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**Narrative Review**

# Role of Telemedicine in Management of Patients During the COVID-19 Pandemic

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**ABSTRACT**

Telemedicine is applied in different medical conditions, such as acute emergencies, nonurgent assessments, and long-term treatment of ongoing neurological illnesses. A telemedicine interaction involves a remote provider and the cases and family at the originating site. For acute care and consultations, a telepresenter at the originating site improves the evaluations and approves results to the remote provider. The skill level of the telepresenter is different depending on the use and the desires of the remote provider. The limits of the evaluations conducted remotely using telemedicine have not been fully investigated during the COVID-19 pandemic. The skill set of the telemedicine must include the capacity to find when these limitations prevent optimal patient treatment and, in such cases, request an in-person assessment to more evaluate manifestations. Therefore, in this review, we aimed to investigate the role of telemedicine in management of patients during the COVID-19 pandemic.

**Keywords:** COVID-19, Telemedicine, telehealth, technology.

## Introduction

Telemedicine is most common defined as the delivery of medical care by electronic communication between a health care provider and a subject needing medical assistance at different regions. The earliest application of telemedicine dates back to the 1940s, but only recently has telemedicine undergone rapid improvements. The improved availability of broadband capabilities, Internet access, and technological advances make a condition that is trigger for expansion of this new mode of care in many aspects of medicine, including COVID-19 (1, 2). Telemedicine is applied in different medical conditions, such as acute emergencies, nonurgent assessments, and long-term treatment of ongoing neurological illnesses. The use of telemedicine may take the different types of real-time video communication, store-and-forward technology, or remote assessment. Store-and-forward methods deliver medical data asynchronously in the form of text with or without images or photographs. This form of telemedicine is effective for visits that do not need an interactive evaluation (3, 4). In other conditions, real-time videoconferencing is essential to provide 2-way video and audio communications between cases and health care providers. Remote assessment of cases in the home is possible by a variety of modalities, from text messaging to Bluetooth-connected methods, and promises to increase preventive care as well as long-term treatment of chronic disease. A telemedicine interaction involves a remote provider and the cases and family at the originating site. For acute care and consultations, a telepresenter at the originating site improves the evaluations and approves results to the remote provider. The skill level of the telepresenter is different depending on the use and the desires of the remote provider. The limits of the evaluations conducted remotely using telemedicine have not been fully investigated during the COVID-19 pandemic. The skill set of the telemedicine must include the capacity to find when these limitations prevent optimal patient treatment and, in such cases, request an in-person assessment to more evaluate manifestations (1, 3). Therefore, in this review, we aimed to investigate the role of telemedicine in management of patients during the COVID-19 pandemic.

## 1. Role of Telemedicine in the Management of Neurological Disorders

### 1.1 Telemedicine and Neurological Disorders

At present, there is a considerable disparity between the requirement for neurologists and the availability of neurological care, especially in rural regions. This disparity is estimated to grow considerably in the next decade. New and innovative approaches are needed to provide neurological services to cases in need throughout the United States. Telemedicine is characterized as a means of bringing specialty expertise to rural or underserved regions (5). Telemedicine has been applied to manage cases with stroke, Parkinson disease (PD), epilepsy, and other neurological disorders, and the reach of teleneurology continues to expand. Many academic neurology systems already provide teleneurology cares, and many of those that do not are planning to start as soon as possible. At some point, telemedicine will become sufficiently integrated into mainstream medicine that the tele may be removed, and teleneurology will become just another path of delivering neurological treatments. This chapter summarizes the current condition of teleneurology as well as some of the barriers to more growth and expansion (5, 6).

### 1.2 Telemedicine Technology

Documentation of teleneurology consultations is always acceptable, whether this is accomplished through entries into an electronic medical record or a separate technology that is available to both the remote and originating site. Availability of imaging investigations is essential for optimal assessment of many teleneurology patients, which may be accomplished by remote access to a picture archiving and communication system (PACS) or transmission of figures directly to the remote provider. There are several modalities available for delivery of telemedicine (7). The most frequently used approach includes a moveable cart with a pan-tilt-zoom camera, liquid-crystal display (LCD) screen, and video codec or computer located at the site of cases care. The remote provider connects to the cart either directly or through a web browser–based technology and manages the camera from the remote site to provide communication with the cases or family and conduct elements of the neurological evaluation. Mobile carts with video and audio conferencing features may be remotely navigated between rooms and adjusted to optimize patient evaluations. With store-and-forward modalities, data is entered in the form of text, JPEG, or PDF files and assessed remotely and asynchronously. The provider then communicates an interpretation, with suggestions, if appropriate, to the originating site (7-9). Remote assessment is carried out with devices in the home capable of sending data to the remote provider through the Internet or telephone lines. Blood pressure, weight, glucose level, and, in some patients, real-time audio and video can be transmitted from the location of patients. Appropriate connectivity is essential to support video resolutions that are appropriate for evaluating neurological activity, and minimal standards have been suggested. Effective encryption should be applied to satisfy Health Insurance Portability and Accountability Act (HIPAA) needs due to transmissions typically traverse the public Internet. The cost of telemedicine equipment is rapidly reducing but remains a barrier to small hospitals with narrow profit margins. In some subjects, telestroke visits have been carried out using tablets and smartphones with appropriate findings, but whether this modality would be useful to other aspects of teleneurology is less certain. The limits of the neurological evaluation conducted remotely using telemedicine have not been fully investigated. Aspects of the evaluations, such as tone, reflexes, and sensation, may be difficult to evaluate visually, even with an experienced telepresenter. The skill set of the telemedicine neurologist must include the capacity to find when these limitations prevent optimal patient treatment and, in such cases, request an in-person assessment to more evaluate neurological manifestations (7, 8).

