CHAPTER

2

Rationale, history, and basics of telehealth

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Definitions

Tele ~ *distance* **medicine** *or* **health** is the use of information and communication technologies (ICTs) to deliver health services where there is physical separation between care providers and/or the recipients over both long and short distances. It is about *transmitting* voice, data, images, and information *rather than moving* care recipients, health professionals, or educators. It encompasses preventive as well as curative aspects of healthcare services for recipients. The interactions can be between care recipient(s), care providers or educators, and lately also computerized devices—standalone, as well as working though a mobile.

Telemedicine describes remote clinical services in the form of patient and clinician contact. It includes diagnosis, monitoring, advice, reminders, education, intervention, and remote admissions. Variations include clinicians discussing a case over video conference; telementoring, which means overseeing a procedure being done by a less trained person; digital monitoring with live feed or application combinations; and forwarding of test reports for interpretation by a specialist. Other examples are home monitoring of the aged or infirm through continuous feeding of patient health data, client to practitioner online conference, videophone interpretation during a consult, and also robotic surgery. In emergent situations, such support can save vital seconds and, in chronic care, cut down frequent travel, saving travel cost and time.

In **telehealth** the scope expands beyond telemedicine to administrative meetings and other nonclinical services too, like inclusion of preventative

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and promotive components. Also included is tele-education, for patients or care providers, through distance learning, meetings, supervision, and presentations.

Besides saving in physical transportation, which could be by the care recipient, the provider, or both, all variants support achievement of quality aims, addressing barriers to care through innovative means and leveraging the proliferation of technology in an increasingly mobile-friendly and technology-centric population.

The information collected can be further processed and analyzed to plan a long-term health strategy of an increasing aged population, many living alone in diverse locations, with a rising number of chronic conditions.

eHealth, (currently Digital Health is the term preferred by WHO) an even broader term, has over 51 definitions[4] including "The use of information and communication technologies (ICT) in support of health and health-related field, including health care services, health surveillance and health education, knowledge and research."

Another one is "eHealth is the use, in the health sector, of digital data -transmitted, stored and retrieved electronically- in support of health care, both at the local site and at a distance." And yet another *eHealth is an emerging field in the intersection of medical informatics, public health, and business, referring to health services and information delivered or enhanced through the Internet and related technologies. In a broader sense the term characterizes not only a technical development but also a state of mind, a way of thinking, an attitude, and a commitment for networked, global thinking, to improve healthcare locally, regionally, and worldwide by using information and communication technology.*

Examples include treating patients, conducting research, educating the health workforce, tracking diseases, and monitoring public health. Another term **mHealth** is further discussed in the succeeding text.

Any of the previous terms can be used interchangeably, but the term *telecare* will mostly be used in this book. This term has no written definition but however would be best understood as encompassing any kind of healthcare where remote support is incorporated. Artificial intelligence (AI), CDSS, and a multitude of direct patient or physician support methods are beyond the scope of this book.

History of telemedicine and telehealth

Efforts for communication beyond the hearing range, that is, smoke signals, drums, and pigeon carriers, have been part of human civilization since its inception. They were also used to access healthcare. The inequality in the availability of good healthcare between the higher and lower classes existed even then, with both the highest quality care and ready access to the same, restricted to kings and such. The elderly and infirm often sent representatives and/or used messages to convey information on symptoms and bring home a diagnosis and treatment options.

Telecommunication, as we know it today, followed the discovery of electricity in the 19th century. As technology developed and wired communication became increasingly commonplace, the ideas surrounding telehealth began to emerge. During the American civil war, telegraphs were used to deliver mortality lists and medical care to soldiers.

The telephone was easier to use than the telegraph; thus access to public began to emerge as well. The earliest telehealth encounter can be traced to its inventor Alexander Graham Bell, in 1876. He had called for help from his assistant Mr. Watson after spilling an acid on his trousers.[8] *The Lancet* in 1879 described a doctor's successful diagnosis of a child over the telephone in the middle of the night and subsequently discussed the potential of remote patient care in order to avoid unnecessary house visits.[9]

The concept of telemedicine evolved in 1905 thanks to a Dutch physiologist who utilized the telephone for transmission and monitoring of cardiac sounds and rhythms. Bicycle-powered radios were used to request for medical help from Australia's flying doctors' services almost as soon as it started.

Formal recognition of the term telemedicine started in the 1920s when two-way television and audio signals were used to communicate. In the 1940s, in Pennsylvania state, transmission of radiography was done through telephone circuits between cities 20 miles apart. The first uses of telemedicine to transmit video, images, and complex medical data occurred in the late 1950s and early 1960s. In 1959 the University of Nebraska used interactive television (IATV) to transmit neurological examinations, widely considered as the first case of a real-time video telemedicine consultation. Telepsychiatry, through remote counseling, followed.

When the National Aeronautics and Space Administration (NASA) began plans to send astronauts into space, the need for telemedicine became all too clear. For monitoring purposes, telemedicine capabilities were built into the spacecraft as well as the first spacesuits. In the 1960s, NASA, Lockheed Corporation, and the U.S. Indian Health Service joined together to work on Space Technology Applied to Rural Papago Advanced Health Care (STARPAHC) project to provide telemedicine access to an American Indian reservation via telecommunication links similar to the one used for space stations. Different projects were funded across North America and Canada in order to realize the exciting potential of this new innovation.

Other programs followed, focusing on the transmission of medical data such as fluoroscopy images, X-rays, heart and chest sounds from a stethoscope, and electrocardiograms (ECGs). The main motivations of these early projects were as follows:

- Providing access to healthcare in rural areas
- Medical emergencies

Radiology was the first medical specialty to fully embrace telemedicine in the 1980s. This was a natural advance from PACS, that is, enterprise level digitization of medical images. PACS was conceived as a cost and space-saving advantage wherein X-ray images were stored in a digital format. This allowed instant access to current and prior images using computer monitors at different locations in the radiology department as well as within wards. Allowing remote access was the next step, which was enabled first for the hospital's own radiologists, so that they could report from home. Now, they report from anywhere across the globe (refer the "Teleradiology" section in Chapter 10).

