raises concern regarding the sustainability of the current health system. Importantly, primary care has been at the core of numerous attempts and initiatives in healthcare reform over the last several decades in the United States, including patient-centered care, the medical home, managed care, accountable care, and population health.

As in the other articles in this series, we start out with a brief discussion regarding the origin, rationale, and scope of primary care, followed by a brief discussion of views regarding its future and the challenges for its implementation. This is followed by a brief description of the methodology used in reviewing the empirical evidence, the time frame, and the eligibility criteria for inclusion in this analysis. The bulk of the article will be devoted to the results of credible research, including highlights of research methods used, technological configuration, types of interventions, and finding highlights pertaining to the feasibility/acceptance and, most importantly, the effects of telemedicine interventions in primary care.

#### PRIMARY CARE: ORIGIN, RATIONALE, AND SCOPE

The origin of the term primary care can be traced to the 1920 *Dawson Report* by Lord Bertrand Dawson,<sup>9</sup> which designated primary health centers as the cornerstone of a proposed regional health system for the United Kingdom. “The distinguishing features of these Primary Health Centres, in contradistinction to Secondary Health Centres, would be that they would be staffed by general practitioners.” Although the Report was immediately shelved by the U.K. government, “...its historical importance was recognized when the King’s Fund reprinted it in 1950.” More importantly, the *Dawson Report* had a significant influence on the development of the National Health Service (NHS), which was enacted in 1948 and persists to the present. However, it should be noted that the British health system differs in some fundamental ways from that of the United States, reflecting both its much older roots (the definition of the British “physician” goes back to the early years of the 16th Century) and the much smaller and more densely populated land area. Unlike in the United States, “general practitioners” (GPs) in the British system not only treat a wide range of ailments but also do not see patients in hospitals.

In the United States, well into the first half of the 20th Century, specialization was distinctly unusual, and most healthcare was delivered by GPs. After the Second World War, the numbers of physicians who chose to enter specialty

training increased rapidly, along with increasing numbers of physicians choosing to sit for specialty board examinations. Shortly after the passage of the Amendments to the Social Security Act of 1965 (Title 18 and Title 19), the privately sponsored and widely distributed report by Folsom<sup>10</sup> declared that “...every individual should have a personal physician, and funds must be made available to support this goal.” Implicit in this conclusion was the idea that for most people their personal physician should be a primary care physician. At the time, there was a concern about a growing trend toward increased specialization in medicine at the expense of primary care, which could result in limiting access to care, a trend that persisted, if not accelerated, over the ensuing years. The American Medical Association–sponsored Citizens Commission on Graduate Medical Education report by Mills et al.<sup>11</sup> (published in 1966) suggested the presence of “...a kind of arrogance in specialized medicine” and stressed the need for a new body of knowledge to guide the work of “primary physicians.”<sup>12</sup> They saw this as a difficult and costly change that would require a radical departure from past practice.

Arguably, worldwide attention to primary care started with the World Health Organization’s Alma Ata Declaration at the 1978 International Conference on Primary Healthcare.<sup>13</sup> The Declaration (signed by the United States and all attending countries) moved attention away from seeing health only in terms of the absence of disease and instead defined health as “a state of complete physical, mental and social wellbeing, and not merely the absence of disease or infirmity,” and it declared healthcare as “a fundamental human right.” In this context, the declaration explained the role of primary healthcare as being “essential” and “based on practical, scientifically sound and socially acceptable methods and technology made universally accessible.” Furthermore, it affirmed that “...people have a right and duty to participate individually and collectively in the planning and implementation of their healthcare.” Although the Conference attracted widespread attention and agreement, it seems clear that the goals set forth in Alma Ata for the year 2000 have not been accomplished anywhere in the world, certainly not in the United States.

Although there is no uniform and consistent definition of primary care in all contexts, most agree that it constitutes (or should constitute) the first point of contact for patients. Beyond that, there are differing views regarding its definition, scope, and functions.

In essence, primary care has been defined from two different perspectives. The first is a *hierarchical* conception, which views primary care as the bottom tier of the healthcare pyramid wherein the majority of the health needs of the

population are met. Specialty and subspecialty care constitutes upper strata and represents narrower and more specialized services to meet the needs of smaller and smaller segments of the population. Frenk<sup>8</sup> suggested that this conception of primary care was borrowed from education, but it is a poor fit because unlike education, the provision of health-care does not fit a hierarchical pattern. Patients with serious health problems usually still need care for ordinary or routine problems. Conversely, primary care physicians are often called on to treat serious illnesses. Specialists may be ill-equipped to provide care for routine problems, because either they lack adequate training or they prefer to focus on care within their respective specialties.

The second definition of primary care is *normative* in nature, and it ascribes several attributes, or desiderata, to primary care, such as helping to "...prevent illness and death...is associated with a more equitable distribution of health in populations..."<sup>14</sup> As such, it constitutes an "an idealized concept that includes prevention, continuity of care, health maintenance, and death with dignity..."<sup>3</sup> It has also been described as "...care that is accessible, comprehensive, coordinated, continuous, and longitudinal...and requires a complex set of skills to manage the emotional, physical, and social problems that constitute what patients describe as their biggest concerns."<sup>15</sup>

The concept of primary care was being formalized in the United States in 1975, when 88% of the adult population reported having "a regular source" of care, and 78% named a particular physician to fulfill that role.<sup>16</sup> Family Practice was developed as the 20th specialty in American medicine in 1969 in response to increased complexity of medical care, escalating costs, changing reimbursement policies, relatively poor population health status in comparison with other industrialized countries, and the need for better implementation of knowledge derived from new research.<sup>17</sup> It may also be argued that this specialty was created, at least in part, because Medicare paid specialists more than generalists. In the late 1960s, some hoped that Family Practice would become the main primary care discipline, would have a well-accepted role in medical training, and would eventually represent 25% of all U.S. residency positions.<sup>18</sup> Others saw Pediatrics and Internal Medicine as continuing to play a major role in the delivery of primary care. At any rate, 40 years later, Family Medicine continues to be one of many primary care specialties, including General Internal Medicine, Internal Medicine/Pediatrics, and General Pediatrics.

Before the age of medical specialization, all medical practice was in the primary care domain. Specialization emerged as a result of several factors, including the following: (1)

changes in science and technology, as well as the expanding knowledge base; (2) the attendant requirement for prolonged education and training, with (2a) the creation of a system for defining specialties and (2b) the utilization of specialty training as a tool for assigning different levels of reimbursement; (3) the development of the modern hospital as a hub for advanced medical treatment, surgery, and training; and (4) professional control over standards and certification. Nonetheless, the distinction between primary and specialty care may be arbitrary because the scope of primary care is continuous, and it is normally aimed at the full range of health services ranging from the prevention of disease and the promotion of health, the delivery of clinical services for the sick and the infirm, the amelioration of pain and disability, and when all else fails assisting in a graceful and humane end of life. In many instances, both primary care providers (PCPs) and specialist providers are simultaneously involved in caring for patients, particularly those with chronic diseases and serious illnesses. Moreover, the boundaries between primary and specialty care are constantly changing, and what was once specialized care may over time become routine.

In brief, primary care can be characterized as having three basic functions:

1. *First contact.* As mentioned earlier, there is a consensus regarding the role of primary care as the first contact for patients under normal or nonemergency conditions. In addition, some have attributed other related functions such as familiarity with medical history, family, and community, meeting the needs of the whole person in a sustained relationship, continuity of care, and referral to specialists and hospitalization.<sup>19</sup> In this role, the PCP is expected to deliver comprehensive care for many common ailments.
2. *Gatekeeper.* As the division between primary and specialty care has changed, there was a concern that patients' self-referring to specialists would lead to inappropriate referrals as well as increased cost. The primary care physician would thus limit access to specialty care. The early emphasis on the gatekeeper function of primary care in managed care systems has created a conundrum. Although it may "protect patients from over-treatment" and the health system from "under-treatment" and "...gatekeeping activities of primary care physicians are critical to an optimal health system..."<sup>20</sup> this function has been viewed by patients as a referral barrier (impeding access to specialists), notwithstanding efficient use of resources and cost containment in managed care. To the extent that patients perceive primary care physicians as unable adequately to care for their

concerns, it can “undermine patients’ trust and confidence in their primary care physicians.”<sup>21</sup>

3. *Manager/coordinator.* From a policy perspective, the most important function of primary care is the coordination/integration of the care process within the entire spectrum of care.<sup>9</sup> However, it may be appreciated that this function is not limited to primary care physicians. Renal physicians, for example, coordinate a very complex set of services, including dialysis, preparations for transplant, balancing electrolytes, and vascular access. Currently, care for chronic illness “is subpar regardless of the specialty of the caregiver,” especially in complex cases.<sup>22</sup> Successful interventions tend to be complex involving changes in clinician behavior, practice organization, information systems, and educational programs aimed at patients.<sup>23</sup> Some authors have expanded the conception of this core function by listing additional attributes such as whole-person orientation, team approach (includes non-physician providers), defined roles and responsibilities akin to a contract, family and community context, and sustained partnership.<sup>18</sup>

From a broader, more global perspective, the Global Health Education Consortium<sup>24</sup> offered a more explicit definition of primary care with the following characteristics: Personal, Hub of health system; First Contact, Equitably distributed; Continuous, High quality; Comprehensive, Cost-effective; Coordinated, Acceptable; and Community-oriented, Accountable.

Finally, some<sup>4</sup> have suggested the unique benefits of primary care, such as

- Reducing or eliminating difficulty with access to regular source of care for relatively deprived populations
- Defining an appropriate domain for PCPs in treating common diseases, allowing for better overall performance on generic measures of quality
- Improving prevention through early detection and screening
- Enabling early management of health problems
- Delivering more appropriate care with a focus on the patient’s overall health rather than specific diseases
- Reducing unnecessary or inappropriate specialty care.

In 2007, the major primary care specialty organizations—American Academy of Pediatrics, American Academy of Family Physicians, American College of Physicians, and American Osteopathic Association—convened to develop the Joint Principles of the Patient Centered Medical Home.<sup>25</sup> These Principles defined features of the ideal primary care practice, including a personal physician for each patient, physician-directed medical

practice, whole-person orientation, coordinated and/or integrated care, focus on quality and safety, enhanced access, and payment reform. Many of the changes in primary care delivery in the past decade have focused on these concepts and have been shown in many circumstances to improve the quality, cost, and satisfaction with care in accordance with the goals of the “Triple Aim,” namely, improving population health, enhancing patient experience, and reducing per capita cost.<sup>26,27</sup>

#### THE FUTURE OF PRIMARY CARE

Primary care is a concept borne, in part, out of a desirable social goal—namely, to achieve the optimal level of health, broadly defined, for the maximum number of people in the community and worldwide. It also embodies goals for the care of the individual patient. Nonetheless, we have yet to achieve its purported aims of serving the medical, and at times emotional and social, needs of the client population because of resource constraints, inability to coordinate and integrate these services, and lack of social recognition and support.<sup>28</sup> Yet, the appeal of primary care persists because of its promise of guaranteed access to care, establishing a continuous relationship with a physician, and personalized referral to a specialist when needed. In view of the aging of the population and the prevalence of chronic illness, “...the future of primary care may depend on its ability to manage the human and clinical needs of an aging, chronically ill population.”<sup>7</sup>

Primary care advocates point out that “...in the future, the public will need an efficient, cost-effective system that can deliver the highest-quality healthcare within available resources and do so in a way that serves patients attentively and respectfully, supports their participation, and gains their trust.”<sup>29</sup> Hence, primary care is expected to provide “convenient access to care, sorting out problems, referring accurately, and coordinating and integrating subspecialty care...be an advocate and coach of patient...become engaged in analysis of population needs and provision of preventive interventions for risk groups, communities, and other specific populations.”<sup>25</sup> In order to achieve these goals, it has been suggested that the ultimate success of primary care of the future (designated for the year 2020) will ultimately depend on the following<sup>30</sup>:

- An emphasis on quality
- Dependence on new technologies, gadgets, and information technology
- Access to primary care by the entire population
- Acquiring political power
- Conducting more research
- Working with patients as masters of their own care.

## CHALLENGES

Some have questioned whether the concept of “primary care has become too complex, taken on too much, promised too much to too many” and whether “...we raised the bar too high, put too much responsibility on the shoulders of primary care?”<sup>3</sup> These same authors wondered whether “...a primary care provider [must] care for all, be up-to-date on all the latest discoveries and treatments and be an expert diagnostician, have the patience to care for persons with chronic illness, the compassion to care for those at the end of life, the sophistication to recognize behavioral and social problems, the communication skills to encourage patient behavior change?”

This may be an impossible task, and perhaps as a result “...primary care physicians are expressing frustration that the knowledge and skills they are expected to master exceed the limits of human capability, making it impossible to provide the best care to every patient.”<sup>2</sup> “[P]rimary care is more precarious than ever... assaulted by forces that had been thought to be friendly to it—managed care and medical education reform.”<sup>31</sup> “Most devastating, the policy promise that primary care could increase quality and reduce healthcare costs was not supported by evidence...,” and “...specialists are more knowledgeable about the management of [chronic] conditions associated with their specialty, more aware of guidelines delineating such management, and more likely to use tests and medications in accordance with guidelines” compared with primary care physicians.<sup>31</sup> It has been suggested that loss of public support and political power has resulted in losing the opportunity “to establish first-rate, frontline services for most of the problems that most people had, most of the time.”<sup>21</sup> On the other hand, care for patients with chronic illness is often a poorly connected string of episodes determined by patient problems.<sup>19</sup>

The gatekeeper function of primary care had the unintended consequence of causing consternation among patients regarding its true intent, as explained earlier. PCPs are challenged in establishing a reasonable work-life balance. For example, a survey of primary care physicians in 2012 reported nearly half “(45.8%) having at least 1 symptom of burnout...” with “...highest rates among physicians at the front line of care access: family medicine [over 50%], general internal medicine [about 55%], and emergency medicine [over 65%].”<sup>32</sup> However, only 26.7% of those who were invited to participate completed the questionnaire. Hence, these figures may not reflect the true state of affairs. Regardless, the shortage of primary care physicians is well documented.<sup>33</sup> An interesting analysis of “hidden” tasks routinely performed by general internal medicine physicians in a typical day revealed substantial amount of work actually performed outside of office visits and often outside of usual working hours, including ordering laboratory tests, images, and consul-

tations, writing prescriptions, responding to patient messages, and reviewing electronic medical record documents. None of this work is reimbursed or even acknowledged in the physicians’ workload.<sup>34</sup>

The Affordable Care Act of 2010 has led to improvements in primary care, including the development of the Centers for Medicare and Medicaid Innovation and support of state and national pilot projects. Financial incentives for quality of care and capitation by private payers have contributed to payment reform.<sup>35</sup> However, many challenges remain. More patients now have access to primary care services, but the primary care workforce is inadequate to meet the increased demand, and providers are responsible for increasing panel sizes (patient volume), raising concerns regarding the quality of care.<sup>36</sup> As a result, primary care physicians are at increasing risk for decreased professional satisfaction and burnout.<sup>32</sup> According to the American Association of Medical Colleges, the projected shortfall of U.S. primary care physicians will be between 12,500 and 31,100 by 2025. In order to meet this demand, primary care must be transformed in terms of moving away from physician-centered office visits and toward greater use of team-based management, with the physician acting as team leader with an expanded role for physician assistants and nurse practitioners (now referred to as advanced practice providers), as well as care models that rely on the capabilities of telemedicine to provide a viable alternative to the traditional office visit. The recent passage of the Medicare Access and Children’s Health Insurance Program Reauthorization Act of 2015 supports a new framework for rewarding healthcare providers for giving better care and a movement away from the fee-for-service payment system.