### 1.3 Telestroke

The remote emergent assessment of stroke is probably the most common application of telemedicine in neurology. The term telestroke was first introduced by Levine and Gorman in 19996 at a time when most communication performed across telephone lines and videoconferencing technologies was primitive by today’s standards. Telestroke networks now make expertise to hospitals in many rural and underserved regions that lack the continuous availability of vascular neurologists with experience assessing and managing cases with acute stroke. Results of assessments using the National

Institutes of Health Stroke scale, when conducted remotely by telemedicine, were highly associated with in-person evaluation both in the acute and nonacute stroke conditions (10, 11). Different studies stated that treatment rates with intravenous (IV) tissue plasminogen activator (tPA) enhanced considerably following the instituting telestroke at community medical centers. Most significant, cases cured with IV tPA after remote assessments by telestroke had outcomes that were similar to cases who were managed in person. Earlier management with IV tPA leaded to a higher probability of good outcome, and telestroke avoids delays in treatment resulting from transporting cases to tertiary care medical centers when stroke expertise is not available. Safety is not compromised with remote assessments. Intracranial hemorrhage rates are similar in patients who are managed by telestroke compared with those who are managed in person. Telestroke networks deliver treatment through a hub-and-spoke or distributed network. In a hub-and-spoke technology, or more stroke centers provide the vascular neurological expertise for many smaller regional medical centers (11). This model allows for transfer of correct cases to a primary or comprehensive stroke center for continuing care after initial remote assessment. With this arrangement, more treatment, such as endovascular treatment or participation in clinical studies, can be carried out with the same group of neurologists involved in the care decisions at both the remote and originating site. In a distributed model, a group of neurologists or a private company provides on-call vascular neurologists to widely dispersed medical centers. These medical centers make preexisting transfer agreements with local stroke centers to accept cases with stroke when critical (12).

The long-term cost-effectiveness of telestroke networks is dependent on the enhanced application of IV tPA and the decrease in disability that results from improved results. Early incremental costs are offset by long-term decrease in health care costs and elevated quality adjusted life years. Limited reimbursement by insurers, the burden of licensing, credentialing issues, and liability concerns are limitations for the continued expansion of telestroke. However, the approved benefits of telestroke will likely result in continued growth of telestroke networks worldwide (10, 12).

### 1.4 Acute Teleneurology

Uncommonly, hospitals in which telestroke has been successfully instituted need urgent consultations for neurological emergencies other than stroke. There may be limited or no neurological coverage for general neurological disorders. Many telestroke health care providers now also offer general neurological consultation coverage. Teleneurology provides facility for local providers to maintain realistic on-call schedules and supplies coverage when local specialists are unavailable or burdened by busy office visits. In rural regions without neurological support, the further expertise should lead to higher levels of quality care and decreased costs (13, 14). Unlike acute stroke, the accuracy of the common neurological evaluations and non-stroke neurological diagnosis when achieved remotely is less established. Interrater reliability for common neurological evaluations conducted by telemedicine is similar to that of in-person evaluations. Evaluations of strength and coordination are more variable, but similar, regardless of the modality of assessment. However, direct comparisons of telemedicine and in-person general neurological evaluations are lacking. Whether remote assessment of general inpatient neurological problems such as delirium, changed mental status, dizziness, and headache leads to similar diagnostic accuracy and quality of care in comparison with in-person consultations is uncertain. Some insight is achieved from a cohort investigation that compared a hospital with teleconsultations conducted by a neurologist with another facility that did not have neurological support. The medical center with teleneurology had decreased lengths hospitalization and no difference in subsequent mortality or more costs and utilization following discharge. No diagnosis was subsequently changed by an in-person examination, attesting to the accuracy of neurological assessment by telemedicine (13, 15).

## 2. Role of Telemedicine in the Management of Cardiac and Renal Diseases

### 2.1 Tele-Coronary Care Unit

Several clinical studies have investigated the tele–intensive care unit (tele-ICU) model. Various investigations have shown that, if used correctly, tele-ICU can decrease mortality, length of hospitalization, and complication rates, and improve best-practice adherence. Tele-ICU technology provides continuous secure transmission of patients' vital signs from an intensive care unit (ICU) to a controlling basement in real time. Furthermore, controlling center personnel provide teleconsultation and support to bedside physicians and nurses by continuous surveillance and 24-hour alert technology (17 ,16). Tele-ICU visit in the coronary care unit (CCU) provides continuous assessment of vital signs, electrocardiogram (ECG), blood pressure waveforms, oxygen saturation, pulmonary artery catheter waveforms, respiration, and also body temperature. This process also provides real-time communication and tele-visits with specialists. The feasibility of this condition was investigated by a recent study. In the Finnish investigation, remote surveillance of the CCU and cardiology ward was carried out by a tele-cardiologist who could use electronic medical reports. The tele-cardiologist role was supportive, and this case was available for visit and emergencies. The remote access of hospital intranet and server uses proved reliable and technically feasible (18). The investigation showed a potential for decreasing the delay for diagnostic and therapeutic interventions. Early diagnosis of acute myocardial infarction and sufficient reperfusion by means of percutaneous coronary angioplasty or thrombolysis has been proposed to decrease morbidity and mortality, especially in the setting of ST-elevation myocardial infarction (STEMI). The 2013 American Heart Association/American College of Cardiology STEMI recommendations stated the need for regional medical technologies to provide reperfusion treatment as soon as possible. Much notion is being paid to the aim of prehospital thrombolysis prior to admission to the CCU. Tele-visit and remote interaction of a paramedic with a specialist available in a CCU holds great promise to decrease delay and increase patient health (17). Tele-visit with the support of wireless and mobile modalities additionally provides assessment and surveillance during transmission. Smartphone applications also provide highly accurate analysis of angiographic plaques and may also serve as a supplementary method for emergency conditions in the critically ill cases. Telecardiology currently uses a wide variety of applications, including the assessment of cardiac rhythm and activity remotely with software modality. Two of the most critical instruments within the cardiologist domain are the 12-lead ECG and the two-dimensional and three-dimensional echocardiogram. With wireless modalities, specialists can remotely access data from patient reports and offer timely diagnostic and treatment suggestions (18, 19).