One of the oldest known telecardiology systems for tele-transmissions of ECGs was established in Gwalior, India, in 1975.[10] This system enabled wireless transmission of ECG from the moving ICU van or the patients' home to the central station in the ICU of the department of medicine. Transmission through frequency modulation helped eliminate background noise. This system was also used to monitor patients with pacemakers in remote areas. The central control unit at the ICU was able to correctly interpret arrhythmia.

Internet use, though widespread by the turn of the century, impacted telehealth much later as the initial systems required higher bandwidth than what was initially available. Among the earliest to benefit were specialities dependent on the interpretation of audio or images, either still or moving (video). Examples of the former were patient conversations, heart sounds, and speech therapy, while the latter included dermatology, cardiology (ECG, echo, and angiograms), ophthalmology, and pathology; a third group was if care could be administered through video conference (psychiatry). Special tools to enable transfer emerged, for example, tele-stethoscope and tele-ECG, and for telepathology, specialized microscopes exist wherein the movement of the slide viewer could be remotely controlled, as well as zoomed in on a real-time basis.

India has been an early leader in telecare among the developing countries. The need was emphasized by a large rural population, between 60% and 70% of the total, where even the few officially posted doctors would rarely be present on duty. Efforts were spearheaded by Indian Space Research Organization (ISRO) along with a special school for telemedicine which was established in the city of Lucknow. In 2001, this center provided consults to pilgrims gathered in the city of Allahabad to take a dip in the Ganges for the Kumbh festival.[11] Emergency remote support provided to high altitude trekkers in the Himalayas after an avalanche made it extremely popular and well known. CPCs and medical seminars with an audience from across the country are being held almost since inception. Telemedicine linkages exist to clinics in remote areas, like Ladakh and Andaman Islands, and also to many hospitals in African countries.[12] ISRO provided opportunities to neighboring countries, for example, Nepal and Bhutan, to use Indian satellites for their own programs. China has similarly assisted Mongolia, Argentina, and Iran.

Almost all early deployments of telemedicine were large undertakings as there was a requirement of special staff and organizational changes. Large projects were created—mostly for government or defense. They were clunky and expensive, hence unsustainable. Customized hardware and software had been created for a specific use, like telepsychiatry. Maintenance was frequently required and not available locally. The inability of various software to talk to each other lead to initiatives toward standardization. Even the few projects that survived the initial phases soon became outmoded due to rapid advances and changes in technology.

The available connectivity option was the key decider for projects, which initially were phone lines (dialup Internet), GPRS, or satellite. ISDN was a cheaper option than satellite and less erratic than others but held sway only for a few years, soon overtaken by broadband Internet and now 3G, 4G, 5G, etc. through mobiles.

There have been other advances:

- memory and storage (databases, object-store for large files such as images and video) and easy availability—through backup servers, which can dynamically increase as per demand load
- standardization (MP4, PNG, etc.)
- security (encryption, password protection, access levels, etc.)
- application development—new programming languages (Java, JavaScript, dotnet, etc.), frameworks, and open-source software (Apache)
- the cloud and virtual servers such as Amazon Web Services (AWS)
- methods to digitize information (digital cameras, scanners, etc.)

Usage of existing computing devices—belonging to patient or physician—helped bring down costs, besides being easy to use, as little further special training was required.

Telemedicine 2.0 was a relatively late beneficiary of this information explosion. Internet protocols allowed support for practically all information and traffic needed for telemedicine, including the following:

- patient education (text, images, and video)
- medical images such as X-rays and scans (DICOM image standards)
- real-time audio and video consultation
- vital signs and other body measurements (ECG, temperature, etc.)

However, there have been objections to provide telecare by clinicians. Some feel that an inability to touch the patient means the interaction is less than ideal and the consult is slow, incomplete, and not to the requisite quality, making them more liable. Reimbursement policies are not very clear; the patient sitting outside their chamber is more paying and less demanding on time.

The current situation

Despite the challenges, many countries like Norway,[13] Canada, Australia, and others within the EU have well-established telehealth programs. A rising number of the aged, many living alone and unable to travel frequently, along with the presence of citizens in an area where access is regularly hampered by distance and climate, offer justification for such projects. A single unified EHR for all citizens makes it easier to implement,[14] but this is as yet exists only in the smaller countries where the need for telehealth is also less. In the United States, efforts to create EHRs for all its citizens through incentives and penalties have given a major push toward eHealth.

Smartphones have had a major impact on public health. There are now an over 325,000 health apps,[6] which remind patients to take their medicine, transmit their health information, and even act as daily fitness trackers. Functions like GPS and cameras allow for improved collection of health data. Software, hardware, and attachments are available to make the mobile work as an e-stethoscope, slit lamp, and microscope using a clip-on lens. A probe for ultrasound, pulse oximeter, and monitor can be added to a special device created, which means that information is not only obtained, but also transmitted seamlessly.

EMR vendors employ the Internet with access to medical information for medical providers and patients. Alongside, patient portals have come up allowing patients to look up their lab results, refill prescriptions, or send a secure message to their physician. Infant monitors allow parents to work. Portable monitors diagnose and send a message to the clinician about cardiac arrhythmias and falls. Drones are enabling emergency care by their capacity of delivering blood samples, medicines as well as medical support to a remote location. An ambulance transferring a patient from a trauma site directly to the operating suite with a surgeon in readiness is considered routine today.