A well-documented analysis of staffing requirements to deliver high-quality care for the 10 most common chronic diseases revealed a serious supply shortage of physician time, especially when the disease is not under control.<sup>36</sup> Moreover, the educational system does not provide role models to be emulated by those receiving their training in academic medical center. Some have suggested a prevailing attitude of lack of respect for primary care.<sup>37</sup> To be sure, there are increasing pressures on the health system resulting from the aging of the population, greater emphasis on prevention, an interest in optimizing population health, and increased demand by an educated consumer, while also facing decreasing supply.

All these trends have created serious problems that are best confronted rather than ignored lest we end up exacerbating the problems of limited access to care, rising cost, and uneven quality. Needless to say, keeping up with scientific and technological advances in diagnosis and treatment must remain a primary focus. But, past technological innovations such as the

telephone, paved roads, and the automobile dramatically expanded the reach of physicians to provide high-quality care. Telemedicine may hold the promise for similar transformations in the way physicians and others deliver primary care.

#### THE TELEMEDICINE INTERVENTION IN PRIMARY CARE

The call for redesigning, prescribing, or “reinventing” primary care has been echoed by numerous experts in the field, including, among others, Rothman and Wagner<sup>22</sup> (in 2003), Safran<sup>19</sup> (in 2003), Frenk<sup>8</sup> (in 2009), Howell<sup>4</sup> (in 2010), Bodenheimer and Pham<sup>38</sup> (in 2010), Iglehart<sup>35</sup> (in 2012), and Phillips and Haynes<sup>23</sup> (in 2001).

The common themes among these calls for reform include the need for greater coordination, continuity, and integration in health systems, improved teamwork between specialists and generalists as well as between physicians and other health professionals, greater patient engagement, and—importantly—greater reliance on information and communication technology in the delivery of care. Telemedicine figures prominently with respect to greater reliance on information and communication technology. As will be seen in the remainder of this article, telemedicine interventions in primary care involve a variety of clinical applications, patient populations, technological configurations, and health provider mixes.

#### Expenditures on primary care

The 2010 Ambulatory Medical Care Survey data indicate that 55% of all office visits, of a total of 1.0 billion, were made to primary care physicians.<sup>39</sup> In 2014, national health expenditures grew 5.3% to \$3.0 trillion, or \$9,523 per person, and accounted for 17.5% of the Gross Domestic Product (GDP). Physician and clinical services expenditures increased 12.2%, amounting to \$297.7 billion in 2014, faster than the 2.4% growth in 2013. The increased growth seen in 2014 compared with the previous 5 years is attributed to an increase in insured persons, primarily in the Medicaid and private insurance population, as a result of the healthcare expansion provision of the Affordable Care Act.<sup>40</sup> From 2014 to 2024, healthcare spending is forecasted to increase at a rate of 5.8% per year, to an expected share of 19.6% of the GDP. In 2010, an estimated 6–7% of Medicare spending went to primary care. If the current amount were nearly doubled to 10–12% of total healthcare funding, it has been estimated that the increase would be cost-neutral, with resulting reduction in overall health spending.<sup>41</sup>

In 2015, the U.S. Department of Health and Human Services indicated a commitment to change from volume-based to value-based payment. Proposed initiatives included incen-

tives for high-value care, team-based care, and improved coordination of care with greater attention to population health and greater reliance on health information technology (HIT).<sup>42</sup>

#### Materials and Methods

As in previous articles in this series, we conducted a systematic process to identify and review the relevant literature on the feasibility/acceptance and impact of telemedicine interventions in primary care. The task was somewhat confounded by the lack of consensus on the definition of inputs as well as measures of output, and there was no clear guide as to what constitutes telemedicine interventions in primary care. Part of the difficulty had to do with the lack of a precise definition of the content of primary care because the boundaries between primary and specialty care are often blurry, possibly overlapping and changing. For example, a classical telemedicine consultation between a GP and a specialist is typically initiated when the GP is seeking an expert opinion regarding a patient in her or his practice. So although the care is provided in a primary care setting, the remote specialist is engaged to render an opinion regarding diagnosis and/or treatment. In some instances, the advice is to transfer the patient to a tertiary-care center where appropriate treatment/intervention is available. Ultimately, the patient is referred back to the PCP for follow-up and ongoing care. Hence, in some instances we used an arbitrary rule to exclude certain studies from this analysis when they did not embody clear demarcation lines between primary and specialty care, and the focus is mostly on specialty care.

In addition, there was no consensus on the precise context and scope of the telemedicine intervention in primary care. Here, we probably erred on the side of including a broader variety of studies that investigated the effectiveness of electronic reminders, text messaging between patient and provider, and electronic visits (e-visits) (direct-to-consumer services). Also, because primary care is not disease-specific, we included studies that investigated the effects of telemedicine on clinic attendance (or no show rates), after-hour-care patients, and compliance with prescribed medical regimen and medications.

Here again, we followed the same four steps in the review process: (1) an inclusive search for publications using the relevant terms to identify the universe of publications from 2005 to 2015 inclusive; (2) a paring down of this list to empirical research articles only, using two criteria—(a) robust research design, randomized controlled trial (RCT), or other relevant methodology such as surveys for estimating population values and (b) sample size of 150 cases or more; (3) a

review of the abstracts of all articles in Step 2 and sorting them by the topical areas of feasibility/acceptance, intermediate outcomes, health outcomes, and cost; and (4) a full review of all relevant articles in the final list of studies eligible for inclusion in this analysis.

## Results

The initial search in Step 1 yielded a total of 2,308 publications. Of these, 146 studies met the initial selection criteria for evidence, but the final list was limited to 86 studies: feasibility/acceptance ( $n=35$ ), intermediate outcomes ( $n=36$ ), health outcomes ( $n=7$ ), and cost ( $n=8$ ). As we have done before, we review these studies according to this classification, presented in historical sequence starting in 2005.

### FEASIBILITY AND ACCEPTANCE

As explained earlier, the scope of primary care can be broadly defined to include nearly all medical care. Hence, it was important to define the content and scope of feasibility studies in restrictive yet logical terms. In essence, this was determined on the basis of what primary care physicians do rather than the consultations they have with specialists of various types. Accordingly, studies with a specialized focus on the following topics were excluded from this review: diagnostic tests (including spirometry), life-style studies (including smoking cessation, weight management, and exercise), pain management, hypertension, asthma, sexually transmitted disease, infectious disease, pre- and postcancer and rehabilitation, vaccinations, electronic prescribing (e-prescribing), and pregnancy. This enabled us to focus on feasibility studies that focused on the role of the primary care physician as the source of care, not only the initial point of care. However, it may be appreciated that some studies could not be cleanly sorted out, and these were treated on a case-by-case basis in compliance with the rule of inclusion where the role of the PCP is prominent.

From 2005 through 2015, 35 studies met the final eligibility criteria for this analysis. The majority (23 out of 35) were based on surveys, with sample sizes ranging from 100 to 652,337, and conducted in 14 countries, nearly 50% from the United States (15 out of 35).

The results from two surveys, both conducted in the United States, were published in 2005.

The first survey inquired about the kind of information patients seek from their physicians via the Internet and their views regarding the type of guidance they want from their physicians.<sup>43</sup> The sample consisted of 494 respondents who were in waiting rooms in four primary care clinics in Rhode Island, and 330 of them completed the self-administered questionnaire (response rate = 67%). Most were female (73.5%), college graduates

(52.3%), and white (92.3%) and had health insurance (91.8%) and a primary care physician (94.4%). About one-half (51%) of the respondents reported having searched the Internet for health information, but only 4.7% indicated that their physicians asked them about it, and 62.1% agreed that their “doctors should recommend specific websites where patients can learn about healthcare.” These findings suggest that physicians can alleviate patient concerns about poor-quality information on the Internet by suggesting authoritative and commercial-free sources.

The second U.S. survey ( $n=601$  patients and  $n=564$  physicians) compared patients’ and providers’ attitudes toward sharing information available on the patient portal.<sup>44</sup> This was a concurrent survey of patients and their providers. The response rate was substantially higher among patients compared with physicians: 79% and 57%, respectively. Here again, the respondents were patients in waiting rooms at six primary care centers in Denver, CO—three were community health centers, and three were primary care clinics at an academic medical center. Patients in both settings were “equally likely to endorse shared medical records (94% vs. 96%).” However, patients in community health centers were more sanguine about “... the benefits of shared medical records” (measured in terms of number of benefits: 7.9 vs. 7.1) and “...somewhat more likely to anticipate problems with shared records.” Previous use of the Internet was a good predictor of patient endorsement of the Internet, number of expected benefits, anticipation of asking more questions between visits, and “anticipation of finding the doctors’ notes to be confusing.” On the other hand, physicians were more likely than patients to believe that patient access to records would cause problems and less likely to anticipate benefits for the patients. Overall, patients’ interest in searching the Internet for health information was related to past experience in the use of the Internet for any purpose, whereas it was not related to ethnicity or socioeconomic status (SES). The key finding in this survey is that patients’ positive expectations regarding the benefits of shared records were not matched by those of their physicians.

In 2006, two related surveys solicited information regarding patient views about the use of patient portals.

The first, conducted in the United States, investigated patient acceptance and willingness to pay for online services (using a patient Web portal) in a “typical urban family medicine practice” in Arizona.<sup>45</sup> This Web portal was designed for one-way communication. Patients could ask questions electronically, but the responses were provided by telephone. The sampling frame consisted of all 346 patients attending the clinic during 1 month; 329 completed the self-administered questionnaire, for a response rate of 95.1%, and 248 (or 75%)

had an Internet connection. Of this latter group, nearly 60% were willing to pay at least \$10 a year for Web portal services, and over 30% would pay \$50 or more. These findings suggest that some patients are willing to pay a small annual fee to connect with their primary care physicians, and their favorite services include patient–physician communication, viewing personal records, and getting prescription refills.

The second was a telephone survey conducted in Norway with 1,007 respondents over the age of 15 years.<sup>46</sup> It investigated patient views regarding the use of the Internet for seeking health information. More than one-half (58%) of the respondents had used the Internet for health purposes in 2005, compared with only 31% in 2001. Internet users tended to be younger, female, and an urban dweller and have a white collar occupation. About one-third (37%) “...considered the Internet to be an important or very important source of health information”; 23% were “...reassured by health information on the net, whereas 10% experienced increased anxiety....” Hence, the authors concluded that “Norwegian’s use of the Internet for health purposes continues to grow, but doctors and other health personnel remain the most important sources of health information....”

Three large-scale descriptive studies were conducted in 2007 in Denmark, The Netherlands, and a combined set of three European countries—The Netherlands, Belgium, and Portugal.

The first was a telephone survey with a systematic random sample of 1,000 adults in Denmark.<sup>47</sup> The use of the Internet for health-related information is common in the Danish population. About 60% of the respondents reported doing so. This was correlated with higher education, women, those in poor health, and those with children. “Every fourth Dane experiences feelings of reassurance or relief after having read about illness on the Internet and this number is 3 times higher than the number of people that experience concern and anxiety.” For the most part, the respondents were reassured regarding their health condition, 58% read their personal health record, and only 8% consulted with their physicians online. They used the Internet as a “supplement to their doctor and many—especially women—use the Internet information in their dialogue with their doctor.” The authors concluded that “Danes increasingly seek solutions to enable them to get online contact with different players in the healthcare sector.”

The Netherlands study was based on a descriptive analysis of telephone consultations ( $n=1,794$ ) involving palliative care for cancer patients that occurred over a period of 5 years.<sup>48</sup> Eighty-four percent of the patients were treated at home by their GPs. Typically, their questions were related to symptom control and end-of-life issues. We include this study

here because it demonstrated the importance of a 24-h teleconsultation service for GPs in dealing with daily dilemmas in palliative treatment of cancer patients during the last phase of their lives.

The third was also a descriptive analysis of the effectiveness of an Internet-based system in monitoring influenza-like illness in three Western European countries: The Netherlands, Belgium, and Portugal.<sup>49</sup> Observations were based on 19,623 participants from the three countries that participated in the surveillance program, referred to as Gripenet. Traditionally, this type of surveillance is conducted by a collaborative program involving mostly primary care physicians who report on such cases. The electronic surveillance program offered significant advantages over traditional collaboration in terms of speed, flexibility, and the uniform (or standardized) reporting of data. This allows for direct comparisons of incidence rates in the populations of participating countries and for regional collaboration in combating the spread of infectious disease.

In 2008, five studies investigated the feasibility of the telemedicine intervention in primary care: two from Canada and one each from Sweden, the United Kingdom, and the United States.

The Swedish study was a large-scale descriptive analysis of 38,217 Internet inquiries (dubbed “ask the doctor”) over a 4-year period, ending in September 2002.<sup>50</sup> The service was available to the general public free of charge. Anyone could submit health- and/or disease-related inquiries at any time and any day during the year. Based on analysis of data from the last year (2002) of the project ( $n=16,306$ ), the typical user was a woman between 21 and 60 years of age. Almost one-half of the inquiries were submitted during evening and night hours when clinics are not open. A trend analysis of utilization data revealed that use rates increased more rapidly among young and middle-aged women than other segments of the population. The most common types of inquiries were related to specific symptoms, followed by questions about joints, muscles, skeleton, skin, and pregnancy and contraceptives, in that order. The authors observed that this text-based consultation with family physicians on the Internet “...is gaining ground with an increasing number having a positive attitude...[toward it].” They concluded by suggesting that “...asynchronous medical consultations carried out as part of the established physician-patient relationships will likely replace or complement some face-to-face meetings.”

Two studies were conducted in Canada in 2008. Both addressed the feasibility and acceptance of in-home monitoring in a primary care setting and the use of an integrated drug information system by primary care physicians.<sup>51,52</sup>



The first<sup>51</sup> was a pilot study that examined the feasibility and efficacy of integrating in-home monitoring into primary care. The methodology included a mix of surveys, in-depth interviews, and focus groups, using a purposive sample of frail and at-risk patients, 50 years of age or older and having a life expectancy of more than 6 months. The initial group consisted of 120 patients in the experimental arm of a randomized clinical trial. Of these, 22 met the eligibility criteria as indicated above. The findings demonstrate the feasibility and benefits of integrating in-home collaborative care within community family practice. Of note, the editor observed “There is a commonly held assumption that older people will be unable or unwilling to use the technology; this study refutes that belief..., which suggests that the technology is not suitable for primary care of elderly people.”

The second study<sup>52</sup> assessed whether access to electronic information and e-prescribing were related to SES ( $n=28$  primary care physicians and 4,096 patients). The analysis was based on the use of an integrated drug information system by PCPs serving a vulnerable population taking multiple medications. The data suggest that physicians’ use of electronic information about patients is inversely related to SES of patients. That is, physicians were “more likely to access electronic information on current drug use of patients of low SES taking multiple medications with fragmented care.” From a provider’s point of view, more benefits can be accrued by patients with a drug history when they have access to their electronic records. Similarly, such patients can benefit because they are at greater risk of adverse drug-related events.

Results of a U.S. survey of 4,014 people (in essence, a volunteer sample) who initiated a health risk assessment using a free-standing kiosk revealed 479 cases that warranted follow-up.<sup>53</sup> This means that about 12% of individuals who completed the kiosk health risk assessment questionnaire on their own had a health problem that required further investigation. “Notices about these sentinel responses were e-mailed to care managers and sent to clinical sites.” The key finding, however, points to the feasibility of collecting patient-entered health data on a free-standing kiosk that can result in the initiation of appropriate medical management, but the system did not provide a tight loop for follow-up, as well as no assurance that follow-up occurred.