### 2.2 Electrocardiogram Telemonitoring

One of the most significant uses of telecardiology is the ability to transmit a report ECG to a cardiologist for assessment. In 3G (third-generation) wireless technology, ECG transmission can be carried out with the application of mobile phones/tablets at home. The information are transmitted by Bluetooth to the hospital. ECG transmission can be carried out without Internet access as well (20, 21). Technology has been improved to report ECG signals as audio inputs. This input is delivered to a hospital with a landline or mobile phone. This modality has allowed cases without Internet access, such as those in rural regions, the ability to record and transmit information to specialized medical centers. One of the deficiencies of this modality is the weak signal quality that may be produced. With the advent of 3G technology and transmission control protocol/internet protocol (TCP/IP), ECG transmission has become promising and the signal quality is increased. Clinical studies associated with tele-ECG assessment have proved its applicability in a real-world condition. Because the time to reperfusion is critical to improving prognosis in cases with acute myocardial infarction, there have been many investigations of prehospital ECG interpretation and early triage of cases with myocardial infarction before reaching the medical center (20, 22). A recent investigation showed preliminary information regarding prehospital ECG triage in cases with STEMI. In this single-center investigation, cases with STEMI admitted by regional emergency medical service (EMS) were enrolled in the investigation. Cases were randomized to receive prehospital ECG triage by telecardiology modalities and directly transferred to cardiac catheterization for primary percutaneous coronary intervention (PCI) or admitted to the emergency unit where the diagnosis would be carried out (21, 23).

### 2.3 Echotelemedicine

Echocardiography is a critical instrument for cardiologists to assess ventricular activity and valvular disease in the critically ill cases. Progressive telemedicine modality has a great potential to improve access to specialists in the ICU. The first report of interpretation of echocardiography by telemedicine support was in the 1980s, by Finley and colleagues. In 1987 they provided a real-time pediatric echocardiography service at a tertiary medical center with service to local hospitals. The system of transmission used was dial-up broadband video transmission. About 70% of the investigations were urgent evaluations (24, 25). A comparison between transmitted images and bedside in-person images revealed few differences in diagnoses and unnecessary transfers. In 1996, Trippi and colleagues reported the application of teleechocardiography in emergency visit telemedicine. In their prospective investigation, urgent echocardiograms were conducted off hours evaluating for ventricular function, ischemia, valvular disease and so forth. Interpretations of the echocardiograms were compared with interpretations provided by reviewing videotapes in a blinded method. Off-site echocardiographers assessed the images in a cine-loop format transferred to home laptop systems. Abnormalities were found in more than 80% of the investigations, including wall motion abnormalities, pulmonary hypertension, aortic dissection, valvular dysfunction, and tamponade (25, 26). Telemedicine and videotape interpretations associated 99% of the time and the time to produce official echocardiogram records were decreased considerably. In the same year, Trippi and colleagues also conducted dobutamine stress echocardiography on 26 cases in emergency rooms admitted for chest pain who were determined as low risk for myocardial infarction. The investigations were assessed by an off-site cardiologist. The images were transmitted to the system of the cardiologist by common phone line linked to a computer modem. Myocardial infarction was ruled out in 25 of the 26 cases. Recent improvements in wireless and smartphone technology have resulted in echocardiographic interpretation with mobile-to-mobile consultation with predictable accuracy (27). Pediatric cardiology has been the first field to use the term of tele-echocardiography. Many neonates in small regions and rural areas do not have access to pediatric sonographers or cardiologists. This lack of access may lead to a long term delay in diagnosis. Maybe the severe shortage of specialists in the field has preempted the early development of telemedicine services. Exact remote diagnosis and the exclusion of congenital heart disease in cases has had an effect on therapeutic plans and may cause cost savings by decreasing transport requirements and unnecessary work-up (25, 27). One clear limitation of tele-echocardiography is that a skilled operator is needed for correct ultrasonography imaging, and the quality of the evaluation is heavily related to the operator's abilities. To overcome this issue, a study introduced and assessed a robotic tele-ultrasonography system (OTELO). It has 2 stations, an expect station where the sonographer controls a virtual probe, and a case station consisting of a real probe held by a lightweight robot. The real probe is located on the case (26, 28). A total of 52 cases had ultrasonography evaluations at 2 different medial centers. The diagnosis was carried out by the remote monitoring system agreed in at least 80% of the patients with the diagnosis made by conventional scanning. Disagreements with the final diagnosis occurred with plaques caused by low resolutions, suboptimal monitoring, and inappropriate imaging. Recent technology provide live streaming of echocardiographic imaging and simultaneous video conferencing over the Web. The EchoCart by StatVideo provides video communication between caregivers/families with health care providers who can guide the imaging process, facilitating understanding about the disease. Because the streaming is over the Web, there is a cost saving as well (28). In spite of limitations, real-time tele-echocardiography has been constructive in assisting with challenging patients needing complex medical treatment. An example of this is a case report that has been published. The case discussed tele-ultrasonography visit between cardiologists at the University of Texas at Galveston and staff in a research center in Antarctica about a case with pericarditis. The use of this technology prevented unnecessary medical evacuation and transfer, allowing the case to receive treatment at the medical center. Other promising uses of tele-echocardiography have been shown in the International Space Station and in heart transplant procurement (24, 26).