The public is accessing telecare in preference to a physician visit.[15] This is done through search engines; use of social media; and sometimes communicating through e-mail, WhatsApp, Skype, or even desktop sharing over and above-specialized applications. Many of the former have privacy concerns and generally frowned upon by academics and experts.

The situation in developing countries is a little depressing. While a near parity exists on the availability of latest software and hardware between developed and developing world—absence of this parity is an invitation to software piracy, poor connectivity remains an issue. Even where ICT infrastructure is available, more basic health concerns like water and sanitation, even food sometimes, which telehealth will never correct, take precedence. There are notable exceptions that are mentioned in individual chapters.

In conclusion, telehealth has become routine in many fields, and the future is bright, though not to the desired extent considering that the initial goal was for improving health access and better care for remote and rural populations. There is better focus and agreement on its use for care of the aged and infirm.

Situations where telehealth has a role

Let us look at the situations that require remote support. There could be an immobility of the patient, for example, someone bed ridden, sick, having a fracture or paralysis and in need of urgent help. Immobility or lack of immediate availability could also be of the provider, in the form of not enough specialists, day off work, or on leave. Another set is an unsurmountable physical barrier disallowing access to the care giver, like for astronauts in space, passengers in a ship or airplane, prisoners, patients who have been quarantined, and those visiting or staying at remote islands and mountain peaks.

Less commented about, but far more frequent candidates for telecare are those with chronic diseases. Here, cost cutting becomes important as there is need for frequent visits even while suffering from a less serious problem. Need for funds for travel, days off work, etc. can be decreased. Recurrent physician visits interfere with day-to-day work. Simple filing and review of test reports, which mostly can be possible remotely, may be the only interaction required. Examples are blood sugar and HbA1C for diabetics, blood pressure in hypertensives, and renal parameters for those with kidney disease, etc.

Some more examples are provided hereby with many more specific instances in the later chapters. In many infectious diseases, physician-patient contact has to be minimized due to fear of transmission of infection. Travel of a high-level public figure, politician, or even a criminal has many issues for security and other reasons like avoidance of a preying media.

Telemedicine largely provides remote assessment, and diagnosis, 90% of which, in older times, was dependent on simple history and examination, most of which, can be digitized but requires effort. Digitization of investigations is easier. And its rising contribution has created a better rationale for telecare. For example, gallstones found on ultrasound are an indication for surgery, and once the preoperative evaluation is complete, patient needs to travel only once for the procedure. Preliminary evaluation, including other tests as well as follow-up stitch removal, can be done locally.

But many clinicians have been averse to deliver remote care as many components, such as patient examination may be insufficient. A frequent complaint is “I do not feel satisfied till I have touched the patient, neither is the patient satisfied.” However, surveys of patients have shown the latter to be a myth. All that the patient wants is complete attention and a serious listening to their problems, which a face-to-face online contact can and does provide. On the other hand, talking on a mobile, glancing at your watch or even outside for the next patient, even while your hand is examining a patient, is much more off-putting.

Other reasons for resistance of clinicians to telehealth include fears of litigation, lack of confidence in understanding the full spectrum of the patients' problem online, as well as of staff and related capability across long distances, legal safety beyond borders, and lack of reimbursement. But the role of telecare is well recognized. With the rising dependence of investigations for diagnosis, not touching the patient is possibly considered normal. There are also guidelines about the need for self-protection, if there is a suspected contagious disease.

In summary, telecare may provide incomplete care, but nevertheless, does provide some care. Whether any telesupport will be worthwhile depends on the alternatives. An important aspect is ensuring that the telesupport has quality in some ways to the level as a physical visit or at least covers up for or compensates some gap in care provision.

Types of telecare

Let us begin by classifying the various methods of administering remote care. The first two are traditional; the latter ones came up with advancing technology. Currently a hybrid of almost all types is used:

1. **Real time** or **synchronous—**here, information or data is transferred live. Video conferencing between a patient and the healthcare provider is the prime example. Others include live viewing of ultrasounds or angiograms as they are taking place, streaming of procedures from the OR, or of heart sounds using a tele-stethoscope. This is a convenient and easy form of telemedicine but requires high bandwidth, constant connectivity, and investment in related hardware.
2. **Store and forward (S&F)** or **asynchronous—**information is recorded and transferred. It can be stored locally or in a server depending on when connectivity becomes available. Viewing, comments, and even incorporation of the data into a different server can occur at the convenience of the other participants of the telehealth stream. It is less dependent on constant connectivity but more complicated to administer. Choice of software and interconnectivity standards has a greater role—as interpretations may differ.
3. **Telemonitoring or remote monitoring—**medical devices record and process personal information and transmit continuously (*real time*) or in a processed summary form (*asynchronously*) to the clinician. Examples are home care devices for old age and infirm as well as tele-ICU.
4. Mobile health or **mHealth**[a] is a special form of Digital Health. Smart mobiles have computing power and connectivity access better than

[a] Chapter 12 explains this in detail.

specialized telemedicine systems of the past. They are inexpensive, have inbuilt audio and video, are flexible to allow both real time, and store and forward transmission as well as viewing from almost anywhere. Telemonitoring through inbuilt or even add-on sensors allows a single device to be a complete telehealth solution for a range of different problems. Many specialized applications or apps can directly inform the patient about their health status.

Real time telecare is relatively easy to do but has a high dependence on technology and connectivity. Since it is visual and also easy to understand with a certain wow factor, that made it the major form to be advertised, as well as sold. However, getting outcomes remains a challenge, with pitfalls in the form of the need of constant connectivity, an inability to garner the entire information in one go, call drops, and a high dependence on training to get the best value. Most failures, as mentioned in the history section were because this type of telecare was oversold. However, real time remains to be the most popular type aided by cheaper connectivity and hardware. It is a major component of mHealth. Most cameras, standalone as well as within microscopes and endoscopes, X-rays, MRIs, etc. use digital formats; hence, sharing or transmitting on a real-time basis is easy.