The technical feasibility of short message service (SMS) in routine primary care was evaluated in Scotland using in-depth semistructured interviews.<sup>54</sup> In total, 180 patients and their providers (including the receptionist, prescription clerk, and GP) were assigned a technologist to help them send and receive text messages on mobile phones. A secure Web server eliminated interruption problems that were encountered early in the project.

Most patients reported being “pleasantly surprised” at the system’s convenience and ease of use. They were especially appreciative of the ready availability of the information, especially “if circumstances arose where they might need their medical information (e.g. emergency situations)” as well as the ability to reorder prescriptions. The authors commented that the initial consternation by “more mature” reception staff regarding their need to learn the new jargon of mobile phones was “not borne out.” They concluded that “mainstream NHS GP services including appointment booking, repeat prescription ordering and clinical enquiries can be safely accessed using SMS and mobile phones.” However, “service uptake was slow” even by younger patients.

Four studies met the selection criteria in this category in 2009: two from the United States and one each from Germany/Switzerland and the United Kingdom.

The first U.S. study was an RCT ( $n=249$ ) that investigated the effectiveness of Internet-based coaching by nurses in a primary care setting.<sup>55</sup> The aim of coaching was to enhance chronic care by “promoting patient-PCP discussion about chronic conditions” in three targeted health problems: depression, chronic pain, and mobility difficulty. Patients with any of these chronic conditions and having routine scheduled appointments with 34 primary care physicians were invited to participate in this program via a secure Internet portal at an academic medical center. Initially 4,047 invitations were sent out electronically, 2,113 were opened, and 1,001 consented to join the study. Of this latter group, 241 were deemed appropriate for the study and were subsequently assigned randomly to either the intervention or control group.

Data were gathered after 1 week and also at 3 months. “More intervention than control patients reported their PCP gave them specific advice about their health (94% vs. 84%) and referred them to a specialist (51% vs. 28%).” Nonetheless, there were no significant differences between the two groups in terms of detection or management of screened conditions, symptom ratings, and quality of life. On the other hand, control patients reported more medication changes than intervention patients (29% versus 15%). Overall, a record review did not show evidence of differences in diagnosis or management between the two groups, which suggested that information from the portal was equally effective as information received in-person. The authors noted that their subjects were generally highly educated, as is typical of portal users, and fewer of them dropped out from the study compared with the control group, indicating their stronger motivation. The authors concluded that “as patients and physicians grow more comfortable using the Internet portal, electronic interventions will become more common and ultimately could prove integral in the successful management of chronic conditions.”

The second U.S. study, also an RCT ( $n=175$ ), assessed the feasibility and acceptance of e-visits compared with face-to-face visits in a primary care setting.<sup>56</sup> Patients in each arm of the study completed two visits. Those in the intervention group made the first visit in-person and the second via telemedicine, whereas those in the control group made both visits in-person. Patients found both types of visits similar in most respects, “including time spent with the physician, ease of interaction and personal aspects of the interactions.” Physicians also reported being satisfied with the virtual visit. Diagnostic agreement between physicians was 84% in the face-to-face and virtual modes and 80% between the two face-to-face visits. “The study suggests that both patients and physicians could benefit if virtual visits were used as an alternative method of accessing primary care services.”

From Germany, a two-part survey was electronically administered to patients with chronic diseases as well as practice assistants and GPs. The survey solicited their respective views regarding the use of an electronic quality of life assessment in general practice.<sup>57</sup> In total, 523 patients completed the electronic questionnaire while waiting to be served at the clinic. Subsequently, 280 patients, 27 practice assistants, and 17 GPs participated in a telephone interview. Nearly all GPs (94%) and a majority of practice assistants (70%) and patients (86%) were satisfied with the use of the electronic questionnaire for assessing quality of life. Hence, electronic quality of life assessment is technically feasible in general practice. Although providers were generally positive about this procedure, they expressed concern over “lack of time” that would be faced if it is routinely applied in everyday medical practice.

From the United Kingdom, a prospective cohort study ( $n=8,546$ ) assessed feasibility of an Internet-based chronic cough diagnostic questionnaire in conjunction with general practice.<sup>58</sup> The questionnaire was based on a “predetermined diagnostic algorithm to differentiate the three common causes of chronic cough”—acid reflux, asthma, and rhinitis. Almost half of the patients were diagnosed as having reflux as the probable cause of the chronic cough. “Participants found the website easy to use (94%), the advice helpful (73%), and that it helped them to communicate with their general practitioner better (60%), and 62% reported taking the recommended treatment.... Internet diagnosis by expert algorithm provides a novel mechanism for patients to assess guideline-recommended therapies and enhances dialogue between patients and physicians.”

In 2010, three feasibility studies were conducted in the United Kingdom, Australia, and Honduras.

The British study used quantitative and qualitative methods to ascertain whether telephones would be helpful for parents of young children in overcoming geographical barriers to

primary care during off-hours.<sup>59</sup> We focus here on a quantitative analysis of 5,697 calls about children 0–4 years of age. Contrary to expectation, call rates decreased with increasing distance from the clinic. Parents who lived furthest from a primary care center made fewer calls compared with those who lived closest (558–582 versus 644–661). “Call rates decreased with increasing rurality.” In other words, remote rural populations in the United Kingdom are not as likely to use the telephone when they need medical help for their young children as do their counterparts. This may be due to “lack of familiarity with the system (notably previous contact with health services), legitimacy of demand (particularly for children) and negotiation about mode of care.” But, the reasons are unclear.

From South Australia, a somewhat unique survey ( $n=3,034$ ) was designed to ascertain the relationship between self-reported health status and the trends in seeking health information from the Internet.<sup>60</sup> This survey was based on a clustered, multistage, self-weighting area sample, a typical methodology for representing geographically dispersed large populations. The proportion of general use of the Internet in this region increased by 48% from 2001 to 2008, and seeking health information from the Internet also increased by 57% in the same period. Of this latter group, 82% found health information on the Internet “helpful.” “Seeking health information on the Internet increased with age and with level of education.” Overall, there was a positive relationship between the use of the Internet to search for health information and self-reported health status, both physical and mental. Ironically, the likelihood of using the Internet was lower among those with poorer health.

The third study in 2010 was a survey ( $n=624$ ) in Honduras.<sup>61</sup> It investigated chronically ill patients’ willingness to participate in a disease management program via mobile phones, as well as the effectiveness of mobile phones and text messaging in assisting them to manage their illness. Surprisingly, 78% of the population living in a poor region of Honduras had mobile phones; over 80% had access to a telephone. More than 80% of the respondents were willing to receive automated calls dealing with appointment reminders, medication adherence, health monitoring, and education. The study concluded that automated telephone disease management support would improve access to healthcare in developing countries.

Three studies met the inclusion criteria in 2011: one each from the United States, the United Kingdom, and Norway.

The U.S. study analyzed data from the 2009 U.S. National Health Interview Survey, the first national household survey to investigate the use of the Internet for health information.<sup>62</sup>

The initial sample consisted of 27,731 adults. About 51% of all adults reported ever using the Internet for “health-related information,” but only 3.4–7% ever used it for “health-related activities.” About 45% of all adults reported using the Internet to search for health-related information during the year preceding the survey. Further analysis was based on a subsample of 5,294 older adults who were 65 years of age or older. This analysis indicated that the use of the Internet for health-related information was significantly lower among those 65 years of age or older compared with younger age groups, “...although the age group 55 to 64 was not different from those younger.” Overall, there was a positive relationship between the use of general health services and the use of HIT, but no such relationship was observed among users of specialized health services (compared with primary care). There were also “access gaps among racial/ethnic minority older adults and poorly educated and/or low-income older adults.” The use of HIT declined with age, with rates “decreasing from 32.2% in the age group 65 to 74 to 14.5 in the age group 75 to 84 and 4.9% in the age group 85 and over.” In general, “older adults with more general healthcare needs were more likely to use HIT than those with fewer general healthcare needs.” But, the “more severe or specialized healthcare needs are not significantly associated with the odds of HIT use.”

The U.K. study was a survey ( $n = 140$ , response rate = 82%) that compared the accuracy of patient recall of the content of telephone versus face-to-face consultations.<sup>63</sup> Patients presenting with various problems—including those with reduced recall based on a memory test—were recruited from 11 general practices in Scotland serving different socioeconomic segments of the population. The results revealed no significant differences in recall between telephone and in-person consultations. Both were equally accurate or with only minor errors. Patients tended to remember important components of both face-to-face and telephone consultations. The authors suggest that this may “reflect the familiar, less anxiety provoking environment of primary care.” Interestingly, the authors advise patients “to restrict the number of problems they present in any one consultation.”

Another survey ( $n = 100$ ) was conducted in Norway in 2011, which focused on patients’ understanding of and adherence to advice of telephone counseling by nurses.<sup>64</sup> The survey was conducted by telephone with patients who had received counseling by a nurse over the telephone during off-hours. The sample consisted of 134 patients, but only 100 responded (75% response rate). The vast majority (79%) reported having received relevant answers to their questions, 15% received partial answers, and 6% did not get relevant answers. “Two thirds of the callers who received advice from nurses had no

contact with their GP, casualty clinic or other health personnel the following week.” These data indicate that the telephone consultations were sufficient in the majority of cases. The authors suggested that “medical and communicative training must be a continuous part of the improvement strategy within the out-of-hours services....”

In 2012, a total of six studies met the inclusion criteria for feasibility/acceptance: three from the United States and one each from Lithuania, Sweden, and the United Kingdom.

We start with the U.S. studies. The first was an evaluation of the impact of patients’ online access to physicians’ visit notes. Data were gathered from three diverse health systems in Boston, MA, Pennsylvania, and Seattle.<sup>65</sup> The study was designed as a quasi-experiment/nonequivalent control group design in a multisite 1-year trial involving 114 PCPs and 22,000 patients. Two sites had existing patient portals, and the third developed an experimental one. PCP participation varied from 19% to 87% across the three sites. Those who refused to participate were used as the control group. A comparison of participants and nonparticipant PCPs revealed that the former were somewhat younger, were more males than females, and generally had smaller panels, compared with their counterparts. Among patients, participants were approximately 50 years of age, and there were more women than men in Boston and Pennsylvania and more men in Seattle, but none of these differences for providers and patients was statistically significant. Important conclusions from this study indicate that “...many primary care physicians were willing to participate in this new intervention despite concerns of a potential burden to their practices related to patient inquiries about their notes....” The authors suggested that patient access to doctor’s visit notes may constitute “the next step in the evolution of transparency in healthcare.”

The second was a survey ( $n = 448$  patients, response rate = 88%) regarding healthcare communication preferences among veteran primary care users.<sup>66</sup> This study was based on the assumption that information exchange in a “comfortable, convenient and preferred manner” would have desirable outcomes. About one-half of the subjects (54%) were regular computer users, nearly all of them Internet users. However, the majority preferred the telephone for most primary care needs. As expected, in-person communication was preferred when the patients believed an examination or visual instructions were required. “About 1/3 of regular computer users prefer electronic communication for routine needs, e.g., preventive reminders, test results, and refills.” These findings may be used to “plan patient-centered care that is aligned with veterans preferred health communication methods.”

Another survey ( $n = 638$ , response rate = 89.9%) was conducted in Missouri to ascertain how primary care patients use

the Internet.<sup>67</sup> A large majority (78%) were Internet users. As expected, lack of familiarity in using the Internet was the most common barrier to its use. Internet use increased with education and income and decreased with age, while the prevalence of chronic illness increased with age. Hence, “improving Internet access for older adults is necessary if they are to reap the benefits of Internet-based support for managing their health.”

A survey ( $n=309$ , response rate=60%) investigated patients’ perceived needs for health-related information on the Internet in Lithuania, where “electronic health information is a new concept.”<sup>68</sup> Data were gathered during clinic visits to primary care physicians. Overall, the Internet was used by 63.2% of the respondents. The profile of users is characterized by more females than males, having chronic disease, living as couples, and having e-health experience. Compared with their counterparts, users were more satisfied and informed about the available electronic information, including registration for physician services, patient portal, clinical investigations, medical consultations, health education, and self-help groups.

A Swedish survey<sup>69</sup> ( $n=543$ , response rate=79%) was aimed at measuring the use of health information among non-urgent care patients visiting emergency departments (EDs) ( $n=147$ ) or primary care clinics ( $n=396$ ), located in an urban region. Patients were interviewed after the initial visit and after 30 days. About one-half of non-urgent care patients attending the ED had used healthcare information or advice before the visit, typically from a healthcare professional. In a primary care setting, men were more likely to have used health information or advice, but the reverse was true in the ED. Overall, very few resorted to the Internet in a case of perceived emergency, but non-urgent care users of the ED were more likely to seek healthcare information before going to the ED than those using primary care clinics. “The problem seems not to be lack of information about appropriate ED use, but to find ways to reach the right target group.”

A British study used mixed methodology (survey and focus groups) ( $n=499$  users and 84 nonusers) to assess patient attitudes regarding their access to renal records.<sup>70</sup> These findings suggested that “Patient Internet access to secondary medical records concerning a complex chronic disease is feasible and popular, providing an increased sense of empowerment and understanding, with no serious identified negative consequences.” Eighty percent felt that access to their records gave them a better understanding of their disease.

In 2013, only one study met the inclusion criteria for feasibility analysis; it was a survey ( $n=438$ , no report of response rate) using a convenience sample consisting of 226 undergraduates (average age, 20 years) and 212 older adults (average age,

72 years).<sup>71</sup> The survey investigated the relationship between Internet use and preference for obtaining health information, autonomous decision-making, and whether this behavior varies by health conditions. As expected, the younger group used the Internet more than the older group, and the frequency of use was positively related to preference for electronic information and decision-making. However, the nonprobability nature of the sample precludes generalization of the findings beyond the respondent population.

Three eligible studies were published in 2014: two from the United States and one from The Netherlands.

Both U.S. studies were based on survey methodology. The first was based on a cumulative sample of patients ( $n=918$ , response rate=67.4%) presenting consecutively at a primary care clinic recruited to participate in the survey until a target number was achieved during a 2-week period.<sup>72</sup> The study site was a practice-based research network in the northwest region of the United States. Fifty-five percent of the respondents owned a smartphone, and 70% of them reported having used it for health purposes, such as finding health or medical information, downloading or using a health application (app), or tracking/managing a health issue (e.g., diet, weight, activity, mood, blood pressure, etc.). Age was negatively associated with the use of mobile phones for health purposes. However, the findings “support the potential role of m-health in improving disease management...” but “greater involvement of healthcare providers may be important for realizing this potential.”

The second U.S. survey ( $n=444$ ) attempted to explain the level of understanding and use of social media for health purposes among patients in a federally qualified community health center.<sup>73</sup> The majority were Hispanic, female, and young adults (between the ages of 18 and 29 years). In this group, texting on a cell phone was the most common form of social media use (74%), followed by Facebook (55%), e-mail (52%), cell phone apps (37%), and YouTube (30%). As expected, patient preferences for their health providers’ social media were consistent with their own personal use of the same media. For staying healthy, the preferred media were texting and e-mail, mostly because of ease of use.