## 3. Role of Telemedicine in the Management of Internal and Dermatological Diseases

### 3.1 Current Status of Teledermatology

Telemedicine (e-health) involves the use of telecommunication modalities to exchange medical data for diagnosis, visit, treatment and teaching. The omnipresence of personal systems, digital photography and the internet that has improved since the last decades of the past century and of smartphones after the turn of the millennium has brought about a revolution in telecommunication. While this was initially limited to research problems, it has found its way into common clinical practice in recent decades. Given that dermatology is a uniquely visual medical specialty, it is especially suited for telemedical diagnosis and visit (29, 30). Two forms of technology are primarily deployed in teledermatology: i) store-and-forward (SAF) technology where clinical images and more data are evaluated at a different time and location , and ii) video consultation which is known by simultaneous image-based diagnosis and visit. Teledermatology visits can be conducted between physicians from different specialties or directly with cases (teleconsultation). A recent systematic review revealed that teledermatology has been applied in a wide variety of dermatological cases, with a particular focus on the diagnosis of skin malignancies. The majority of investigations originate from regions with an unequally distributed density of dermatologists and large geographical distances, such as the USA, or regions with a low density of specialists, such as the United Kingdom (29, 30). This shows the original application of teledermatology predominantly as a modality of overcoming large spatial distances, especially in link with the provision of care to dermatological cases at research stations, during military surgeries or during space missions, as well as to assist general physicians if there are no dermatologists available. The primary focus of different investigations on teledermatology was placed on diagnostic precision as compared to face-to-face visits, with the majority of investigations reporting equal or even superior reliability and effectiveness of teledermatology. Both with regard to teledermatology research and in terms of providing teledermatology treatments, Germany is obviously lagging behind other regions, a circumstance that will have to change in the future (31, 32). On the one hand, even today office-based dermatologists commonly find no successor for their practice when they retire, especially in rural regions; on the other hand, it is possible that many cases who become increasingly immobile (due to aging and requirement for home care) will be more and more dependent on telemedicine for specialist treatments. Furthermore, the possibilities opened up by artificial intelligence (AI) and machine learning with regarding image-based diagnostic support are expected to provide added diagnostic value with the application of teledermatology modalities. Until now, the growth of application of teledermatology in Germany has been reduced not only by a lack of telematic infrastructure but also by the inappropriate remuneration of telemedical structures by statutory health insurance funds (31, 33). Other variables include legal uncertainties and a lack of education and experience on the part of practitioners and nursing personnel with regarding modern data and communications methods. The German federal government has found this fact. An correction to the E-Health Act is planned for the current legislative, with the aim of establishing electronic case reports and improve interconnectedness. In a position article published in 2015, the German Society of Dermatology and the Professional Association of German Dermatologists actively promoted teledermatology, especially in the form of video visits. Establishing a primary diagnosis via telemedicine was, however, known as problematic unless this took place in the context of a visit between practitioners. In Germany, the latter is limited by legal barriers concerning professional conduct (29, 33).

### 3.2 Telemedicine in Occupational Dermatology: Current Status

Occupational dermatology is characterized by applied dermatology in the field of occupational and environmental dermatoses, with a particular focus on exogenous skin diseases predominantly resulted from a patient’s occupational activity. This associates both with dermatitis triggered by exposure at the workplace and, increasingly, also to skin malignancy induced by occupational carcinogens or natural ultraviolet (UV) radiation. Since the introduction of the dermatologist’s intervention in the 1970s, expert medical evaluation and care of cases with known occupational skin disorders, which initially dominated the field of occupational dermatology, have increasingly been supplemented by prevention (32, 34). To date, teledermatology techniques have only rarely been employed in occupational dermatology. One typical example of its use involves the medical support for workers affected by skin diseases who are deployed to regions where dermatological expertise is not accessible. Coastal states are needed to provide telemedical assistance services (TMASs) for ship crews. Given that skin diseases are a common reason for visiting the TMASs, telemedical assistance services cooperate with dermatologists in order to enable medical care centers on board and thus avoid costly evacuations. In a similar way, the German armed forces have for some time now depended on telemedicine and teledermatology support based in Germany during foreign missions (35). The benefit of SAF teledermatology in occupational health care was approved in a case series of railroad workers. By bringing in dermatological expertise, it was possible to find skin lesions occurring at the workplace as phototoxic reactions and to remove the hazard by decreasing the exposure and implementing protective measures. A prospective comparative investigation on SAF teledermatology at the workplace among workers in “wet” occupations showed that subjects of incipient hand dermatitis could be diagnosed by teledermatology with a high degree of accuracy; there was, however, a tendency to overestimate the severity of hand dermatitis (36). Teledermatology evaluation of the “Osnabrück Hand Eczema Severity Index” (OHSI) and the “Hand Eczema Severity Index” (HECSI), which are approved scoring methods for hand dermatitis, showed that a specific score was effective when evaluating incipient hand dermatitis using teledermatology. Since 1973, the Occupational Safety Act (ASiG) has made the mandatory legal basis for occupational health care of employees in the Federal Republic of Germany. Tele-visit between occupational health practitioners and dermatologists play an effective role in optimizing occupational preventive care. On the one hand, this may contribute to enhancing and ensuring the quality of occupational health care; on the other hand, it may help save employers and employees time and budget as it allows employees to directly present to an off-site specialist (35, 37). Given the lesser amount of time and other resources needed, the store-and-forward technique is likely to be superior to a video visit. Especially with respect to the treatment of chronic wounds, it has been reported that SAF techniques are diagnostically reliable and that the treatment plans made from SAF techniques match those forming from face-to-face visits. The time and travel needed for skin patch assessment, which is commonly part of the guideline-based diagnostic workup during the dermatologist's intervention, could be decreased by using telemedical techniques (37). With regard to the diagnosis of UV-induced skin malignancies by means of teledermatology, especially nonmelanoma skin cancer, it is not yet possible to come to a conclusive evaluation. While teledermatology was correlated with a high degree of diagnostic accuracy in a Brazilian investigation, a US investigation showed teledermatology to be only moderately reliable. In this context, however, it is critical to keep in mind that non-dermatologists frequently select plaques that are not appropriate for teledermatology, which may propose a false degree of identifying accuracy (34, 35).