S&F essentially depends on gathering patient information and sharing the same after processing. While sharing photos, there is need to create a relevant case of whose photo? and why an opinion is required. This required typing not only by the referring person, but also by the expert who may have some further questions or is providing the opinion in the form of a written prescription or advice. Sending scanned copies or photographs of prescriptions and reports is also extremely time-consuming besides being inefficient as the specialist might be just wanting to know the ESR and CRP, but will have to one by scroll through the entire set of 9 or 10 pages of the sent reports. The doctors' scrawl is famous for unreadability, photographs of such handwritten text, one can imagine would be even more difficult to interpret. Simple typing of the relevant information is also inefficient, slow and a reason for mistakes which may get accentuated, if anything, by autocorrect. This has been another reason for failure of telemedicine systems of the past. We now describe a better way.

Any student starting clinical courses undergoes a grilling about the value of medical documentation. Documentation helps to create the diagnosis through compilation and assessment of various components like history, examination, and test reports. Following the diagnosis, some advice, medication, or procedure, and maybe a combination of all three, is done.

Documentation of almost all components of care can be digitized (see Fig. 1), which was previously done on paper but is now largely done

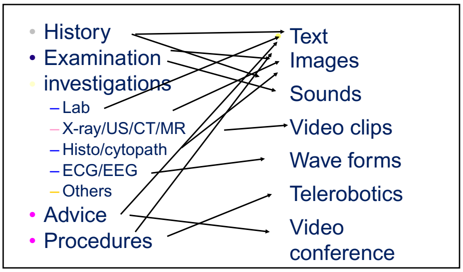

FIG. 1 Digitalization of a patients' medical record breaks the components into text, sound, or images. ECGs/EEGs constitute wave forms. Video conference allows face-to-face interaction.

electronically, that is, an EHR. An EHR on sharing enables a virtual physician-patient interaction and is in a way, the easiest form of telehealth.[b]

Images and sound require usage of simple devices like camera and microphone. However, newer advanced devices can extend the scope of telecare as they can read and process information far beyond what the human body is capable of. Examples include GPS; implantable sensors; swallowable miniature cameras, which can see inside the body; and, not to forget, artificial intelligence, which does the information processing at electronic speeds.

Such methods are changing health diagnosis and care delivery and side by side enabling telecare. Once an entry is made, information can travel anywhere within nanoseconds, even before the patient comes back, say from the operating room (OR) or radiology department. Whether the patient is present in the next room or across the globe becomes irrelevant.

Following the prescription, there is a period of follow-up; reassessment; and change of plan as per need, with further advice/procedure. In chronic diseases, such processes continue on a long-term basis. Data availability through the EHR allows remote care to become as good as physical care.

We need to remember, however, that virtual interaction is slightly deficient when compared with the physical one, as procedures and more importantly, somewhat essential components of a physical examination like palpation and smell cannot be done remotely. These limitations are getting obviated through newer sensors and robotics.

The consultant's time is the most expensive element of a physician-patient interaction. To save time, many practices ask residents or sometimes patients themselves, to fill forms. This can be done remotely and also the direct questioning. Such forms can be provided beforehand for a type of store and forward interaction. On-screen forms are not only faster to work with, but with incorporation in an EMR, searchability is

[b]More details of the components of EHR are in Chapter 3.

immediate and better. Templates, drop-down lists, CDSS, and other forms of automation, like highlighting relevant answers or reports, are standard components of an EHR.

Telecare is easier for revisits and follow-up, hence highly recommended. Imagine going on a daily basis for reporting on your urine output or blood sugar when all it may need is a small or maybe no change in medication. Secondary uses of information entered are easy to incorporate in a telehealth-enabled environment. These include analytics, public health strategy, and also remote medical education through video conference and web streaming.

EHRs have made a team approach easier but have made healthcare more complicated.[16] The best storage for an EHR is cloud[c] based, but here, constant connectivity is essential. There are reasons beyond telehealth for the rationale behind EHRs and meaningful use. Examples include the clarity of printed reports (see Box 1), CDSS, AI[c], prevention of drug

BOX 1

Computerized prescriptions

The concluding section any of visit to the health provider is the advice which can be hand written or printed text. Advice generally constitutes a drug prescription, or suggestion for a procedure, but also may be an order for further investigations. There are many arguments favoring a printed prescription as against the famous doctors' scrawl. Previously the printing was through a typewriter, but now the same is done digitally. And digitization makes remote care easy. The same links can allow for the printing to be done remotely. They also allow for patient evaluation and follow up notes. Besides that, a digitally authenticated signature can also be stamped on it. In many countries, prescription are being directly sent to the pharmacy. It is also possible to provide summary guidelines or handouts, for example, a diet chart that the patient can view online or take a print. Advantages over physical handouts include the following:

A. The number of choices is relatively unlimited, so it can be individualized to very specific needs.
B. Further on the spot editing widens the choices even further.
C. There can be built-in error checking for drug-drug interactions as well as of glaringly incorrect advice, which are known components of ePrescriptions.

[c] Abbreviations used throughout this book are explained fully in the Glossary.

interactions, avoidance of repetitive investigations, and facilitation of a team approach, and this is what constitutes **eHealth**.

Common other examples of store and forward include patients asking for help through e-mail or WhatsApp, which are, however, frowned upon by telehealth experts, mainly for security and privacy concerns.