A quasi-experimental study—pre- and postintervention comparison without control—was conducted in The Netherlands ( $n=682$ ) to evaluate the effectiveness of an online intervention in facilitating multidisciplinary communication among frail elderly people.<sup>74</sup> No significant differences were observed between those receiving instructions online versus those receiving instructions in-person. However, “only a small percentage of frail elderly people in the study intensively used ZWIP [the online e-health tool].” The authors concluded that

this may not be the ideal population for introducing the use of e-health interventions.

Three studies also in 2015 met the eligibility criteria: two from the United States and one from Canada.

The first U.S. study (published online in 2015) was a survey ( $n = 1,734$ , response rate = 54%) that attempted to evaluate patient satisfaction with an online “direct-to-patient” telemedicine program in a pharmacy setting (CVS Minute Clinic).<sup>75</sup> Nurses provided the consultation over videoconferencing. Seventy percent of the respondents were women, and 41% had no usual source of care. The vast majority reported being satisfied with their experience, citing convenience and quality of care as their reasons. However, the low response of 54% means that these results may not be reliable. The study was sponsored by CVS Health (Pharmacy).

A case control quasi-experiment was conducted among women in the Veterans Health Administration (VHA) ( $n = 266,301$ ) to ascertain travel time and attrition (or dropping out).<sup>76</sup> Attrition was defined as not returning to the VHA outpatient clinics in fiscal 2009. The findings indicated a positive relationship between travel distance and attrition, more so among new patients. The authors concluded that “linking new patients to VHA services designed to reduce distance barriers (telemedicine, community-based clinics and mobile clinics) may reduce attrition among women new to VHA.”

Finally, a large-scale record review ( $n = 652,337$ ) in Ontario, Canada revealed a differential reliance on telemedicine for medical services: residents in remote northern areas of the Province used telemedicine mostly for specialized services such as surgery, oncology, and internal medicine, whereas residents in southern urban areas used telemedicine mostly for primary care.<sup>77</sup> (This article was submitted in 2015 and will be published in final form in 2016.)

#### INTERMEDIATE OUTCOMES: ATTENDANCE, ADHERENCE, AND USE OF SERVICE

In total, 35 studies met the inclusion criteria for studies concerned with the intermediate outcomes of the telemedicine intervention in primary care. The term “intermediate outcomes” is used in this context to refer to near-term changes that have a logical or theoretical link to long-term health outcomes or cost. Intermediate outcomes are normally measurable and observable in the short term. Overall, they were conducted in 14 countries, nearly one-half of them in the United States (14 out of 35). About one-third were based on RCT designs (9 out of 35). As before, these are reviewed in historical order, starting in 2005 (Table 1).

In 2005, two studies met the inclusion criteria: an RCT from Norway and a retrospective record review from the

United States. Another retrospective record review from the United States normally would be eligible, but because its findings were reported in our earlier article<sup>78</sup> on skin disorders, it<sup>79</sup> will not be included here.

The Norwegian RCT ( $n = 200$ ) investigated the effectiveness of a secure Web-based messaging system in providing patient care in a primary care setting.<sup>80</sup> Patients in the intervention group were given access to a secure messaging system, whereas those in the control group received standard care without the messaging system. Measured outcomes included number of online consultations, telephone consultations, and office visits. Data were compared from 1 year to baseline and for 12 months after the intervention. The findings suggest a modest degree of substitution between text messaging and office visits. “The reduction in office visits over time was greater for the intervention group [using text messaging] than for the control group.” However, there were no differences in the number of telephone consultations between the two groups. “The use of a secure electronic messaging system will reduce both the number of office visits and telephone consultations at the general practice.”

A retrospective analysis of the effects of electronic health records on use and quality in an ambulatory care setting was conducted at the Colorado ( $n = 376,795$ ) and Northwest ( $n = 449,728$ ) regions of Kaiser Permanente.<sup>81</sup> The analysis was based on two very large datasets, 2 years after the implementation of electronic health records in both regions. Overall, age-adjusted office visits decreased by 9%, whereas primary care visits declined by 11% in both regions. Specialty care declined by 5% in Colorado and 6% in the Northwest. Use of laboratory and radiology services did not change conclusively, and intermediate measures of quality remained unchanged or improved slightly. Because of the large numbers, all differences were statistically significant. The study concluded that “readily available, comprehensive, integrated clinical information reduced use of ambulatory care while maintain quality and allowed doctors to replace some office visits with telephone contacts.” Because both regions “are high performing” to start with, it was difficult to identify marginal quality improvements (as indicated by advice on smoking cessation, cervical cancer screening, and retinal examination in diabetes).

Four studies were published in 2006: two from the United States and one each from Canada and Malaysia.

The first U.S. study examined the factors associated with physician-patient e-mail and the effect of electronic communication on physician adherence to recognized guidelines for e-mail communication.<sup>82</sup> This was a cross-section survey of all primary care physicians in Florida ( $n = 10,253$ ) and a

**Table 1. Summary List of Empirical Evidence Pertaining to Intermediate Effect**

REFERENCE	YEAR	COUNTRY	STUDY DESIGN	SAMPLE SIZE	MODALITY	INTERVENTION	DURATION	FINDINGS	COMMENTS
Bergmo et al. <sup>80</sup>	2005	Norway	RCT	200	Internet/telephone	E-consults	2 years	Moderate substitution	Telephone alone = no effect
Garrido et al. <sup>81</sup>	2005	United States	Record review	376,795	EHR	EHR	2 years	Ambulatory visits ↓	Marginal quality improvement
Brooks and Menachem <sup>82</sup>	2006	United States	Survey	4,203	Internet	Physician adherence to guidelines for e-mail	Cross-section	Adherence to e-mail protocol about 50%; 16% used e-mail	Physician-to-patient e-mail negatively correlated with age but positively with medical training
Chaudry et al. <sup>83</sup>	2006	United States	Controlled trial	212	Telephone	Nurse guidance	6 months	First-line antibiotic use ↑	Inappropriate antibiotic use ↓
Lang et al. <sup>84</sup>	2006	Canada	Cluster randomized	2,022	Internet	Communication ED-GP	2 10-week intervals	Resource use ↔	Physicians appreciated receiving communication from ED
Leong et al. <sup>85</sup>	2006	Malaysia	RCT	993	Mobile phone	Appointment reminders	48 h and 3 months	Attendance ↔	Cost of text messaging is lower
Stroebel et al. <sup>86</sup>	2007	United States	Record review	241	Internet/telephone	Nurse management of URI	12 months	Web-based similar to telephone	Opportunity cost if not replaced by other modes of communication, and cost is supported by practice
Fairhurst and Sheikh <sup>87</sup>	2008	United Kingdom (Scotland)	RCT	173	Internet/telephone	Appointment reminders	12 months	Nonattendance higher in control group	Modest improvement attendance for health priorities
Chen et al. <sup>88</sup>	2008	China	RCT	1,859	Internet/telephone	Appointment reminders	12 months	Nonattendance higher in control group	Both SMS and telephone improved attendance but not different from each other
Lorig et al. <sup>89</sup>	2008	United Kingdom	Prospective survey	568	Internet	Self-management	12 months	Improved efficiency	Decreased symptoms; improved health behavior
Weingart et al. <sup>90</sup>	2008	United States	Survey	1,821	Internet	MedCheck	10 days post	50% of problems identified were resolved	Clinicians responded to 68% of messages 93% within 1 week
Angstman et al. <sup>92</sup>	2009	United States	Prospective case control	728	Internet	E-consults	2 weeks	Early return visits	Quality ↑ Return visits ↑
Weiner et al. <sup>93</sup>	2009	United States	Record review	40,487	Internet	E-scheduling appointments with tracking	12 months	29% improvement	Improved access to specialty care
Parmar et al. <sup>94</sup>	2009	United Kingdom	Record review/audit	416	Internet	Electronic referral and booking	8 months	Attendance ↑	Electronic booking improves attendance rates
Liew et al. <sup>95</sup>	2009	Malaysia	RCT	931	SMS/telephone	Appointment reminders	6 months	Telephone and text messaging similar effects	Nonattendance ↓: text messaging, 13.7%; telephone, 15.6%; no reminders, 23.0%
Perron et al. <sup>96</sup>	2010	Switzerland	RCT	2,123	SMS	Sequential reminders	3 months	Missed appointments ↓ 11.4%	Significant for primary care and smoking cessation. Not significant for HIV and diet. 93% were not bothered by reminders.
Ernesäter et al. <sup>97</sup>	2010	Sweden	Retrospective record review	426 incident reports	Telephone	Incident reporting	12 months	Incorrect assessment = 25% of incident reports	Broad range of errors
North et al. <sup>98</sup>	2011	United States	Record review	20,230	Telephone	Triage patients with appendicitis	2 years	Nurse triaged patients within 8 h in 91% of cases	Appendicitis care: triage = 91% within 8 h; without triage = 39% within 8 h
Kahane et al. <sup>99</sup>	2011	Canada	Survey	153 patients 54 MDs 21 residents	Internet	Online searches by physicians	Cross-section	Family physicians overrated decrease in patient confidence when using online searches	Younger patients were more dubious

continued →

**Table 1. Summary List of Empirical Evidence Pertaining to Intermediate Effect** *continued*

REFERENCE	YEAR	COUNTRY	STUDY DESIGN	SAMPLE SIZE	MODALITY	INTERVENTION	DURATION	FINDINGS	COMMENTS
Graham et al. <sup>100</sup>	2012	United States	Quasi-experiment	3,295	IVR telephone	Telemonitoring/case management	30 days	30% reduction in re-admissions; 47% when combined with case management	Combined telemonitoring and case management reduced 30-day re-admission
Lund et al. <sup>101</sup>	2012	Zanzibar	Cluster randomization	2,550	Mobile phone/text messaging	Pregnancy management	12 months	60% skilled delivery versus 47%	Mobile phone increased skilled delivery and infant survival
North et al. <sup>102</sup>	2013	United States	Retrospective record review	7,332: 6,430 messages and 892 e-visits	Patient portal	Text messaging/e-visits	1 month	Only 3.5% were potentially high risk	Sensitivity 15% Predictive value 29%
Perron et al. <sup>103</sup>	2013	Switzerland	RCT	6,450	Mobile phone/text messaging	Appointment reminders	6 months	Text message equivalent to phone reminders: both improved attendance	Missed appointments = 11.7% for text messaging; 10.2% for telephone
Simonyan et al. <sup>104</sup>	2013	Mali	Prospective case control	180	Mobile phone	Monitoring service	6 months	Utilization ↑	Children under 5 years of age had increased use of service
Jackson et al. <sup>105</sup>	2014	United States	Survey	22,307	PHR	Sharing sensitive information/visit notes	Cross-section	Open access offers opportunities to engage family/support	Those who shared sensitive health information were more health conscious; engaged family and friends (overall 55%)
North et al. <sup>106</sup>	2014	United States	Retrospective record review	2,357	Internet	Portal messaging	Minimum 4 months	Secure messaging does not change face-to-face visits	No change in visit frequency to primary care provider
Arora et al. <sup>107</sup>	2014	United States	RCT	374	Internet	Automated text messaging	3 months	Post-emergency follow-up	Follow-up attendance, 72.6% versus 62.1%
Kortteisto et al. <sup>108</sup>	2014	Finland	RCT	13,568	PHR	Text reminders	12 months	Quality ↑	Volume of reminders lower in intervention group
Moth et al. <sup>109</sup>	2014	Denmark	Survey	385	Telephone	Off-hours service	12 months	Medication prescribed in 19.9% of cases	Prescription rates declined over time. Less likely for "severe" reason for children
Hussian et al. <sup>111</sup>	2014	Australia	Record review	206,487	In-person/telephone	In-person consults	24 months	In-person visits increased telephone consults	Face-to-face consults correlated with evacuation and telephone consults in indigenous populations
Dhalla et al. <sup>112</sup>	2014	Canada	RCT	1,923	Telephone	Virtual ward	12 months	Individualized plans did not affect re-hospitalization	No effect on re-hospitalization
Uscher-Pines et al. <sup>113</sup>	2016	United States	Retrospective record review	3,043	Telephone	E-visit	18 months	Negative or neutral effects	Quality similar in back pain; worse in bronchitis.
Shah et al. <sup>114</sup>	2015	United States	Observational	494	High-intensity telemedicine	Geriatric consults	12 months	Use of ED declined 18%	Mortality unchanged
Tran et al. <sup>116</sup>	2016	Canada	Observational	1,055	Internet	Remote consult	12 months	Avoided referrals ↑	40% avoided referrals; depends on type of questions
Craig et al. <sup>117</sup>	2015	United Kingdom (Scotland)	Survey	441	PHR	Off-hour consults	12 months	Benefits include palliative care, clinical management, and reduced hospitalization	Data based on perceptions
Marcolino et al. <sup>118</sup>	2015	Brazil	Survey	895	Telehealth service	Teleconsults	Cross-section	Telehealth support primary care in remote cities. Avoided referrals 28%	Most frequent queries are about disease etiology/treatment

E-consult, electronic consult; e-visit, electronic visit; ED, emergency department; EHR, electronic health record; GP, general practitioner; HIV, human immunodeficiency virus; IVR, interactive voice response; PHR, personal health record; RCT, randomized controlled trial; SMS, short message service; URI, upper respiratory infection.

25% sample of ambulatory care specialists ( $n = 3,954$ ). Physicians were queried about their adherence to recognized guidelines for e-mail communication. A total of 689 (16.6%) had personally used e-mail to communicate with patients. E-mail use was negatively correlated with age but positively

related to medical training and family medicine, but not internal medicine, practice size, or geographic location. Only 46 physicians (6.7%) adhered to at least half of the 13 selected guidelines for communication. "Yet, the fact that physicians are regularly using e-mail from their offices to communicate

with virtually all other entities (except patients) indicates that barriers seem to be specifically impeding e-mail use with patients.” This may represent an “opportunity cost” to some physicians, especially if e-mail does not replace other modes of communication and the cost of supporting a secure system has to be borne by the practice.

The second U.S. study (a controlled trial,  $n=212$ ) was a comparative analysis of patients with sinusitis receiving nurse-based telephone protocol-driven care versus those receiving usual care.<sup>83</sup> Patients with upper respiratory symptoms (cough, runny nose, sinus pain, or sinus infection) were triaged to a guideline-based registered nurse, telephone treatment protocol (intervention) or usual care (control). Usual care did not include protocol use. The effects were focused on clinical outcomes and satisfaction. The key measure of clinical outcome was antibiotic administration. After 6 months, a greater proportion of patients in the intervention group received first-line antibiotics for the infection compared with those in the usual group (81% versus 53%, respectively). The authors concluded that “protocol-based nurse telephone management results in comparably low rates of antibiotic use for upper respiratory infection (URI), increased first-line antibiotic prescribing to treat sinusitis, an acceptably low rate of adverse events and need for subsequent care, and a stated preference for telephone care with future illness.” Furthermore, they suggested that “primary care practices and insurance companies should consider the implementation of and reimbursement for protocol-based nurse management for minor illnesses.”

A Canadian study (crossover cluster randomized design,  $n=2,022$  patient visits) investigated whether the use of a Web-based communication system in the ED that enabled family physicians to receive detailed reports on their patients would reduce subsequent visits to family physicians.<sup>84</sup> Relevant information would include medications at discharge, treatment given, test and imaging, specialty consultation reports, and discharge plans. The intervention was administered during two separate 10-week intervals. The results indicated that the availability of this information did not result in duplication of requests for diagnostic tests, but rather a greater duplication in specialty consultation requests. The editor of the *Journal (CMAJ)* noted that information gathered in the ED rarely accompanies the patient and that “this dissociation is a loss to the patient and to the healthcare network; it can be dangerous as well.” Whereas family physicians in the intervention group appreciated having this information, there was no evidence that it resulted in reduced resource use.