## 4. Role of Telemedicine in the Management of Ophthalmological Diseases

### 4.1 Disease-Specific Tele-Ophthalmology

Diabetes remains an common disease in the United States. Twenty years following the initiation of diabetes, 90% of cases with Type 1 and over 60% of cases with Type 2 diabetes will have diabetic retinopathy. Diabetic retinopathy remains the important cause of vision loss in cases under the age of 60 despite evidence-based treatments and suggestions of annual dilated eye evaluations in this population. Only 35–50% of managed care cases receive the suggested annual eye evaluation. A 2008 investigation from the National Health and Nutrition Examination Survey revealed that over 70% of those with diabetic retinopathy were unaware of their disease (38). The Department of Veterans Affairs has the largest telemedicine diabetic retinopathy monitoring program in the United States which has led to reduced travel time for eye evaluations monitoring at younger ages, and the detection of more known patients with diabetic retinopathy. The Indian Health Service-Joslin Vision Network also uses teleophthalmology at over 80 primary medical centers for monitoring remote at-risk cases including American and Alaskan Natives. The University of Wisconsin-Madison applies a Topcon NW400 non-mydriatic retinal camera to provide tele-ophthalmology services at their primary medical centers. Upon the primary care physician's suggestion, the patient goes to the tele-ophthalmology department to receive fundus photographs prior to going home (39). These are assessed remotely by an eye physician after the visit. The primary care physician and the case both receive a copy of the reports. There are a few active tele-Retinopathy of Prematurity (ROP) monitoring programs in the nation, including one at South Shore Hospital in Massachusetts in conjunction with Boston Children's Hospital and another at Stanford University in conjunction with five community neonatal intensive care departments. Findings have been supportive thus far; a 6-year retrospective analysis at Stanford University's tele-ROP program revealed sensitivity and specificity both approaching 100%. Due to the high stakes involved in ROP and limited view of the periphery with the RetCam product line which is clinically approved as an adjunct to indirect biomicroscopy, the American Academy of Ophthalmology (AAO) and the American Academy of Pediatrics still suggest at least 1 in-person ROP assessment (40). There is currently no active hospital- or clinic-based established tele-ophthalmology monitoring program for age-related macular degeneration (AMD). Investigations have approved the application of non-mydriatic digital fundus cameras in identifying patients with AMD; although some investigators have claimed that incorporating optical coherence tomography (OCT) images will increase reliability. Tele-ophthalmology is not limited to retinal disorders. Glaucoma affects 3 million Americans and is known as the second leading cause of irreversible blindness in the United States (39). An investigation comparing cup-to-disc ratio by tele-ophthalmology compared to in-person evaluations by glaucoma specialists revealed a positive predictive value of 77.5% and negative predictive value of 82.2%. Investigations on tele-ophthalmology in glaucoma revealed that it has increased referral rates, reduced patient travel time, and is cost-effective. Tele-medicine is also playing an increasing role in glasses prescriptions. Opternative is a Chicago-based healthcare providing company that provides online refractions for glasses and contact lenses. Netra is a smartphone-based auto-refractor. An investigation of 152 eyes revealed the mean relative difference in spherical equivalent between the Netra smartphone refraction and an in-office manifest refraction was only −0.27 diopters (41).

### 4.2 Benefits to Ophthalmologists

Ophthalmologists stand to benefit considerably from advances in tele-ophthalmology. Studies reveal that there is a shortage of ophthalmologists in the country, and with an aging population, the demand for eye practitioners is likely to increase. Teleophthalmology may, therefore, assist eye practitioners provide cost-effective care for a large population by monitoring and triaging cases before being seen in the office. This could lead to practitioners only seeing surgical cases or cases with active disease needing treatment or close investigating, while common monitoring and annual evaluations are assessed remotely (41). It may also broaden ophthalmologist's reach, allowing remote evaluations to take place in common underserved communities. Lastly, it is plausible that post-operative cases could eventually be assessed via tele-ophthalmic care, either completely electronically or through co-managed care with local optometrists and technicians. Taken together, telehealth reimbursement is considerably lower than in-person case care visits, but this has changed considerably in the setting of the COVID-19 pandemic. It is unknown what the future holds for tele-ophthalmology, but should pay parity for remote and face-to-face evaluations persist, then telemedicine could open up considerable new revenue streams for ophthalmic managements (38).

## 5. Role of Telemedicine in the Management of Oral Diseases (Dental Interventions)

### 5.1 Current Evidence for Teledentistry

Previous studies successfully established the application of teledentistry in oral medicine in a community dental service in Belfast, N. Ireland, by a prototype teledentistry system. It has been proposed that distant diagnosis is an effective alternative in the diagnosis of oral plaques by transmission of digital images using email. Summer felt FF showed a teledentistry-assisted, affiliated practice dental hygiene model developed by the Northern Arizona University Dental Hygiene Department, that provided dental hygienists to provide oral healthcare to underserved subjects by digitally linking up with a distant oral health group (42).

### 5.2 Role in Oral and Maxillofacial Surgery

It has been revealed that diagnostic evaluation of the clinical diagnosis of affected or semi-affected third molars assisted by the telemedicine approach was equal to the real-time evaluation of clinical diagnosis. According to the results of previous investigations, telemedicine visits, in appropriately investigating cases for dentoalveolar treatment with general anesthesia and nasotracheal intubation, are as reliable as those performed by conventional techniques and that telecommunication is an efficient and cost-effective mechanism to provide pre-operative assessment in conditions in which case transport is difficult or costly (43). Brickley M reported that there is a requirement and demand for change in the referral system for oral operation specialist care. Telemedicine could conceivably be one path to improve availability of specialist oral surgery treatment. Aziz SR and Ziccardi VB reported that Smartphones allow fast and clear access to electronically mailed digital figures and provides the oral/maxillofacial surgeon free mobility, not limited by the constraints of a desktop personal system. This in turn provides improved efficiency of the specialty visit and improved monitoring, finally providing improved care to the maxillofacial case (43, 44).