Another method of classifying telehealth is by defining the partners and the direction of the flow of information. These **Telehealth Streams** are hereby listed as follows:

- **Between patient and provider.** Phone calls, emails along with text, or multimedia messaging services are used to explain the problem at hand and request for an appointment at the first instance and later to review investigation reports, assess progress, and provide online prescriptions. Social media and commercial tools like Skype as well as a range of ready-to-use apps have made this stream very diverse.
- **Between providers of different levels**. If patients are considered as tier 0, healthcare delivery is classified under primary care (GP, tier 1), secondary (specialist, tier 2), or tertiary (super specialist, tier 3) with costs escalating with each rise in level. Tier 1 may even be provided at the subprimary level, meaning the nurse practitioner. In this stream, interactions take place between tiers for assistance in diagnosis and for management of emergencies. Information flow is more focused and better directed as compared with the previous stream. A complete history may be provided, and also a more detailed examination conducted by the remote practitioners. While procedures and advanced care is done at higher centers, follow-up like stitch removal, dressings, or prescriptions for pain is again relegated to the remote caregivers. This is the most important form of telehealth. Boxes 2 and 3 are two representative examples.

BOX 2

Telemental health after the tsunami in India

Village-level counselling was provided from Chennai for patients with PTSD following the 2004 tsunami in India.[429] Village-level volunteers were trained to identify symptoms of PTSD; such patients were collected and asked to remotely consult the psychiatrist sitting in their hospital at an appointed time. Two suicides had been prevented from just one location, where the evaluation took place. *Read more on this in the subchapters on telepsychiatry (Chapter 10) as well as telemedicine in disasters (Chapter 11).*

BOX 3

Teleophthalmology example

In Mizoram, India, a hilly state, with poor roads, eye problems especially cataracts are common. Eye surgeons are found only in towns which are at a 6–12 h driving distance, the latter meaning an overnight halt generally with a relative accompanying. A cataract surgery would mean an average of five such trips, some for preoperative assessment. Reasons for wasted trips included "this is not cataract," "surgery not recommended at this stage," "diabetes control required," "the list is full for the next 2 days," and "doctor has gone on leave." In the teleophthalmology project run by SATHI,[147] trained ophthalmic assistants did preoperative workup, fixed appointments so that there is only one visit required for the day of surgery, and also performed postop care like stitch removal and glasses. Instead of five average trips for, say, a cataract, only one was required—that is, for the actual surgery, saving 80% of travel costs.

- **Between providers of the same level.** Formal tele-education is through online CMEs, meetings and webinars. Medical schools with less than ideal number of faculty can benefit from classes held elsewhere.[17] Most conferences these days have a remote speaker and remote delegate component. Many a time, one may be confronted with an atypical case or need help for a complication from a more experienced colleague. Online discussion forums like plastic_surgery@yahogroups.com and bulletin boards are a more informal set. There has been a recent flood of groups operating on WhatsApp, Telegram, and other mobile platforms.
- **Within an enterprise.** An example is cardiac hospital chains, wherein angiograms are done in a set of peripheral franchises, and then patients are referred for surgery to the higher center. Follow-up care is again local with unified billing and care administration.
- **For public health purposes.** Data collection and analytics; discussions within the team for health administration; online meetings; healthcare system integration; assessment of need for support in emergencies; inventory management to ensure the flow of essential supplies; etc.
- **Home healthcare**. The patient stays at home mostly with ICT-based monitoring with or without involvement of medical personnel. Home Healthcare is being used extensively in developed countries for care of the aged and infirm.[d]

[d] There is a section on this in the last chapter.

Telehealth allows multiple, different disciplines to merge and deliver a much more uniform level of care using the efficiency and accessibility of everyday technology. Increasing usage of telehealth challenges the notions of traditional healthcare delivery, and different populations are starting to experience better quality, access, and personalized care in their lives.

Classification based on connectivity. It is mentioned only in passing. During the early days the connectivity option used to be a major decider of projects, for example, the data sent by phone, SMS, or satellite link. Omnipresence of the broadband Internet as well as 4G and 5G has overcome these barriers. Such issues still predominate in some areas of the developing world.

Classification based on specialty. While there is a complete chapter devoted to it, it would be easy to understand that those specialities that use images as an important component were among the earlier ones to adapt to telecare. An abbreviated list of the top departments or services, which have benefited from telehealth, is provided in Table 1.

The rationale behind telehealth (why)

Telehealth systems and processes provide benefits for a range of stakeholders, although many may not be aware of it. There are issues also, that constitute a *Why not*.

For the patient. Faster, efficient, and cheaper care delivery without the constraints of time and distance. Travel costs are decreased. One must remember that this is required both for the patient and the accompanying relatives, who not only have to take the day off from work but also pay for the stay in hotels. Much of such stay before the procedure can be wasteful, for example, delay in appointment for a particular test or simple issues like *specialist is on leave* or *you have to come fasting*. Since the workup is done jointly over time with the help of the referring doctor, there is less chance of preprocedure tests being missed. Postprocedure care is also done locally. Outcomes improve—no wonder 76% of U.S. citizens elect telecare over a physical visit.[5]

For nurse practitioners and GPs. Medical knowledge today is not humanly manageable. Being a GP is one of the most difficult jobs as one never knows what the next patient will have. ICT not only provides access to written knowledge but also creates instant referral to a particular specialist. Hence, GPs and nurse practitioners can cater to a wider range of problems and better satisfy health needs within their local community leading to an expansion of clientele, who are more confident about the GPs capability. Results improve as one learns, even while the patients are jointly managed.

Specialists. One neurologist for around 200,000 population in the United Kingdom[18] is considered less than ideal. However, many

TABLE 1 Departments which can benefit from telecare.