A study from Malaysia (an RCT,  $n=993$ ) investigated whether the use of text messaging would improve attendance

in primary care clinics.<sup>85</sup> This was a three-arm multicenter randomized trial involving mobile phone reminders, text messages, and a control group that did not receive any intervention. Attendance was measured at two intervals after the intervention: 48 h and 3 months from discharge. Attendance rates for telephone, text messaging, and control groups were 59.6%, 59.0%, and 48.1%, respectively. Whereas the telephone and text messaging were equally effective in improving attendance, the cost of text messaging was substantially lower than that of mobile phone reminders.

One study in 2007 met the inclusion criteria for this review. It was a retrospective record review of patients ( $n=241$ ) having URI symptoms and presenting in a primary care practice.<sup>86</sup> A Web-based system for managing patients with URIs was developed and tested in a primary care practice. Over one-half (57%,  $n=137$ ) of patients met the guideline criteria for non-visit care and had their symptoms managed by a registered nurse. Of these, 51 were diagnosed as having URI, and 86 as having acute sinusitis. The majority of the first group (84%) were not prescribed antibiotics—as appropriate—whereas 80% of the latter group (those with sinusitis) were prescribed first-line antibiotics—also as appropriate. The authors concluded that patients using the Web-based system had similar outcomes to those derived from telephone-based treatment. However, the small sample size of the intervention group precludes any definitive conclusions from this study.

Four studies meeting the inclusion criteria were published in 2008: two from the United Kingdom and one each from China and the United States.

We start with the British studies. The first was an RCT ( $n=173$ ), designed to ascertain the effects of texting appointment reminders to repeated nonattenders (or “no-show” in two or more appointments) in a general practice.<sup>87</sup> Patients allocated to the intervention group received a text message reminder, whereas those in the control group did not receive any reminders. Data were gathered for 415 appointments made by 173 patients. Nonattendance was measured on the basis of failing to show up for two appointments during the preceding year. “This meant that patients whose appointments were included in the study included many who frequently attended and for whom the two non-attended appointments in the preceding 12 months represented a small proportion of appointments made.” Nonattendance was higher in the control group (17.1% versus 11.7%, about a 5% risk difference), but the difference was not statistically different. Although somewhat promising, text messaging did not produce demonstrable reduction in nonattendance among repeat nonattenders.

Clinic attendance was also investigated in a Chinese study (an RCT,  $n=1,859$ ). This study was focused on the differential



effects of texting and the telephone on attendance at a health promotion center.<sup>88</sup> It compared text messaging with telephone reminders over a period of 2 months. Patients were randomly assigned to one of three groups: SMS, telephone reminders, and no reminders, the latter as a control group. Attendance rates of SMS, telephone, and controls were 87.5%, 88.3%, and 80.5%, respectively. Although there was no significant difference in attendance rates between telephone and SMS groups, both modalities were more effective compared with no reminders. However, the cost of SMS was significantly lower than that for the telephone group.

In the United Kingdom, a prospective longitudinal study ( $n=568$ ) evaluated the effectiveness of an online self-management program among people with long-term conditions.<sup>89</sup> This was an online self-management program based on self-efficacy theory, which is based on “processes to enhance efficacy, skills mastery, reinterpretation of symptoms, modeling and group persuasion.” The 12-month program had four components: self-management instruction, discussion groups, self-management tools, and a book on healthy living. The findings were nuanced in terms of specific variables measured. Overall, this multifaceted program “appears to decrease symptoms, improve health behaviors, self-efficacy and satisfaction with the healthcare system and reduce utilization up to 1 year.”

Patient views regarding the safety of medication applications via an Internet portal (labeled MedCheck) was assessed by a sample survey in the United States. A stratified random sample of 267 subjects was selected from 1,821 MedCheck users over a 1-year period.<sup>90</sup> Patients received MedCheck, a medication safety app 10 days after they received a new or changed prescription. It contained an inquiry as to whether the prescription was filled and whether the patient experienced any medication-related problems. This information was forwarded to their primary care physicians. “Patients opened 79% of *MedCheck* messages and responded to 12%; 77% responded within 1 day.” Nearly one-half of the respondents identified problems with their prescriptions (48%), drug effectiveness (12%), and medication symptoms (10%). Clinicians responded to 68% of patient messages, 93% within 1 week. Patients in this study experienced a total of 21 adverse drug events (ADEs) and reported 17 electronically. “Patients and physicians responded promptly to patient-directed electronic medication messages, identifying and addressing medication-related problems including ADEs.” Findings from the same study were published in another article in 2013 concerning the same intervention with similar results.<sup>91</sup> The data from the 2013 publication are not included separately in *Table 1*.

In 2009, four studies met the inclusion criteria: two from the United States and one each from the United Kingdom and Malaysia. All of them investigated issues related to return visits, nonattendance, or scheduling.

The first U.S. study was a retrospective record review (case-control design,  $n=728$ ), and it was aimed at evaluating the impact of electronic consults (e-consults) on frequency of return visits among family medicine patients.<sup>92</sup> The intervention group ( $n=228$ ) consisted of all consenting patients who were scheduled for an e-consult with a specialist within 2 weeks between 2005 and 2008. The control group consisted of 500 consecutive patients who were seen by a specialist after 2005. The dependent variable was early return visits (i.e., within 2 weeks). Two types of return office visits were used as dependent variables: those within 2 weeks for any reason and those for the same reason. The results showed a higher return rate for visits for the e-consult group compared with in-person consults: 38.2% versus 27.6%, respectively. After adjusting for comorbidity, age, sex, and marital status, the odds of an early return visit for any reasons after an e-consult were elevated (odds ratio = 1.88). Hence, the authors concluded that “e-consults by referral specialists were associated with increased odds of early return visits for primary care patients with a primary care provider.” This means that telemedicine consultations with specialists not only assured *a priori* high-quality care for patients but also an increased rate of primary care follow-up.

The second U.S. study in 2009 was a record review and analysis of abstracted data ( $n=40,487$  referrals, pre- and postintervention) from an electronic registration and scheduling system.<sup>93</sup> The purpose of the analysis was to detect the effects of a Web-based system with automated tracking features on scheduling appointments for specialty consultation. Patients were adults 21 or more years of age referred from 11 primary care clinics to any of 25 specialty clinics. The traditional referral mode was based on fax. Before the intervention, 54% of contacts resulted in a scheduled specialty visit, compared with 83% after the intervention. The median time to an appointment was 168 days before and 78 days after the intervention. “With a new Web-based referrals system, referrals were more than twice as likely to lead to a scheduled visit. This system improves access to specialty medical services.”

An audit ( $n=416$ ) of a national electronic referrals and booking service (Choose and Book) was conducted in the United Kingdom to determine its impact on attendance rates at an audiology clinic.<sup>94</sup> The audit compared attendance rates of new patients booked through this system versus those booked in the traditional system for a period of 8 months. Among patients booked in the traditional mode, 30.2% did not attend,

compared with 17.8% among those who used the electronic system. “This audit suggests that when primary care agents book outpatient clinic appointments online it improves outpatient attendance.”

A somewhat related study was conducted in Malaysia. This was an RCT ( $n=931$ ) aimed at assessing the effectiveness of text messaging in reducing nonattendance in chronic disease follow-up.<sup>95</sup> Patients in primary care clinics were randomly allocated to three groups: those receiving text message reminders, those receiving telephone reminders, and those without reminders. These groups were observed over a minimum of 6 months. Nonattendance included first-visit nonattendance, early attendance (i.e., showing up before the scheduled time), or late attendance without rescheduling. Attendance was defined as showing up at the scheduled time or changing/canceling with notification. The nonattendance rates for the three groups were 13.7% for the text messaging group, 15.6% for the telephone group, and 23.0% for the control group. When the control group was used as reference, the odds ratio for the telephone group was 0.53, and that for text messaging was 0.62. Differences between telephone and text messages were not statistically different, and both types reduced nonattendance more than the control group.

In 2010, a large-scale RCT ( $n=2,123$ ) was conducted in Switzerland,<sup>96</sup> and a retrospective incident reporting ( $n=426$ ) was conducted in Sweden.<sup>97</sup>

Similar to those reported earlier, the Swiss study investigated the rates of missed appointments between two groups that were randomly assigned to the intervention and control groups. Patients in the intervention group received sequential reminders, starting with (1) a telephone call (fixed or mobile), (2) if no response, an SMS, and (3) if no phone number available, a postal reminder. Data were gathered over 3 months on missed appointments, cost of the intervention, and the profile of patients who miss their appointments. Missed appointments were defined as not showing up at the appointed time without informing the clinic in advance. Twelve percent of the patients had no phone. Among patients in the intervention group, 51% received a reminder on their mobile phones, 19% on fixed phone, 18% by SMS, and 10% by post. Overall, the sequential reminders reduced the rate of missed appointments by 11.4%. This reduction was statistically significant for primary care and smoking cessation appointments but not significant for human immunodeficiency virus and diet consultations. “The net financial benefit of the intervention was estimated to be €1,850 over 3 months...once costs linked to the intervention were deducted.” Finally, when patients were asked about their views regarding the reminders, 93% were not bothered by them, and 78% considered them

useful. The study concluded that “a practical reminder system can significantly increase patient attendance at medical outpatient clinics. An intervention focused on specific patient characteristics could further increase the effectiveness of appointment reminders.”

A different kind of study was conducted in Sweden, which focused on incident reporting in a national nurse-led telephone triage system ( $n=426$  incident reports that occurred in 2007).<sup>97</sup> Incident reports encompassed a broad range of errors, including provider availability (41%), incorrect assessment (25%), routines/guidelines (15%), technical problems (13%), and information/communication (6%). There were significant differences between incoming (from the patients) and outgoing reports (by the nurses). Errors of “over-triage” and “under-triage” may be caused by the caller misreporting information. In addition, “telenurses have limited possibilities for referring the caller to their primary healthcare provider or specialist, which may cause them to over-triage or under-triage the callers’ need for care.” The authors suggested that the information loop could be counterproductive by “increasing territorial thinking and inhibiting cooperation between the Swedish Health Department (SHD) and other healthcare providers.”

A somewhat similar study was conducted in 2011 in the United States regarding the value of a nurse-led telephone triage for patients with appendicitis.<sup>98</sup> The analysis was based on claims data over a 2-year period comparing telephone triage with the callers’ original intent (what they wanted to do). There were 20,230 calls to a telephone triage center. Among these, 46 had a diagnosis of appendicitis. “In 91% of the appendicitis cases, triage nurses directed callers to care within 8 h, but without triage advice, only 39% of callers stated they would have sought care within 8 h.” Therefore, telephone triage resulted in a significant reduction in the delay for appendicitis care, thereby potentially reducing the morbidity associated with appendicitis.

Also in 2011, a Canadian survey ( $n=153$  patients, 54 family physicians, and 21 family practice residents) addressed a unique question—namely, whether patients would lose confidence in their physicians when they see them consult Internet search engines looking for answers to medical questions during the clinical encounter.<sup>99</sup> The patient sample was skewed (76% female, 71% completed college or higher). The response rate for patients was not reported; however, it was 36% among family physicians and 84% among residents. Overall, “patients younger than 40 years of age were 8 times more likely to report decreased confidence than patients older than 65 years age.” Interestingly, when the information source used by the physicians was not specified, “9% and 7% of

patients reported decreased confidence.” On the other hand, when the source was specified, the negative responses were higher (46% versus 9%). Patients expressed more positive views when their physicians looked up information in hard copy medical books. However, a number of patients demonstrated their own sophistication by pointing out that “their responses would depend on the nature of what was being looked up.” Overall, these findings suggested that physicians’ concern over the potential loss of their patients’ confidence in them when they look up information during clinical encounters may be exaggerated. From a patient point of view, the best sources of information are sites designed specifically for physicians and medical textbooks.

In 2012, only two studies met the inclusion criteria: one from the United States and one from Zanzibar.

The U.S. study was a quasi-experiment (pre-post parallel quasi-experimental design) with a total sample of 3,772 Medicare patients; 1,333 were enrolled in a case management program, and 2,439 were not. Ultimately the case cohort consisted of 875 patients and the control group consisted of 2,420 patients.<sup>100</sup> Claims data were used to assess the effects of the monitoring system using interactive voice responses on 30-day re-admission rates. The results indicate “a 44% reduction in 30-day readmissions in the study cohort, when using the control group [with case management only] to control for secular trends.” The authors concluded that “... the combination of telemonitoring and case management, as compared with case management alone, may significantly reduce readmissions in a Medicare Advantage population.”

A study in Zanzibar (cluster-RCT,  $n = 2,550$ ) investigated the association between the use of a mobile phone as a health communication tool and skilled delivery attendance among pregnant women.<sup>101</sup> Skilled delivery attendance was based on the World Health Organization definition: “...attendants are midwives, doctors or nurses who have been educated and trained in the skills needed to manage pregnancies, childbirth, and the immediate postnatal period...” Pregnant women in the intervention group were provided with registered phone numbers with a unidirectional text messaging capability and a mobile phone voucher for two-way communication with a PCP. The system provided basic health education and appointment reminders for routine antenatal care, skilled delivery attendance, and postnatal care. Skilled delivery attendance was observed in 60% of women in the intervention group versus 47% in the control group. Women living in urban areas benefited from this intervention, whereas those living in rural areas did not, an odds ratio of 5.73.

Three eligible studies were published in 2013: one each from the United States, Switzerland, and Mali.

The U.S. study (a retrospective record review,  $n = 7,322$ , consisting of 6,430 secure messages and 892 e-visits) assessed the safety of patient portals, especially when they are relied on for patient self-reporting of time-sensitive symptoms such as chest pain or dyspnea.<sup>102</sup> Risk was assessed in terms of deaths within 30 days of the message and hospitalizations and the ED visits within 7 days. In addition, message content was reviewed for symptoms of chest pain, breathing difficulty, or other high-risk symptoms. During the study period, two deaths occurred within 30 days, but these were unrelated to the message; six hospitalizations were related to a previous secure message (a rate of 0.09%) versus two hospitalizations related to a previous e-visit (a rate of 0.22). However, “...a subject line search to identify these high-risk messages had a sensitivity of only 15% and a positive predictive value of 29%.” Overall, patients used the portal messaging capability “3.5% of the time for potentially high risk symptoms,” such as chest pain, breathing difficulty, abdominal pain, palpitations, light-headedness, and vomiting. Death, hospitalization, and ED visits following a secure message or e-visit were infrequent. Large proportions of the messages on the portal were for information regarding medications and test results. About three-fourths of these messages and e-visits occurred during regular office hours. The portal did not allow for live chats. Hence, minor enhancements to allow this functionality would be helpful to the patients. For example, when a message is received during off-hours, an immediate response would inquire whether a time delay would be acceptable or else offer a triage number for another appropriate and available source of care.

The Swiss study was a large RCT ( $n = 6,450$ ) investigating the effectiveness of text messaging and telephone reminders in reducing missed appointments.<sup>103</sup> Patients scheduled for an appointment at an academic primary care clinic who had a cell phone were randomly assigned to receive a text message or telephone call 24 h before their appointments, and a comparison was made between text and voice reminders. Data were gathered for 6 months. In addition, a survey was conducted among 900 respondents (response rate = 41%) to ascertain their satisfaction with reminders. The rate of missed appointments was similar in both groups (11.7% for text messaging and 10.2% for telephone). Attendance was slightly higher following telephone reminders compared with text messaging reminders among primary care patients, but not so among patients with mental health disorders. The data on satisfaction were positive, but they were based on a sample with a very low response rate.