### 5.3 Role in Pediatric and Preventive Dentistry

Kopycka-Kedzierawski DT and Billings RJ revealed that teledentistry is as good as visual/tactile evaluations for dental caries monitoring in young cases. It has been proposed that teledentistry offers a potentially efficient means of monitoring high-risk preschool cases for manifestations of early childhood caries. They successfully showed a teledentistry project made in inner-city child-care centers in Rochester, NY. It has been reported that remote diagnosis of children dental problems based on noninvasive images constitute a valid resource. Furthermore, it has been shown that the intraoral camera is a feasible and potentially cost-effective alternative to a visual oral evaluation for caries monitoring, especially early childhood caries, in preschool children attending childcare centers (44, 45).

### 5.4 Ethical and Legal Issues

Concerns about the confidentiality of dental data arise from the transfer of medical histories and reports as well as from general security issues of electronic data stored in systems. The physicians of teledentistry should take utmost care to ensure that subject privacy is not affected by unauthorized entities. However, cases should be made aware that their data is to be transmitted electronically and the possibility exists that the data will be intercepted, despite maximum efforts to maintain security (46, 47). Concerns also may arise about the correct modality of informing cases of the potential transmission of their information. Informed consent in teledentistry should cover everything that exists in a standard, common consent form. The subject should be informed of the inherent risk of wrong diagnosis and/or management due to failure of the modality involved. In teledentistry practice, medicolegal and copyright issues also have to be noted. These problems arise primarily because of lack of well-defined values. Currently, there is no way to ensure quality, safety, efficiency, or effectiveness of data or its exchange. There are privacy and security issues as well as reward, fiscal and taxation issues related to electronic commerce. Many of the legal issues, such as licensure, jurisdiction, and malpractice, have not yet been definitively chosen by legislative or judicial branches of various governments. In 2000, 20 states in the US enforced restrictive licensure laws needing teledentistry physicians to achieve full licenses to practice across state lines. In spite of this, data on teledentistry licensure does not appear to be readily available today (46, 47).

## 6. Role of Telemedicine in the Surgical Cares

### 6.1 Telesurgery Systems Currently Available

Many telesurgery methods are under improvement but only two are currently available for clinical application. The first telesurgery system was developed by Green and colleagues at the Stanford Research Institute in 19923. It had a surgeon’s workstation with a high-resolution color three-dimensional image with modifiable magnification. The system included common surgical tool handles for the surgeon to use placed underneath the viewing screen, so maintaining the eye–hand axis normally present in operation. There was also stereo audio input and force-feedback grasping, whereby motors in the surgeon’s console tools re-created the amount of resistance being encountered at the remote surgical location (48). This system was then developed commercially as the MONA telesurgery method, and was later improved and renamed the da VinciTM telesurgery modality. This is a master–slave telemanipulator, with three modular robotic arms mounted on mobile trolleys that can be wheeled into the operating scene. The first surgery using the MONA modality on humans was carried out in Belgium in 19973 and within a year over 150 cardiac interventions had been conducted in France using this system. By 2000, 131 cases had been operated on using this technique. VinciTM system now uses EndoWristTM technique, giving the arm seven degrees of freedom in its articulated movement, and has two cameras to allow three-dimensional images to be presented through a specialized binocular arrangement. Larger operating ports are essential to accommodate these complex articulated tools (49, 50). The ZEUS technology is similar in design to the da VinciTM technology. It has robotic arms on the case side that attach directly to the surgical table, and the surgical location is viewed on a screen by theatre personnel. Until the recent inclusion of MicroWristTM technique, giving the tools a wider range of motion inside the body, standard straight adapted laparoscopic tools were applied. The ZEUS technology uses a voice-controlled automated endoscopic technology for optimal positioning (AESOP) robotic arm to hold a camera and has a range of laparoscopic tools that attach to the other two arms. The system was first introduced in 1996 for remote suturing and conducting anastomoses on cadaveric hearts, and then in 1999 for coronary artery bypass grafting (CABG) surgeries in humans. The efficacy of the ZEUS and da VinciTM technologies has been compared in pigs subjected to a series of surgical interventions, including pyeloplasty, adrenalectomy and nephrectomy. The da Vinci systemTM had a shorter learning curve and was related to additional intuitive execution of surgical measures, although the authors did not apply the ZEUS system’s new microwrist in their study. Both technologies generated technically successful results, but the da VinciTM system had significantly shorter surgery times (48, 50).

### 6.2 Benefits of Telesurgery

The potential benefits relate to cost, convenience and increased efficacy. Money might be saved through decreased travel costs of cases and specialists. The expertise is brought to the case, with national or international specialists available to advise or treat the case remotely. Telesurgery may also increase and extend the skill and range of the surgeon through its application of a robotic interface. Laparoscopic surgery has commonly involved the surgeon viewing the surgical site on a small two-dimensional screen, often inconveniently positioned across the table, with a staff controlling the camera (49). The absence of shadows and movement parallax make it difficult to indicate spatial distance and movements appropriately although, with experience, the surgeon can compensate. Furthermore, any movement in the camera may resulted in motion sickness in viewers. The Automated Endoscopic System for Optimal Positioning (AESOP) robotic arm, used in the ZEUS telesurgery technology, was designed to relieve these problems. It attaches to the surgical table, and is assessed by voice commands or with a foot switch. Magnified three-dimensional figures allow exact positioning of tools. In the da VinciTM technology this is obtained by the practitioner wearing specialized binoculars. Telesurgery technology robotic arms and their computer controller can operate at an accuracy of around ± 5 µm, compared with ± 50 µm for the best microsurgeons (50, 51). Tremor is removed and movements can be scaled so that a 1-cm movement of the surgeon's finger may translate to an actual movement of 1 mm at the remote location. This sort of technology provides condition for surgeons to conduct tasks that would otherwise be impossible, such as retinal vein cannulation. In cardiac surgery, control technologies can generate a virtual heart arrest, providing the surgeon to work on a motionless figure of the heart while the movements of the surgery are automatically gated to the beating. Robotic devices can also be used to be intrinsically safe, with movement limited to a location where it can do no impairment, and extremely large or small forces can be safely used. It is estimated that up to 54 percent of surgical errors might be reduced, and direct intervention of an expert via telesurgery may make better the standard of surgical treatment throughout the world. Ultimately, the application of telesurgical consoles decreases fatigue in the operating surgeon and the surgeon's efficacy should therefore remain optimal for longer (48, 51).