Service	Important components	Role
Wound care	Unless very serious, wounds should be managed at the subprimary level. Requires transfer of images mostly. Sometimes telementoring and VC	Very high
Radiology	Images and video. Preexisting digitization and PACS make it easy. DICOM a specific standard	Very high
Dermatology	Images. Most problems are chronic, so decrease in frequency of visits is important	Very high
Cardiology	Tele-ECG, telestethoscope, and emergency support for MI	High
Ophthalmology	Images, which used to be taken through a slit lamp, an ophthalmoscope, and a fundoscope, can now be replaced by smart mobiles with special attachments	High
Psychiatry	Video conference and face-to-face contact for counseling	High
Pathology	Images and opinion. Special microscopes allow remote manipulation of the slide	Moderately high
Intensive care	Monitoring devices and emergency support	Moderately high
Emergency care	Allows care to begin as soon as a 911 call is made	Moderately high
Rehabilitation	Immobility of patients is a constant concern	Moderately low
Pediatrics	Emergency support and telemonitoring home-based care. A comfortable environment and access to parents is helpful for child development	Moderately low
Orthopedics	X-ray films. Home monitoring of splints and dressings. Emergency support	Low
Neurology	Tele-ICUs with robotic assistants and home care	Low
Plastic surgery	For preop assessment, planning, and also follow-up care (See example in Box 4)	Low

specialists do not manage to find adequate work because patients are unable to reach them because of time or distance. Many specialists cover different hospitals on different days with much time wasted in traveling. Referrals done through the ePlatform are faster and easier with a high patient satisfaction rate. Cardiologists and neurologists can cover a range of hospital CCUs and ICUs and control administration

BOX 4

Example of Telecare in Plastic Surgery

For a felt need, a patient can consult a plastic surgeon directly online or through his GP.

Photographs are sent, and a complete preoperative assessment is done beforehand. A face-to-face meeting through VC is done to discuss the finer counselling points like what surgery is to be done, costs, postop care, and expected outcomes.

Travel is hence restricted to only for the date of the procedure, unless some further tests or evaluation is required. After surgery—generally done as a daycare—the patient comes back, and the GP does the stitch removal and minor dressings. Emergency management is done jointly with the plastic surgeon.

With such processes, cleft lip and palate surgery is being done by the thousands in Varanasi, India. A short documentary of this clinic (*Smile Pinki*) was awarded an Oscar in 2008.[575]

of streptokinase for MI and stroke,[19] respectively, even while staying at home. Patients do go window shopping for specialists, but they are more likely to freeze the decision after contact is established in any way. Specialists also need to refer their patients to other specialists, for example, a diabetic person with a stroke would need an endocrinologist and many a times an eye surgeon, a nephrologist, a vascular surgeon for diabetic foot, etc.

Telemedicine can be further classified according to the **care process—** whether it is for consultation/monitoring/appointment provision or simple data collection.

In summary, the advantages of telehealth can be listed as per the U.S. Government Accountability Office, 2017:

- increases access to specialized and timely urgent care,
- increases the capacity and efficiency of specialists,
- reduces wait times for appointments and follow-up visits,
- reduces emergency department visits and the time patients spend in hospitals,
- reduces the discomfort and anxiety associated with patients traveling to receive services,
- reduces the costs and carbon emissions associated with patient travel,
- connects care teams to provide greater continuity of care,

- connects remote family members with long-stay patients,
- connects healthcare professionals for knowledge sharing,
- integrates with conventional care delivery models,
- keeps patients in their homes and communities longer.

Some issues

Clinicians remain relatively averse to telecare as compared with patients. These issues are discussed in Table 2, as well in Chapter 9.

The process (how)

While processes employed for telecare are detailed in the rest of the book, a sample flow chart is provided in Fig. 2 on how a telecare provider can do the coordination. The telecare administrator can be the health-care provider himself, an outsourced agency, or directly operated by the government or insurance provider.

Another example of utilizing S&F is a simple creation of an EHR as described previously:

- All medical records stored in the form of an EHR. This would include the basic demography in the form of *name, age, gender, social and economic factors, and geography* along with summary of complaints, history, diagnosis and progress, and relevant reports sorted according importance.
- On need for opinion, patients' record with all images and reports is transmitted. A tentative diagnosis and reason for referral needs to be provided in addition to the preceding text. It is important that relevant reports be highlighted, with, if possible, markings of the area of concern in an X-ray. A small note on the immediate problem for which

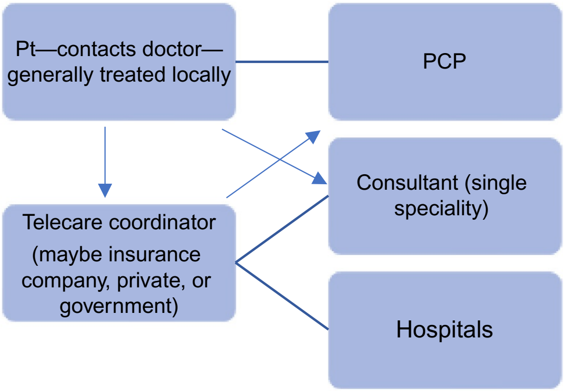

FIG. 2 A simple onine referral flow chart.

TABLE 2 Issues linked with Telecare.