A prospective controlled study was conducted in Mali to ascertain the effects of a telemedicine program on the use of

primary care services for children under the age of 5 years over a period of 6 months.<sup>104</sup> The program (Pesinet) offered “micro-insurance” for these children together with a monitoring service aimed at promoting the use of primary care. The intervention consisted of weekly visits by trained “weighing agents” who collected routine information on the child (body weight, temperature, breast feeding, vomiting, stools, cough, and complaints) and recorded the information on their mobile phones. This information was transferred to a GP who analyzed the data and determined appropriate steps that may be needed. Children received the consultations at no charge as well as reduced prices for prescribed medications. Those in the control group did not receive these weekly visits or any discount on medications. As expected, children in the intervention group received more primary care services than those in the control group, with an odds ratio of 2.2. In other words, children who participated in the Pesinet program were more than twice as likely to get primary care services compared with nonparticipants.

Seven studies were eligible for review in 2014: three from the United States and one each from Finland, Denmark, Australia, and Canada.

The first U.S. study (a survey,  $n=22,307$ ) explored the characteristics and attitudes of patients who report sharing (or allowing access to) their electronic visit notes (One Note) with family and caregivers and the associated benefits and risks.<sup>105</sup> In total, 22,703 patients were invited to participate in the survey and 22,307 completed the questionnaire (85.3% response rate). Of these, 11,115 had One Note available to them, and 4,516 completed the questionnaire. Nearly one in four, or 21.7%, reported showing their visit notes: 35.6% named a family member, friend, or relative who took care of them; 56.5%, another family member; 9.7%, another friend; 17.6%, another doctor or other provider; and 10.9%, someone else. Overall, 55% of the respondents expressed an interest in allowing a family member or a friend access to their visit notes. Those who were older, unemployed, and in poorer health were more likely to do so than their counterparts. Those willing to share their visit notes were not particularly concerned about privacy or divulging sensitive information about themselves, such as substance abuse, mental health, or sexual history. Nonetheless, the authors cautioned about the hazards of sharing sensitive information. “Divulging sensitive information, wittingly or unwittingly, could affect personal relationships, job opportunities, or litigation. A doctor’s note freely accessible on the Internet could generate positive or negative comment from a wide variety of viewers.” Nonetheless, those who reported having shared personal information were more health conscious than their counterparts, and they were not

especially concerned about privacy. “Open access to visit notes offers exciting opportunities to engage a patient’s family and social support members, and now is the time to establish standards and develop the technology to open these portals.”

The second U.S. study in 2014 was a retrospective cohort record review ( $n=2,357$ ), assessing the frequency of primary care visits among adult patients before and after the first use of messaging via a patient portal.<sup>106</sup> The setting was a large primary care practice that included family medicine, primary care internal medicine, community pediatrics, and adolescent medicine. Patients who did not have an in-person visit during the study period as well as those who were not registered for the complete study period were excluded from the analysis. The portal allowed patients to contact their healthcare team via a message or an e-visit. The latter consisted of a computer-directed interview that created a structured message to the provider, with the option of responding asynchronously by text message or telephone. Response time was no more than 24 h (except on weekends). After adjusting for the initial surge in visits, the average annual number of visits per patient was 2.35, both before and after the first message. High utilizers of the messaging system were also similar to low utilizers in terms of visit frequency. Hence, “No significant change in face-to-face visit frequency was observed following implementation of portal messaging. Secure messaging and e-visits through a patient portal may not result in a change of adult primary care face-to-face visits.”

The third was an RCT ( $n=374$ ) that investigated the impact of automated text messaging on clinic attendance at post-emergency follow-up over a 3-month period.<sup>107</sup> Often, when patients are discharged from the ED, they are referred to go back to their PCP and/or a specialist, often with follow-up appointments. Attendance at these follow-up appointments is associated with improved outcomes and decreased return visits to the ED. This study investigated whether an automated text messaging system would increase attendance at follow-up appointments in a predominantly Hispanic safety-net population. The subjects had to have access to text-capable mobile phones. “Both intent to treat and a per-protocol analysis of the data were performed.” The latter method “isolates the effects of the intervention by comparing patients who actually received it compared with those who did not.” The adherence rate in the intervention group was 72.6%, compared with 62.1% in the control group. Moreover, patients with the lowest follow-up rate (English speakers with specialty care appointments) benefited the most from the intervention. The authors commented that this intervention is a “low cost and highly

scalable solution to increase attendance at post-ED follow-up appointments.”

A large-scale RCT ( $n = 13,568$ ) was conducted in Finland to ascertain the trends and effects of patient-specific electronic reminders in primary care.<sup>108</sup> The intervention was an evidence-based computerized decision-support system aimed at bringing relevant evidence to the attention of the provider at the point of care. The system is integrated into the electronic patient record. The investigators hypothesized that the number of triggered reminders concerning 59 different health conditions would decrease the more PCPs used the electronic record for each patient. They assumed that such decline would indicate an improvement in quality of patient care because trigger reminders occur when patient care as rendered is not evidence-based; hence the lack of a reminder indicates that patient care complies with the gold standard. After 12 months, the incidence of trigger reminders increased in both intervention and control groups, but overall no differences were observed between the two groups. However, after 6 months, the incidence of reminders was significantly lower in the intervention group compared with the control group, especially when the data were adjusted for confounding factors such as age, gender, comorbidities, and medications.

In Denmark, GPs answer all telephone calls during off-hours and typically resolve 60% of the problems by providing medical advice and/or prescriptions. An electronic survey of GPs from the Central Denmark Region ( $n = 385$ ; response rate = 55.5%) was conducted to ascertain telephonic prescribing patterns as reported by primary care physicians who make these calls.<sup>109</sup> The respondents reported that 19.9% of the telephone consultations resulted in a prescription. The most frequent types were antibiotics and analgesics: 10.8% and 2.5%, respectively. Consultations resulting in antibiotic prescriptions were reported to be “more severe” compared with other contacts. However, for high-severity contacts, there was a lower likelihood for prescription (prevalence ratio = 0.28), and consultations for children had a lower likelihood of receiving a prescription compared with consultations for adults. The prescription rate seemed to decline over time during the off-hours. It tended to be highest during the first 4 h of the off-hours. Overall, “...drug prescription by telephone was less likely to be offered in cases involving ‘severe’ reason for encounter or children.” The fact that one in five telephone consultations resulted in a prescription demonstrates the need for care during the times when the primary care clinic is closed.

Another survey ( $n = 159$ ; response rate = 45%) of physicians (primary care and specialists) was conducted in Spain to determine the impact of an Internet platform for communication between outpatient primary care and hospital care on quality

and hospitalization.<sup>110</sup> The data on quality and hospital referrals were based on respondent perceptions. The findings confirm the expectation that “the intensity” of using the Web-based platform led to improved primary care quality and fewer hospitalizations. Again, these data were reported by the physicians in the survey. Therefore, these findings cannot be considered definitive because of the very low response rate in the survey, and the outcomes measures were based on perceptions or opinions and will not be presented in *Table 1*.

Using a somewhat reverse logic to the main theme of this article, a study in Central Australia investigated whether increasing the delivery of face-to-face primary care services in remote underserved areas would be associated with a reduced need for remote telephone consultations and acute medical evacuations.<sup>111</sup> The study area constitutes about 10% of the land area of Australia with only two regional population centers with respective populations of about 30,000 and 3,500. More than 90% of the residents in the remote areas are indigenous. Locally available clinical services are supplemented by remote telephone consultations. The study was based on record review ( $n = 206,487$  consultations) over a 2-year period. Contrary to expectation, the provision of face-to-face GP consultations in the remote areas was positively correlated with acute medical evacuations and with remote telephone consultations. The highest conditions for evacuations were respiratory disease and injuring/poisoning (20.5% and 19.2%, respectively). The authors offered several explanations for their findings, including pent-up demand or unmet need, increased scrutiny over practices and overcaution, and increased burdens on GPs.

Finally, a Canadian RCT ( $n = 1,923$ ) investigated the effects of a “virtual ward” on hospital re-admission or death among high-risk patients.<sup>112</sup> The virtual ward consisted of detailed instructions about available services and a telephone number to call when needed. The telephone was answered by clerical staff who directed the call to the appropriate team member during regular business hours or to the virtual physician pager during off-hours. The team consisted of care coordinators, part-time pharmacist, part-time nurse, full-time physician, and a clerical assistant—essentially a primary care team. They met each morning to develop and execute individualized care plans for new and continuing patients. Primary care physicians received a letter or fax informing them of the arrangement, and patients were strongly encouraged to contact their primary care physicians. There were no statistically significant differences in re-hospitalization or death between patients discharged to virtual wards compared with usual practice at 30 days, 90 days, 6 months, or 1 year after discharge.

In total, five studies published in 2015 were deemed appropriate for this analysis: two from the United States and one each from Canada, Scotland, and Brazil.

The first U.S. study (published online in 2015) was a record review of claims data from April 2012 to October 2013 (intervention group,  $n = 3,043$ ; comparative group,  $n = 230,872$ ) for the California Public Employee Retirees health maintenance organization who were users of the Teledoc system, also known as “direct-to-consumer” telemedicine.<sup>113</sup> The vast majority of the visits were conducted over the telephone, but the patients could submit photographs and/or elect to use live videoconferencing. Teledoc users were more likely to be younger and female. The nonusers included all retirees who used other sites for care as well as those who did not seek care. The experiences of Teledoc users and nonusers were compared in terms of disease-specific performance measures (pharyngitis, back pain, and bronchitis) and rural location (as an indicator of health manpower shortage). Performance was determined on the basis of conformity with the Health Effectiveness Data and Information Set, a commonly used performance measure on important dimensions of care and service.

For pharyngitis, “Teledoc performed worse than physician offices (3% versus 50% respectively);” for back pain (as indicated by not ordering imaging), 88% versus 79%; and for bronchitis (not ordering antibiotics), 16.7% versus 27.9%. In terms of access, “Teledoc users were not more likely to be located within a healthcare professional shortage area.” Thus, the authors concluded, “Teledoc providers were less likely to order diagnostic testing [for back pain] and poorer performance on appropriate antibiotic prescribing for bronchitis. Teledoc users were not preferentially located in underserved communities. Short-term needs include ongoing monitoring of quality and additional marketing and education to increase telemedicine use among underserved patients.” All outcome measures were based on aggregate data and not adjusted for risk. It was not clear why the researchers did not use a case-control methodology to match cases and compare risk ratios between intervention and control cases. Finally, it should be pointed out that Teledoc is a corporation that administers services for its physicians and thus constitutes a professional association that employs or has contracts with licensed physicians.

The second U.S. study in 2015 was designed as a prospective cohort study over 3.5 years ( $n = 494$  in the intervention group and 1,058 in the control group); it was aimed at determining whether “high-intensity telemedicine” would decrease ED visits by “senior living community residents.”<sup>114</sup> Of 705 patients who were asked to participate, 494 subjects or their

proxies did, a response rate of 66%. High-intensity telemedicine was defined as technician-assisted with resources beyond videoconferencing to treat acute illnesses. Whereas the ED use among participants in the intervention group decreased at an annualized rate of 18%, there was no difference in the control group. Furthermore, the use of primary care services and mortality were not significantly different in the two groups. The same results were reported in another article published in 2016,<sup>115</sup> but the latter publication is not included in *Table 1*.

An analysis of the impact of the specific content within e-visits on outcomes was conducted in Canada using the Building Access to Specialists through eConsultation, a system that linked PCPs to specialty services.<sup>116</sup> The study (published online in 2015) focused on factors associated with success in e-visits and whether e-visits would reduce the need for face-to-face visits. The variables of interest included question type (e.g., whether it had to do with diagnosis or disease management), the specialty being addressed, and whether it was a referral by a primary care provider. Overall, 40% of the e-visits resulted in an avoided referral. But, the highest referral rates were for diagnosis (44%), nonspecific requests for direction (44%), questions without specified interventions or outcomes (47%), and dermatology (49.5%). “Specialists agreed on the need for referral in 82% of the cases, with most discrepancies due to the PCP making a referral without the specialist recommending one.” Hence, the authors concluded that “referral outcomes are associated with the type of question being asked, the formulation of each question and the specialty being addressed.”

From Scotland, a survey of primary care physicians ( $n = 441$  general practitioners and 33 off-hours clinicians) was conducted to ascertain the impact of having “key information summary” available on electronic patient records available for unscheduled care providers during off-hours.<sup>117</sup> The findings suggest that the availability of “key information summary enhances patient safety, improves clinical management, reduces hospital admissions, empowers clinicians, aids communication across services and enables decisions to be responsive to patients’ wishes.” Off-hour clinicians reported being pleased to have these summaries.

Finally, a survey in Brazil ( $n = 895$ ) assessed physician perceptions regarding the impact of teleconsultations on clinical practice.<sup>118</sup> Family physicians and dermatologists accounted for the majority of teleconsultations (33% and 19%, respectively). The majority of the consults were about etiology (30%) and medication (25%). The respondents reported that “teleconsultations avoided patient referrals in 78%” of the cases, thereby demonstrating “the potential of

telehealth to provide support to primary care practitioners in remote cities.”

### HEALTH OUTCOMES

The majority of studies that investigated the effects of the telemedicine intervention in primary care focused on intermediate outcomes, as presented in the preceding section. We identified only eight studies with a focus on health outcomes, and only two of them used mortality as a measure of outcome. The other five used “soft” measures of outcome, such as adherence to healthy life-style behaviors, quality of life, and effective pain management. Outcome studies were conducted in five countries—four in the United States and one each in Belize, Spain, Brazil, and Zanzibar—and published between 2010 and 2015 (Table 2).

We start with the U.S. studies (all RCTs) and present them in historical order.

The first (an RCT,  $n = 324$ ) was published in 2010.<sup>119</sup> It investigated the effects of an Internet-mediated walking program on adherence to recommended physical activity guidelines among sedentary, ambulatory patients who were overweight and had type 2 diabetes or coronary artery disease. Participants were randomly allocated to the intervention group or control group at a ratio of 5 to 1 (254 versus 70) “to ensure a large participant pool to sustain online community dialogue.” Those in the intervention were provided wearable enhanced pedometers that uploaded the number of steps over a 16-week period with access to a Web site. The system tracked their walking and also provided tailored motivation messages and updated weekly goals. This intervention group was referred to as the “online community” because the participants could post and read messages from each other. Those in the control group did not have access to this system. The two outcomes were attrition from the study and average daily step counts. The results indicated significant increases in daily steps in both intervention and control groups. However, the percentage of participants who remained (did not drop out) throughout the study period was 13% higher in the “online community” compared with those in the control group. Participants who started out with lower social support posted more messages and viewed more posts compared with those who started out with higher social support. The authors concluded that the “online community” feature did not increase daily step counts but that it reduced attrition in participation.

The second, also an RCT ( $n = 415$ ), was published in 2011.<sup>120</sup> This study examined the relative effectiveness of two behavioral weight loss interventions for obese patients with one or more cardiovascular risk factors in a primary care setting. One

intervention provided weight loss support via telephone, designated Web site, and e-mail, whereas the other received the same remote support plus in-person sessions along with weight coaches. A third group (true control) did not receive any weight loss support. Weight loss was assessed by body mass index (weight in kg divided by the square of height in meters). After 24 months, weight losses in the two intervention groups—support by the three media and support by the three media plus in-person support—were 4.6 kg and 5.1 kg, respectively, whereas weight loss in the control group was 0.8 kg. The percentages of participants who lost 5% or more of their weight in the two respective interventions were 38.2% and 41.4%, versus only 18.8% in the control group.