## 7. Role of Telemedicine in the Management of ear, nose, and throat (ENT) Diseases

### 7.1 Telemedicine and ENT Diseases

Telemedicine refers to the application of telecommunications technology to provide remote availability of medical diagnosis and subject treatment. As modality has improved and the costs of using that technology have reduced, the promise of telemedicine and its potential to increase the quality of treatment, improve efficiency, and decrease costs has grown considerably. The application of the Digital Imaging and Communications in Medicine (DICOM) imaging standard in radiology, for instance, resulted in the widespread adoption of a telemedical approach to radiologic imaging and interpretation that has now become the standard of treatment (52, 53). Historically, radiology, dermatology, psychiatry, and cardiology account for the most widespread application of telemedicine in the United States, but otolaryngology remains uniquely effective in the application of telemedicine. In addition to case history and physical evaluation, many otolaryngologic diagnoses reflect data achieved from objective sources, such as tympanograms, audiometry, and telescopic and diagnostic figures. These data can be easily transmitted to provide remote interpretation. Like many medical specialists, otolaryngologists are commonly found in urban regions, making access to specialty treatment in remote and rural regions challenging. One promising application of telemedicine involves allowing treatment to rural regions that would otherwise be difficult to provide in person, and this is a particular requirement that telemedicine is uniquely positioned to make it (52).

### 7.2 Telemedicine: Store and Forward versus Live Feeds

The live and interactive technology is intuitively appealing since it most closely approximates a real-life case encounter; however, the application of a live visit needs a level of coordination between the case, referring practitioner, and specialist physician that makes this technology of teleconsultation both more expensive and more challenging logistically. The second type of telemedicine visit is frequently known as store and forward. This involves the referring practitioner collecting and forwarding all of the relevant case data, including history and imaging, to the consulting practitioner who then can assess the information at a later time. One advantage of this type of visit is that it does not need the physical presence of the referring practitioner or the case (54, 55). In 1997, Sclafani and colleagues at the New York Eye and Ear Infirmary reported an investigation at the annual congress of the American Academy of Otolaryngology - Head and Neck Surgery evaluating the use of live and store-and-forward telemedicine in their otolaryngology practice. Cases were assessed by a chief resident in otolaryngology who conducted a relevant physical exam and flexible fiberoptic nasopharyngolaryngoscopy and who then presented his results to two groups: a locally available otolaryngologist and a remote otolaryngologist. Both the local and remote otolaryngologists could see the interaction as well as a fiberoptic nasopharyngolaryngoscopy and to direct the chief resident (53). Afterward, another otolaryngologist, who was not present for the live encounter, was requested to assess the electronic patient reports. The authors showed concordance rates of 92% between the local and remote otolaryngologists (live videoconference) with a slightly lower concordance of 64% between the live practitioner and the delayed remote practitioner (store and forward). The authors clarified the diagnostic discordance seen with the store-and-forward remote practitioner as primarily the result of technical problems: color-shifting phenomenon, degraded video quality, and an insufficient quantity of high-quality figures. Sclafani and colleagues reported that these are problems that are easily remedied by the capability of new technology to provide a higher number of higher-quality still and video images. They stated that remote interactive tele-otolaryngology can be applied to assess a range of patient complaints with a high degree of diagnostic reliability (52, 55).

### 7.3 Telemedicine and Video Otoscopic Imaging

Otitis media is one of the most frequent encountered diagnoses in both pediatric and otolaryngologic practice, and the cost correlated with the diagnosis and management of the disease is estimated to be in excess of 5.3 billion dollars per year. Acute otitis media is the most frequent bacterial infection in children and is the most common indication for antimicrobial treatment in the pediatric population. Cases who suffer from either recurrent acute otitis media or chronic otitis media are often managed with tympanostomy tube insertion, which is currently one of the most frequent interventions conducted in children in the United States (54). After surgery, cases are visited in follow-up in the clinic to evaluate the patency of the tympanostomy tubes. This follow-up commonly occurs 1 month following the surgery and at regular intervals thereafter. Because a significant proportion of the United States subjects lives in rural regions without nearby access to subspecialty surgical treatment, arranging follow-up for these cases can be challenging, which presents a unique opportunity for telemedicine to play a significant role in the postsurgical follow-up of cases with tympanostomy tubes (52, 54).

## 8. Role of Telemedicine in the Management of Psychiatric Diseases

### 8.1 Telepsychiatry

Telepsychiatry has been reported as: The delivery of healthcare and the exchange of healthcare data for the aims of providing psychiatric services across distances. For the aims of this paper, the provision of a telepsychiatric services delivered via videoconferencing technologies will be assessed. Mental health care appears to be especially well suited for telemedicine as psychiatry uses mainly audio-visual data as diagnostic and therapeutic methods and there is little requirement for hands on interventions or laboratory evaluations (56). The service needs the organization of videoconferences between specialized secondary care psychiatric service and cases via their local primary care providers. This will enable a local physician to be present with the case during the evaluation. Real-time telepsychiatry is primarily provided with the application of videoconferencing. It is the use of live two-way interactive, full-colour, audio, video and data communication. Telepsychiatry can connect cases and mental health specialists, allowing effective diagnosis, management, education, visit and transfer of medical information (57). This can allow cases to remain in their own community and have communication with their psychiatrist more efficiently than if they had to take the day off work to travel to a city medical center. The application of telemedicine to support mental health care dates back to the 1960s where closed circuit television was applied for psychotherapy, but there has been slow adoption of these modalities. It was not until the 1990s that the application of telepsychiatry became more widespread. Real-time telepsychiatry is more recently an application that has been suggested to cases commonly in both America and Australia. Much of the evidence and recommendations for the application of telemedicine to support mental health is derived from both these regions (56, 58).