	Type	Problem	Explanation	Possible solution	Serious?
1	Clinical	Care provision with less than ideal information or misinformation	Examination and procedures not possible	Knowing the limits and stating them upfront. Clinical decision support using adaptive learning methods; ICT should not override the clinicians	Yes
2	Administrative	Cross-border care (multijurisdictional)	Licensing rules may restrict care provision across borders of various countries and, sometimes, states	Governance and cooperation	No
3	Administrative	Care provision by relatively less or untrained persons	It is always difficult to know whether the supposed care provider is a fraud or hack Sometimes, family members are asked to answer a query	Ensuring guidelines ("Map of Med" for telehealth)	Yes
4	Technical	Lack of emergency support and retrieval care	Inadequate connectivity or broken links to the requisite support team	High bandwidth connectivity; systems interoperability	Yes
5	Administrative	Diversion of funding from more deserving immediate problems (and lack of funding through conventional mechanisms)	Telehealth systems have been promoted as a technology answer to each and every problem (a major reason for failures)	Health economics and cost-benefit analyses; public-private funding models	No
6	Administrative/ technical	Bias toward "best-connected" demographic (including developing world)	Telehealth was supposed to decrease the rich-poor gap allowing developing countries to leap frog. It has not happened	Scalable solutions; platform independence of services; better penetration of connectivity	Maybe
7	Clinical	Unusability of patient remote monitoring information (including adverse events) especially on software upgrade	High-end systems do fail. A system for local maintenance and availability of trained persons is a constant need	Automated customized personal surveillance systems; enthusiasts and promoters; help and support on version change	Yes

8	Technical	Noninteroperability of monitoring devices/sensors	As above	Standards and open systems	No
9	Technical	User acceptability of new telehealth technology (games, avatars, and immersion). Intrusive—asking for too many passwords	The best of systems fail because of human factors. An unused technology or system is literally useless	Participatory design; interventions targeting youth; training; proper reimbursements	No
10	Clinical	Services established outside ordinary protocols; weak links to EHRs	Occurs whenever change management principles are ignored	Include the service into the traditional healthcare system and EHRs (if available)	No
11	Personnel	Loss of interpersonal relationships due to wrong words and misinterpretation	Miscommunication and misinformation are common, for example, autotyping leading to wrong words	Rechecks; a general slowdown; Guidelines	Yes
12	Personnel	Loss of respect for timelines	Calls for help on a 24/7 basis—sometimes the care seeker is in a different time zone	Strict appointment system; guidelines	Yes
13	General	No clear method of reimbursement. Care access through unconventional means competing with regular channels	Insurance companies do not reimburse the travel and time cost. In India, telehealth has had higher success rate as healthcare expenses are out of pocket	Creation of telehealth-related care and reimbursement protocols; engagement of insurance companies	Yes

Adapted from Gogia SB, Maeder A, Mars M, Hartvigsen G, Basu A, Abbott P. Unintended consequences of tele health, and their possible solutions. Contribution of the IMIA Working Group on telehealth. Yearb Med Inform. 2016;(1):41–46. doi:10.15265/IY-2016-012.

the opinion was sort will ensure satisfaction and shorter visit time—consultants' time being the most expensive component of any consult. If a cloud-based EHR is being utilized access to the patients record to the specialist may be the only step required.
- Specialist reviews the data either before or on appointed time.
- History and clinical examination done online, which could be in the form of direct questioning or whatever, are examinations possible online, for example, finger movements for suspected tendon injury. Alternatively the PCP or coordinator is asked to do some tests like BP, pulse, and pinch sensation. Further tests are in the form of repeat or additional investigations, pictures or X-rays.
- The last step by the online consultant could be in the form of
  - provision of an online prescription,
  - referring doctor informed on what to do,
  - patient asked to come for procedure,
  - patient given next appointment, which could be physical or online,
  - explain next steps, anticipated problems as well as means of transfer.

The clinician may initiate steps in anticipation like the OR made ready for urgent procedure even before the patient arrives.

Telehealth services are reshaping healthcare

Gunnar Hartvigsen

According to the American medical doctor Eric Topol,[21] we are facing a transformation from today's medicine, which he describes as old and dumbed down to a new, personalized medicine that is facilitated by digitizing humans. What we see, he explains, is a super convergence of wireless sensors, genomics, medical imaging, information systems, mobile connectivity, Internet, social networking, and computational power. Through a creative deconstruction of "old medicine," a new form of medicine will be established.

One of the areas this transformation is happening is telehealth. For several decades, telehealth has become important but still remains a small-scale health service and technology. This is about to change with the use of all kinds of telehealth services that are "coming to your home." New technologies are reintroducing a digital version of the house calls where people are taken care of at their bedside. We are in the middle of a telehealth revolution in which ICT, medical devices, sensor systems, and new telehealth services are reshaping parts of healthcare. According to Bruce Judson (2017), this development is driven by several factors[22]:

1. Health authorities' approval of remote diagnostic tools, in particular the U.S. FDA.

2. The advancement of different telehealth platforms for managing chronic conditions and achieving specific patient outcomes.
3. The development of different telehealth services offered by private and public healthcare organizations and systems.
4. Innovative direct-to-consumer initiatives by Samsung, Apple, American Well, and others.
5. Do-it-yourself (DIY) initiatives that force healthcare institutions and industry to change their business models and open up their devises and systems.
6. Social media and cloud-based solutions have moved healthcare initiatives from healthcare professionals to patients and relatives.
7. Standardization enables exchange of health data between all stakeholders in healthcare.

Health authorities' approval of remote diagnostic tools has been very important for the advancement of telehealth services.[22] In many countries, healthcare organizations and services are not allowed to use nonapproved diagnostic tools. Healthcare Information and Management Systems Societies (HIMSS) reported that 36 connected health apps and devices had received clearance from the U.S. Food and Drug Administration in 2016.[23] This number will rise to 51 next year.[24] Examples of the approved devices include VivaLnk's Fever Scout, which is a peel-and-stick continuous thermometer for children; Shenzhen Kingyield's Bluetooth-connected wrist-worn blood pressure monitor that sends data to a smartphone for archiving or evaluation; and CareTaker's extended wrist-worn (including a finger cuff) continuously connected blood pressure and heart rate sensor. The data is sent to an Android phone or tablet or directly to a hospital via cellular networks. An interesting functionality is the device's ability to operate as a wearable hub for recording and displaying. In this way, data from other devices like weight scales, glucometers, thermometers, and spirometers can be displayed on the tablet.