The third U.S. RCT ( $n = 413$ ) was published in 2014. It assessed the effects of a primary care-based intervention on quality of life among risky drug users.<sup>121</sup> The intervention consisted of clinician advice and up to two drug-use health telephone sessions over a period of 22 months. The control group received usual care and information on cancer screening. Outcomes were measured in terms of changes in the Short Form Health Survey (SF-12), mental health component survey score, and physical health component survey score (PCS). “The trial found a marginally significant effect on improvement in PCS, and significant and stronger effect on SF-12 physical component among patients with greater frequency of initial [risky] drug use.”

Also in 2014, an U.S. RCT ( $n = 250$ ) investigated the effectiveness of a telemedicine system for collaborative chronic pain management in a primary care setting at the VHA.<sup>122</sup> The intervention consisted of two components: automated symptom monitoring and analgesic management—based on an algorithm-guided stepped-care approach for optimizing analgesic use and delivered by telephone. The control group received usual care from their primary care physicians. The intervention and control groups had similar baseline scores on a 10-point pain level (5.31 and 5.12, respectively). After 12 months, “patients in the intervention group were nearly twice as likely to report a 30% improvement in their pain score... Secondary pain outcomes also improved.” Hence, the telemedicine collaborative management “increased the proportion of primary care patients with improved musculoskeletal pain...by optimizing nonopioid analgesic medications using a stepped care algorithm and monitoring.”

Three additional outcome studies were published from 2013 to 2014 originating from three countries: Belize (in 2013), Brazil (in 2013), and Zanzibar (in 2014).

A pre-post record review was conducted in Belize, based on that country’s experience after the deployment of a national fully integrated patient-centered health information system

Table 2. Summary Listing of Empirical Evidence Pertaining to Health Outcomes

REFERENCE	YEAR	COUNTRY	STUDY DESIGN	SAMPLE SIZE	MODALITY	INTERVENTION	DURATION	FINDINGS	COMMENTS
Richardson et al. <sup>119</sup>	2010	United States	RCT	324	Mobile phone	Messaging	16 weeks	Significant increase in daily steps in both groups	Online access did not increase daily step count. Intervention group low dropout rate
Appel et al. <sup>120</sup>	2011	United States	RCT	415	Telephone/ Web	Weight loss support	24 months	Weight loss of 5% in both telephone and combination of telephone and in-person greater than no weight control support	Loss of 5%: in telephone, 38.2%; telephone and in-person, 41.4%; control, 18.8%
Baumeister et al. <sup>121</sup>	2014	United States	RCT	413	Telephone	Phone clinician advice	22 months	Stepped algorithm optimized analgesic medication	Stronger effect among patients with initial risky drug use
Kroenke et al. <sup>122</sup>	2014	United States	RCT	250	Telephone	Symptom monitoring and analgesic management	12 months	Algorithm-guided management is effective	Intervention group twice as likely to report 30% improvement in pain score
Graven et al. <sup>123</sup>	2013	Belize	Pre- and postintervention record review	300,000+	Patient health record	National information system	12 months	Quality ↑ Mortality rates ↓ in 8 domains: children 1–5 years old; HIV; maternal; acute respiratory infection; acute gastrointestinal infection; adverse drug reaction; hypertension	Deployment 90% in first year
Dos Santos et al. <sup>124</sup>	2013	Brazil	Pre-/ postintervention comparison; no control	502	Internet	Educational program	6 months	Adherence to hypertension medication ↑	Adherence to medication, physical activity, and sodium control improved by 8.9%, 1.3%, and 4.1%.
Lund et al. <sup>125</sup>	2014 <sup>a</sup>	Zanzibar	Cluster randomization	2,550	Mobile phone	Messaging	12 months	50% reduction in perinatal mortality	Increased recommended antenatal visits, 43.8% versus 31.1%

<sup>a</sup>See Lund et al.<sup>101</sup>

HIV, human immunodeficiency virus; RCT, randomized controlled trial.

(Belize Health Information System).<sup>123</sup> Belize is a small middle-income developing country with a population of over 300,000 (in 2010) and an estimated per capita GDP of \$6,800 (in 2005). Only 5.2% of the GDP was spent on healthcare in 2010, with only 6% of it in the private sector. Part of the health sector reforms of 2004 included the deployment of free, open source software to support the deployment of a national electronic information system. The authors attempted to assess the rate of the deployment of the Belize Health Information System and its impact on mortality rates. This last outcome was measured in terms of mortality rates in eight domains: neonates and infants, children 1–5 years old, human immunodeficiency virus–positive patients, maternal, acute respiratory infections, acute gastrointestinal infections, adverse drug reactions, and hypertension. The deployment pace was high: over 90% of all clinical encounters were entered into the Belize Health Information System during the first year. Three years after deployment, mortality rates decreased in the eight protocol domains and either increased or remained the same in three domains without protocols. “Hypertension related deaths dropped from 1<sup>st</sup> cause of death in 2003 to 9<sup>th</sup> by 2010. Public expenditures on healthcare stea-

dily rose until 2009 but then declined slightly for the next three years.”

The Brazilian study was a before and after (no control) comparison ( $n = 502$  patients and 21 health professionals) that assessed the impact of a telehealth strategy on increasing adherence to protocol in the treatment of hypertension in primary care.<sup>124</sup> Patients from two family health clinics were offered an educational program via Web conferences for 6 months. The topics included hypertensive drugs, low salt diet, and physical activity. After 6 months, “the rates of adherence to hypertensive medication, physical activity, and sodium control before and after [the program] were 37.8% versus 46.7%; 90.3% versus 89.9% and 92.2% versus 96.3% respectively.” Hence, this educational program improved adherence to hypertensive drugs and low salt diet but had no effect on physical activity, which was already high at baseline.

Finally, an RCT ( $n = 2,550$ ) investigated the effect of a mobile phone intervention on perinatal mortality in a primary care setting in Zanzibar.<sup>125</sup> The study was conducted from 2009 to 2010 on the island of Unguja in Zanzibar, a semi-autonomous part of the United Republic of Tanzania. It used cluster randomization, which means that all patients of a



given primary care facility would be allocated to either the intervention or control group. This simplified the selection process, but the effectiveness of randomization is dependent on individual variability within each clinic (or cluster) and the number of clinics, in this case 24. The authors described these clinics as being similar, typically staffed by one or two midwives with access to basic infrastructure and equipment. The intervention consisted of a mobile phone application (referred to as *Wired Mothers*) that linked women throughout their pregnancy, childbirth, and postnatal care using text messaging and a free call voucher system. On average, 37% of women owned mobile phones, and 58% resided in rural areas. More women in the intervention group received the recommended four or more antenatal visits compared with those in the control group (43.8% versus 31.1%, respectively). Other results from this study pertaining to skilled delivery attendance were reported earlier,<sup>103</sup> under intermediate outcomes. Here we report on outcomes only. “Children born by women in the intervention group had a 50% reduction in perinatal mortality compared with children born by women in the control group.” This difference was explained on the basis of “improving women’s choices of care and access to care during pregnancy and in the time surrounding delivery.”

### COST

Studies of the economic effects of telemedicine interventions in primary care typically consist of cost comparisons between two modalities of care delivery: in-person versus telemedicine. The methods used include cost-effectiveness analysis, cost-benefit analysis, or some variant of cost-benefit analysis. Cost-benefit analysis estimates the monetary value of benefits and costs as a means for identifying the strengths and weaknesses of alternatives. Cost-effectiveness analysis is an alternative to cost-benefit analysis, used when it is difficult to conduct cost-benefit analysis because of lack of consensus on assigning monetary values to certain benefits such as valuing life expectancy. Cost-effectiveness analysis compares the relative costs of the two modalities in terms of a specified effect; hence cost-effectiveness analysis is especially useful in allocating resources for more effect. *Table 3* gives our findings.

We identified a total of seven studies conducted in four countries and published from 2005 to 2015.

In 2005, a U.S.-based prospective trial estimated the cost implications of an Internet-based store-and-forward pediatric consultation service as indicated by consult response time and evacuation cost avoidance.<sup>126</sup> The analysis was based on 267 cases from 16 military sites located in the U.S.-associated Pacific Islands in the South and Western Pacific over a period

of 12 months. All consults originated from a primary care source. The Web-based system introduced a new benefit for referring PCPs by enabling them to obtain consultations from a range of specialists rather than a specific one who may not be the most appropriate. The system was used for a wide range of consultations at the primary care sites. “Generally, the response time to the initiating physician was excellent...with an average reply time of 32 h and a standard deviation of 14 h.” Cost savings were estimated for patients for whom travel was avoided (typically a 5-h flight and more than 1-week stay at the medical center. “The total cost for 1 air evacuation in this model was estimated to be \$5,794.” The authors concluded that this intervention “improved the quality of patient care by providing expeditious specialty consultation. Significant cost avoidance in this military pediatric population was documented. Store-and-forward Internet-based teleconsultation is an effective means of providing pediatric subspecialty consultation to a population of underserved children.”

Also, in 2005, a cost-effectiveness analysis (based on an RCT,  $n = 278$ ) was conducted in Scotland.<sup>127</sup> It compared the cost-effectiveness of nurse-led telephone consultations versus face-to-face asthma reviews. In terms of background, the authors explained that despite the guidelines for proactive care in general practice, only a third of the people with asthma attend their annual review appointments. Hence, there is an urgent need to develop cost-effective systems to improve attendance at these reviews. The trial observations were based on 3 months, and cost-effectiveness was assessed from the perspective of the NHS. Patients were randomly allocated to either telephone consultations or surgery (i.e., in-person). Telephone consultations were significantly shorter compared with surgery (average of 11.19 min versus 21.87 min). Total respiratory costs of providing 101 telephone reviews were similar to those for 68 in-person reviews, and the average cost per consultation was lower in the telephone group compared with in-person (€7.19 vs. €11.11). Therefore, “nurse-led telephone consultations can cost-effectively increase the proportion of patients reviewed when compared with face-to-face consultations (74% versus 48%) at an average saving of € 3.92 per consultation achieved.”

A different type of economic analysis was conducted in Norway in 2007, based on “willingness to pay.”<sup>128</sup> This method poses a hypothetical scenario (in this instance, access to electronic communication with general practitioner) and asks the respondents the maximum amount they would be willing to pay for it. This might indicate the value people attach to the service. In total, 199 patients were recruited from primary care waiting rooms. They were randomly allocated to the intervention group, who were given access to a secure

Table 3. Summary Listing of Empirical Evidence Pertaining to Cost

REFERENCE	YEAR	COUNTRY	STUDY DESIGN	SAMPLE SIZE	MODALITY	INTERVENTION	DURATION	FINDINGS	COMMENTS
Callahan et al. <sup>126</sup>	2005	Pacific Islands	Prospective trial/ cost avoidance	267	Store and forward	Pediatric consult	12 months	Significant cost avoidance resulting from obviated evacuation	Military pediatric population
Pinnock et al. <sup>127</sup>	2005	Scotland	RCT CEA	278	Telephone	Nurse consult	3 months	Telephone consults shorter by 10.68 min and cost less by €3.92	Cost-effectiveness from NHS perspective; attendance improved at no additional cost
Bergmo and Wangberg <sup>128</sup>	2007	Norway	RCT Willingness to pay	157	Telephone	E-access/ messaging with GP	Cross-section	52% willing to pay	Those who already have access less willing to pay
Datta et al. <sup>131</sup>	2010	United States/ VHA	RCT	588	Computer-based	Nurse-led decision support-behavioral intervention	24 months	Cost-effectiveness \$42,457 per life-year for men and \$87,300 per life-year for women	Nurse-administered tailored behavioral interventions were cost-effective
Rohrer et al. <sup>132</sup>	2010	United States	Retrospective record review	766	Online	E-visits	6 months	Reduced cost outliers	Outliers in e-visits, 21.2%; median cost, \$161. Outliers in in-person visits, 28.5%; median cost=\$219
Wang et al. <sup>133</sup>	2012	United States/ VHA	RCT	591	Telephone	Self-management	18 months	No statistically significant differences	Cost included inpatient, outpatient, and medication management
Nymark et al. <sup>134</sup>	2013	United Kingdom	Retrospective case-control	8,400	Telephone	Coaching/case management	12 months	Average cost of secondary spells: intervention=\$1,305; control=\$1,678	27% reduction in "secondary spells" per year
Henderson et al. <sup>135</sup>	2014	United Kingdom	Cluster randomized trial	2,600	Remote automated and passive system	Telecare	12 months	Cost of QALY similar in both groups. Social and health cost higher in intervention group	Only 1,189 agreed to participate. Sizeable percentage dropped out of both groups: 32% for telecare and 40% for control. Cost assessed in terms of QALY

CEA, cost-effectiveness analysis; E-visit, electronic visit; GP, general practitioner; NHS, National Health Service; QALY, quality-adjusted life year; RCT, randomized controlled trial; VHA, Veterans Health Administration.

messaging system that allowed them to communicate electronically with their GP for a year, or to the control group, who continued to communicate with their GP through office visits and telephone calls. However, only 151 (76% response rate) responded: 67 intervention and 84 control. Overall, 52% of the respondents were willing to pay for the electronic contact with the GP. This rate was lower in the group that already had such access compared with those who did not. In Norway, the co-payment fee for an office visit is small, and patients' valuing of online access may be influenced by the small size of this fee in relation to the substitute. In addition, some may believe that the additional cost should be borne by the government as part of their benefits. Hence, generalizing these findings beyond Norway may not be appropriate.

Two related cost studies were published in 2008. The first was conducted at the Group Health Cooperative, "the nation's oldest and largest consumer-governed integrated healthcare organization."<sup>129</sup> Data were obtained from the electronic health information system, which captures cost data for all services provided for its members, either directly by Group

Health Cooperative physicians or contractually by the Group Health Permanente Medical Group. The scope of the intervention is much broader than telemedicine, but it is consistent with the objectives of a broadly defined telemedicine system, including patient-centered care, improved access, and quality of care. Utilization and cost data were collected on quarterly basis in panels ( $n=352$ ) or subgroups (defined as having a primary care unit with at least 250 members). The findings indicate a significant decline in cost between baseline and full implementation resulting from gains in productivity and clinical efficiency. However, this article was not included in *Table 3* because it was not focused on the telemedicine intervention in primary care.

The second was an investigation of the economic value of these models of provider-to-provider telemedicine encounters.<sup>130</sup> Computer simulation methodology was used to extrapolate cost information for the three models: store-and-forward, real-time videoconferencing, and hybrid systems. Four healthcare settings were used—correctional facilities (CFs), EDs, nursing homes (NHs), and physician offices (MD to

MD)—with six possible provider-to-provider pairings: (1) CF to ED, (2) NH to ED, (3) ED to ED, (4) CF to MD, (5) NH to MD, and (6) MD to MD. The simulation indicated that the hybrid model would be the most cost-effective, with a predicted annual saving of \$4.3 billion across the United States. However, the results from this analysis “are the product of a computer model that extrapolated the existing evidence, not the actual experience of implementing telehealth systems nationwide.” In addition, the simulation does not include “potential costs and benefits from workflow re-engineering, credentialing and privileging, and cross-state licensure.” Again, these findings are not presented in *Table 3*.