The advancement of different telehealth platforms for managing chronic conditions and achieving specific patient outcomes are important for the advancement of telehealth.[22] An example of a telehealth platform is TytoCare's ecosystem of connected tools for remote medical examinations. TytoCare provides complete virtual visit, including physical exam. TytoCare Home includes otoscope (ears), stethoscope (heart, lung, and abdomen), basal thermometer, and digital camera (skin and throat). According to the company, TytoCare enables doctors to remotely diagnose conditions such as ear infections, flu, upper respiratory infections, sinus infections, pink eye, rashes, bug bites, wounds, sore throat, and pneumonia more accurately.[25] With TytoCare and similar devices, people with chronic conditions can monitor their health status from their own homes.

Side to side, working at the clinicians' end are Web-based programs like IBM's Watson and UpToDate by Wolters Kluwer, which have CDSS as well as inbuilt search engines to help make a diagnosis, be it for a patient they are seeing or remotely.

There are many different telehealth service systems on offer by private and public healthcare organizations.[22] One example is doctor on demand. It offers a mobile app providing access to doctors, psychologists, and other healthcare providers. The company was cofounded by Phillip McGraw and allows patients to video chat with doctors instead of physically visiting them. High in the complexity scale, we find Mercy Health Virtual Care Center in St. Louis, Montana, which is the world's first large hospital without any patients. Mercy Virtual Care Center hosts 330 specialized medical professionals and zero patients. Through the use of high-resolution two-way cameras, online-enabled instruments, and real-time monitoring of vital signs, Mercy's medical professionals can visit their patients regardless of being in one of Mercy's traditional hospitals or a physician office or even in the patient's home. Mercy's telehealth programs includes **Mercy SafeWatch** (doctors and nurses monitor patients' vital signs and provide a second set of eyes to bedside caregivers in 30 ICUs across five states), **Telestroke** (patients with symptoms of a stroke who come to one of the 30 emergency departments [EDs] without a neurologist present can be seen immediately by a neurologist via a two-way audio and video connection), **Virtual Hospitalists** (a team of doctors is dedicated to seeing patients within the hospital 24/7 using virtual care technology), and **Home Monitoring** (Mercy provides continuous monitoring for more than 3800 patients, intervening quickly when needed). On the other end of the complexity scale, we find telehealth services based on technology like text-based SMS and standard smartphone photo and video services, presented, for example, by the WHO.[26]

Another factor for the development of telehealth services is the innovative direct-to-consumer initiatives by Samsung, Apple, American Well, and others.[22] Together with American Well, Samsung's Ask an Expert (AAE) offers users to connect, via video, to contact of the 1200 board-certified licensed physicians. American Well presents their service as a connected healthcare ecosystem. In addition to the telehealth features, both Android- and iOS-based smartphones offer a lot of health, fitness, lifestyle, and food/nutrition services. American Well provides complete telehealth service to connect patients and doctors via video-based applications. The company was, in 2015, the first to be accredited by the American Telemedicine Association for online patient consultations.

The fifth contributor to the telehealth revolution is the do-it-yourself (DIY) initiatives that force healthcare institutions and industry to change their business models and open up their devises and systems. One of the initiatives is the Nightscout project, which "is an open source, *DIY* project that allows real time access to a CGM [continuous glucose monitoring] data via personal website, smartwatch viewers, or apps and widgets available for smartphones."[27] Many of the diabetes DIY projects use the hashtag #WeAreNotWaiting to present what they are discussing or developing, including platforms, apps and cloud-based solutions. Some of the groups have reverse engineered existing products to get access to proprietary data formats. In this way, they have been able to develop new solutions for the users, for example, to make blood glucose data from CGMs available for everyone and not only for the CGM user.

The next contributor is social media and cloud-based solutions, which have moved healthcare initiatives from healthcare professionals to patients and relatives. One of the most known services is PatientsLikeMe.[28] With more than 600,000 members, living with more than 2800 conditions, people with chronic health conditions can get together and share their experiences living with their disease. The company was founded in 2004. In its new initiative, DigitalMe, a "virtual you" for each patient is created by combining multiple sources of health data, including biological, experimental, medical, and environmental data. The company states that: "There's a small chance that what you contribute may help you directly, but we will continue to learn from each other along the way. The goal is to advance what is known about disease, health and aging, and continue building a health learning system that can give people a better quality of life for longer." In 2017 the U.S. business magazine Fast Company appointed PatientsLikeMe as one of the top 10 most innovative companies in biotech. In the other end of the complexity scale are different patient organizations and interest groups' use of Facebook to connect with their users.

A crucial factor for the realization of telehealth is the use of standards—standardization enables exchange of health data between all stakeholders in healthcare. When Norway, for example, in the beginning of the 1990s developed teleradiology in its northern areas, the first obstacle was to convince vendors involved in the service to implement a larger portion of the DICOM standard for medical images.[13] The problem with standards is that there are a lot of them. In some areas, however, we see a convergence of standards. In the exchange of health data, Health Level 7 (HL7) has become the dominant standard for the exchange of health data. Health Level 7 (HL7) International is "a not-for-profit, ANSI-accredited standards developing organization dedicated to providing a comprehensive framework and related standards for the exchange, integration, sharing, and retrieval of electronic health information that supports clinical practice and the management, delivery and evaluation of health services."[29]

The list of factors for the development of telehealth services is not complete, but the factors earlier are among the most important factors.

What is undoubtedly important for this development is that technology is playing a vital role in healthcare disruptions in general. One example is the alliance between Amazon, Berkshire Hathaway, and JPMorgan who are looking for new ways of organizing healthcare for the employees. One of the ideas they are discussing is to make an online healthcare dashboard that based on the condition they chose from a drop-down menu will connect their employees with the best doctor in that particular field.[13]