Two studies met the inclusion criteria in 2010, both from the U.S. The first was an RCT ( $n = 588$ ) involving hypertensive veterans served at a VHA primary care clinic in North Carolina.<sup>131</sup> The purpose of the study was to ascertain the health outcomes and cost-effectiveness of a nurse-led computer-generated decision-support system designed to improve compliance with medical therapy guidelines. The primary outcome was blood pressure level, but here we focus on cost-effectiveness of the two modalities of care delivery. During 2 years of follow-up, the cost-effectiveness of the intervention “ranged from \$42,457 per life-year saved for normal-weight women to \$87,300 per life-year for normal-weight men.” The results suggest that “a nurse-administered, tailored behavioral intervention can be implemented at minimal cost [in primary care clinics] and be cost-effective” in the VHA system.

The second study in 2010 was a nonrandomized retrospective (case control,  $n = 766$ ) record review, which investigated the impact of online primary care visits on standard costs.<sup>132</sup> The specific purpose of the study was to ascertain whether online primary care visits (e-visits) would reduce the odds of being a cost outlier in a conventional primary care clinic. An outlier was defined as incurring costs exceeding the 75th percentile during a 6-month period after the index visit (which could be either online or in-person). A logistic regression adjusted for differences between the intervention and control groups. The percentages of cost outliers in the two groups were 21.2% and 28.5%, respectively. Median standard costs were \$161 for online visits and \$219 for same-day acute visits. The adjusted odds for being a cost outlier was substantially lower for the online group than for the standard visit group (odds ratio = 0.52).

In 2012, one U.S. study was eligible for this analysis. This was an RCT ( $n = 591$ ) economic evaluation of telephone self-management for blood pressure control at the VHA.<sup>133</sup> Eligible veterans were randomly assigned to one of three telephone-based interventions using home blood pressure telemonitoring with (1) behavioral management, (2) medica-

tion management, or (3) combined 1 and 2. Cost data were collected during the trial. Personnel costs (two registered nurses) constituted the main part the intervention costs. However, cost data also included inpatient and outpatient care and prescription medications. Intervention costs per patient were \$947 for behavioral management, \$1,275 for medication management, and \$1,153 for combined management. After 18 months, “...there were no statistically significant differences in total VA medical care costs between treatment arms and usual care.”

In 2013, only one publication met the inclusion criteria for this analysis, a retrospective cohort study ( $n = 8,400$ ) that investigated the economic impact of a telephone-based case management service for people with long-term conditions.<sup>134</sup> The program was a partnership between the U.K. NHS and private business, and it involved telecoaching, signposting, and motivational interviewing from a trained healthcare professional, at an average of one call per month. Participants were identified by their GPs and assigned to their local care manager. This was a primary care intervention, and secondary care (specialist) physicians were not involved in referring patients to the service. The control group was selected randomly from those who did not consent to participate in the program. The main outcomes were measured in terms of “secondary spells”—defined as the experience between hospital admission and discharge—and cost of care (the cost of activities during secondary care spells). The average number of secondary spells in the intervention group was 0.61 in the intervention group and 0.84 in the control group, or a 27% reduction in secondary spells per person per year. The average cost of secondary spells in the intervention group was \$1,305 and \$1,678 in the control group, or a 22% reduction in the cost of care in the intervention group.

In 2014, the cost-effectiveness of a “telecare” intervention for people with social care needs (such as day care and community social care, as contrasted to medical care needs) was examined using a cluster-randomized trial with a nested economic analysis in the United Kingdom.<sup>135</sup> Initially, a total of 2,600 individuals with social care needs from 217 general practices participated in a community-based “telecare” system. These were randomly allocated to “telecare” intervention ( $n = 1,276$ ) and usual care ( $n = 1,324$ ). Of these, 46% participated in the survey that collected the data on use of service: 1,189 were randomly allocation to intervention ( $n = 550$ ) or control ( $n = 639$ ), with response rates of 43% and 50%, respectively. The final percentages agreeing to participate in the survey were 48% in telecare and 43% in usual care. Moreover, a sizeable proportion of both groups dropped out of the study at the 12-month follow-up: 40% of the control group and 32%

of the telecare group. An imputation method was used to estimate the missing data. The technology in this evaluation consisted of remote, automatic, and passive systems. Cost data were based on self-reported units of service multiplied by the relevant, or nationally applicable, per unit cost. The analysis was based on the NHS perspective and did not include user charges or privately purchased equipment. Cost-effectiveness was assessed in terms of the cost of an additional quality of life year. The analysis revealed that quality of life year gain was similar in both groups, but social and health services costs were higher in the intervention group. However, given the difficulty of estimating the actual costs of a rapidly changing technology, as well as the low response rates in the survey, these findings must be treated with caution.

Also in 2014, a Canadian cost-effectiveness analysis was based on modeling scenarios involving low-risk postoperative ambulatory surgery patients.<sup>136</sup> The intervention was a mobile phone application that connected patients from their homes with their surgeons as a substitute for in-person visits. Cost was assessed from a societal perspective regardless of the payer; cost-effectiveness of telemedicine and conventional care was measured in terms of successful outcomes at 30 days after surgery, and it was modeled with data on similar patient populations and surgical risks. “The costing assumes that 1,000 patients are enrolled in bring-your own device mobile app follow-up per year and that 1.64 in-person follow-ups are attended in the conventional arms within the first month postoperatively.... The analysis reveals that mobile app follow-up care for low-risk postoperative ambulatory surgical patients can be cost effective from a societal and healthcare system perspective.” However, this analysis will not be presented in *Table 3* (as part of the evidence on cost) because it focused on post-surgical care between patients and their surgeons, rather than involving their PCPs.

Finally, we include a multicountry European (Spain, Greece, and Norway) assessment of an integrated care services model, the European Union NEXES project, in terms of enhanced outcomes and cost containment.<sup>137</sup> It focused on targeted case management for a broad spectrum of illness severity, ranging from wellness and rehabilitation ( $n=338$ ), enhanced care for frail chronic patients ( $n=1,340$ ), and home hospitalization and early discharge ( $n=2,404$ ) to remote diagnosis in primary care ( $n=8,139$ ), a total of 12, 221 subjects from the three countries. Both RCT and pragmatic study designs were used to ascertain whether a patient-centered management approach that transfers care from the hospital to the community would enhance outcomes and contain cost. In brief, the project demonstrated “...the high potential to enhance health outcomes with cost-containment...” in terms of fewer hospitalizations in chronic

respiratory patients, reduced hospital stays for all patients, and increased quality of testing for patients with respiratory symptoms. However, there were “marked differences among the sites,” which suggests that the intervention was not uniformly implemented or the contexts had independent effects. There is much to learn from this multifaceted project in terms of implementation, but not in terms of the economic effects of telemedicine interventions in primary care.

## Summary and Conclusions

Despite the lack of consensus on precise definitions of the content and boundaries of primary care, there is near universal agreement that PCPs serve three essential functions in health-care: first contact, gatekeeper, and manager/coordinator. In addition, there are widely accepted views that (1) primary care is essential in creating a rational system of care and an effective division of labor among providers of care, (2) given the available resources, the demands on primary care are excessive and likely to worsen with projected shortage of primary care physicians, and (3) alternative care delivery models must be developed and utilized to expand the reach and effectiveness of available resources in primary care, including telemedicine. Indeed, the rise of scientific medicine during the past several decades has not overshadowed the important place of primary care in the delivery of health services, which include prevention, continuity of care, health maintenance, and death with dignity, among others.

This article is based on a selective review of the extant literature on the feasibility/acceptance and impact of telemedicine interventions in primary care. Selectivity was based on scientific rigor (research design and sample size) and recent vintage (last decade). The reasons for methodological rigor are obvious. The limited time frame was deemed appropriate in view of continuing changes in the underlying technology of telemedicine that affect both quality and cost as well as basic changes in clinical applications that may render older findings dated or no longer applicable.

Thirty-five studies met the feasibility/acceptance inclusion criteria during 2005–2015: 15 were conducted in the United States, and 23 were based on sample survey designs. Research in this area addressed a wide range of issues, including e-visits, e-prescribing, electronic access to providers, sharing visit notes, patients’ access to their electronic record, Internet use for health information by patients and providers, nurse-coaching, and disease management. The common finding from these studies affirmed the feasibility and acceptance of telemedicine interventions in primary care by both patients and providers who used them. More specific and nuanced findings can be summarized as follows:

- Patients were generally in favor of sharing their visit notes with concerned family members and caregivers. Also, patients perceived several benefits from having electronic access to their own medical records, whereas their physicians were less sanguine about the benefits to be accrued by patients from such access.
- Patients were in favor of having access to their PCP over the Internet or telephone during off-hours, as well as when seeking advice on health problems, prescription renewals, and making appointments. Some were willing to pay modest amounts out-of-pocket for such service.
- Typically, established users of the Internet who are already familiar with the technology were more likely to seek health information over the Internet compared with those less familiar. Nonetheless, the use of the Internet and mobile phones for health purposes is increasing, especially among younger individuals, women, and Hispanic Americans and in developing countries.
- Patients tended to adhere to health advice and coaching provided by nurses over the telephone as a substitute for in-person visits.
- Patients were satisfied with the convenience of e-visits and e-prescribing, and they equated e-consulting with in-person except for conditions that require physical examination, where they preferred in-person visits.
- The Internet proved to be an effective tool for cross-country surveillance of infectious disease in Western Europe.

Thirty-six studies met the inclusion criteria for the evidence on intermediate outcomes: 15 from the United States, 4 each from Canada and the United Kingdom, and the remainder from 11 other countries. In terms of research design, 13 were RCTs, plus three quasi-experiments, nine surveys, nine record reviews, and two observational. Sample size ranged from 153 to 376,795. Here again, several types of interventions were used, including e-consults, electronic scheduling, medication checks, appointment reminders, incident reporting, triage, provider to provider communication, and pregnancy management. Intermediate outcomes included clinic attendance, provider adherence to protocols, use of service, and patient compliance. A summary of the findings can be highlighted as follows:

- The technology used in most of these studies consisted of telephones (including mobile phones, SMS messaging, and interactive voice response) and the Internet (including Web sites, electronic health records, and patient portals). Only one study used “high-intensity telemedicine,” and one simply mentioned “telehealth service.”
- Findings pertaining to the effects of e-consults (typically by telephone) indicated a moderate improvement in quality in

- some studies and equivocal findings in one study, which reported similar quality in the treatment of back pain but lesser quality in bronchitis. Other effects include 40% avoided referrals for chronic conditions, as well as increased early return for regular visits (when indicated). Portal messaging was not associated with primary care visit frequency.
- Reliance on the electronic health record resulted in 9% decrease of office visits in a large health system over a 2-year period, as well as modest improvement in quality.
- Use of the Internet had generally positive effects in several areas, including electronic scheduling appointments (29% improvement in specialty care), improved referral and booking, and identifying medication adverse events and addressing them.
- Appointment reminders by telephone and SMS texting resulted in improved clinic attendance (converse of no-show) by about 10 percentage points, but cost of texting is lower. Electronic scheduling with tracking improved access to referred specialty care.
- Medication checks resulted in error detection and adverse events. There was no change in visit frequency to PCPs.
- Use of the Internet produced similar results to that of the telephone in the following areas:
  - Nurse-led telephone triage improved prompt follow-up for patients with appendicitis; also, nurse guidance over the telephone improved appropriate use of antibiotics for URIs.
  - Telemonitoring/case management reduced 30-day re-admission by 30%.
  - Physicians’ concern regarding patients’ apprehension when seeing them look up information on the Internet during the clinical encounter was not substantiated by the patients themselves. This is especially true of older patients, who justified this behavior as appropriate, but younger patients were not as sanguine, and the majority of both older and younger patients had a nuanced opinion based on the type of information being sought and the credibility of the sources. However, medical textbooks were preferred.

Only seven studies (originally eight) meeting the inclusion criteria focused on health outcomes: four from the United States (all RCTs) and the remaining three from three other countries. The small number of studies in this area may be explained by the nature of the topic. Unlike our previous reviews of studies dealing with the impact of telemedicine interventions on quality of care in specified diseases or health conditions where there is a clear connection between the telemedicine intervention and clinical outcomes, this article

deals with a mode of medical practice where this connection is not direct or clear. This also explains why many more studies were focused on intermediate outcomes.

Findings from health outcome studies can be summarized as follows:

- Interactive online access did not increase daily step count among patients who were overweight or had type 2 diabetes or coronary artery disease compared with controls. However, both intervention and control groups improved from baseline, participants in the intervention were already more active at baseline, and the intervention lasted only 4 months.
- A remote behavioral intervention by telephone and Internet resulted in significant weight loss, especially when combined with in-person individual sessions with a PCP among obese adults with one or more cardiovascular risk factors.
- A stepped algorithm-driven clinician advice rendered over the telephone optimized analgesic medication among patients with risky drug use. Similarly, an algorithm-guided monitoring and analgesic management telephone intervention reduced pain.
- The adoption of a national information system improved health outcomes through lower mortality from several diseases.
- An educational program delivered over the Internet improved adherence to hypertension medication, physical activity, and sodium control.
- A mobile phone messaging systems among pregnant women in a developing country resulted in 50% reduction in perinatal mortality.

A total of eight studies investigated the cost differential of telemedicine versus in-person care, all demonstrating positive economic value. The specific effects noted included cost avoidance from obviated expensive evacuations, shorter consult time, cost savings per life year, and reduced cost outliers.

Some final observations are in order. Reviewing the use of telemedicine poses challenges analogous to reviewing primary care in general—in that both are rapidly changing. Just as the meaning of primary care is constantly being redefined, so too are the capabilities of telemedicine, for patients, physicians, and health systems. Indeed, although it is impossible accurately to predict what new tools will become available over the next few decades, it seems reasonable to predict that substantial advances in information and communication technology and related fields would enable doctors and patients to interact with each other and among themselves in ever more efficient and effective devices and platforms, not now feasible.

This trend will continue and accelerate. Our literature review is thus useful as a snapshot of a moment in time, with the obvious caveat that new tools will doubtless change the landscape perhaps in ways that may seem inconceivable today. Nonetheless, it is useful to know where we are today as we try to implement effective policy.

The majority of the articles we reviewed were based on research done in the United States, but substantial numbers were based on research done in other countries. This raises the obvious question regarding the generality of evidence gathered in different socioeconomic contexts, or if there are different national styles in the use of telemedicine. The basic telemedicine tools are essentially the same, and the means of electronic communication on which telemedicine is based might suggest that the underlying technology would be the same in a variety of different social and national contexts, as would the observation that studies in different countries have arrived at generally similar conclusions about telemedicine. Nonetheless, we need to remain cognizant of the possibility that superficial similarities in language may mask deeper underlying differences in meaning, as for example, with the fact that the term “physician” has different meanings in the United States and the United Kingdom.

Over the past few decades, a large literature has demonstrated disparities in the delivery of healthcare along a wide range of parameters. Most of the articles studying telemedicine that we reviewed did not significantly attend to issues of ethnicity, gender, or class. One article did look for racial and ethnic disparities in the delivery of acute stroke care in Texas but did not find any.<sup>138</sup> However, this topic was outside the purview of this review and was not included in our analysis.

All things considered, there is ample evidence from rigorous scientific research that low-cost telemedicine interventions in primary care are feasible and acceptable to both patients and physicians, typically resulting in improved quality and cost savings. Future developments pointing to improved technological capabilities, more ubiquitous distribution, and declining price would ultimately lead to the inevitability of incorporating this modality of care in mainstream healthcare.

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