### 8.2 Efficiency of Telepsychiatry

In order to evaluate the efficacy of telepsychiatric services, an electronic search was performed for papers published between 1998 and 2006 in the MEDLINE, EMBASE, PsychINFO and Telemedicine and Information Exchange (TIE) databases (59). The search was conducted using the following keywords: telepsychiatry, videoconferencing and telepsychology. A total of 178 papers were found from peer-reviewed journals and based on review of the abstracts, 72 full text papers were chosen as being specific to efficacy, cost-effectiveness and satisfaction with psychiatric services delivered using videoconferencing (56, 57). There are many clinical approvals of telepsychiatry programs which can be found when evaluating the literature. It has been found to be highly feasible for managing and evaluating elderly cases and also adolescents and children with mental health diseases. There are also examples of its application for managing many different disorders including delivering cognitive behavioural treatment to cases with agoraphobia or depression providing psychotherapy to cases with brain injury. Although there are different descriptions of feasible uses for this technology, careful consideration is required to find its effectiveness. Findings from outcomes investigations have provided some preliminary evidence that cases can improve with services delivered using videoconferencing (58). In a recent project evaluating elderly cases, telemedicine was shown to be as accurate as in-person clinical evaluation in establishing a diagnosis of dementia. In other investigations where telepsychiatry was compared with in-person visit, no differences were found in clinical outcomes or attendance. A recently published article assessed mental health outcomes and showed that telepsychiatry clients approved significant improvements on pre- and post-SF12 mental health variables. Literature has shown the strengths and weaknesses of telepsychiatry within different clinical conditions showing that it can be an appropriate alternative to in-person visit, although additional research is needed to determine the reliability of telepsychiatry for specific subjects (58).

## 9. Role of Telemedicine in the Management of Pediatric Diseases

### 9.1 Telemedicine and Pediatric Diseases

Pediatricians can use telemedicine for a broad range of uses. Telemedicine can be applied for tele-education, teleconsultation, telepractice, and teleresearch. Tele-education can be provided through live interactive audio visual (AV) links, by live streaming video, and by viewing stored educational concepts. Tele-education programs allow practitioners to stay current, travel less often for continuing medical education (CME), receive free CME, foster relationships between academic and community-based practitioners, and make widespread peer groups to learn from each other and from academicians (24, 60). Teleconsultation commonly involves establishing a communication relationship between physicians who need visits on cases under their care and experts located in distant medical centers. Such visits can occur through a live, interactive AV link or through store-and forward modality. An example would be the storage of echocardiogram figures for an expeditious, but not real-time, reading by a distant cardiologist. Teleconsultation works well for both acute and chronic disease treatment. Benefits of such visits include increased access for the medically underserved, improved access for the rural and inner-city child, increased care through faster and more accurate evaluation than can be provided by telephone visit, and reduced cost to the health care system and the patient's family (60). Telepractice involves establishing relationships between practitioners and their cases who may be located in a child care center, preschool, school, or juvenile detention facility. Telepractice does not replace the in-person consultation but rather adds to it. The benefits of such relationships include an increased medical home in which personal practitioners care for children; decreased health care system costs, as well as fewer school absences for the children; less money spent by parents on travel; less time away from employment for parents; and less crowding in emergency units. Teleresearch involves the dissemination of translational research from the academic center to primary care practitioners, the application of telemedicine to broaden a population base under investigation, and improved collaboration between investigators within and between departments (24). The rapid dissemination of translational research findings has a high national priority. Telemedicine provides the best instrument for such rapid dissemination. The application of telemedicine as a significant mode of health care delivery has occurred in a number of conditions, and the future holds promise for more expansion. Technological developments are increasing the number of methods that can be applied for telemedical management while driving down the cost of these instruments. Moreover, government forces, such as legislation mandating telemedicine reimbursement, will drive the more improvement of telemedicine (60, 61).

### 9.2 Inpatient

In urgent clinical conditions, telemedicine visits can enable pediatric subspecialists to extend the reach of their expertise to children receiving treatment in distant urban and rural medically underserved areas. Telemedicine is increasingly applied to provide specialty visits to infants and children receiving treatment in community and rural hospitals. The application of live interactive videoconferencing, coupled with the optional application of peripheral devices, including stethoscopes, otoscopes and ophthalmoscopes, and ultrasonography machines, can initiate an in-person bedside visit with a specialist (60). These uses are often used for cases with unanticipated specialty requirements, including newborn infants delivered at level I or II nurseries, pediatric cases hospitalized without local access to pediatric specialists, and infants, children, and adolescents presenting to emergency units with acute medical emergencies. For pediatric cases located in medical centers with limited pediatric expertise, telemedicine can be applied to access specialists who are not otherwise available in the community. The application of this technology overcomes the barriers of time and distance, allowing specialists, such as pediatric hospitalists, emergency medicine specialists, and critical care practitioners, to bring their skills to the bedside of the child in need. Models of treatment include connecting community and rural nurseries to perinatal and neonatal specialists for common advice or assistance during emergencies (62). This assistance includes assessments for critical illness, congenital heart disease, genetic abnormalities, and retinopathy of prematurity. Telemedicine has also been increasingly applied to provide other specialty visits, including critical care and pharmacy services, to children hospitalized in general pediatric units or nonpediatric intensive care units. The use of telemedicine in these conditions has been revealed to decrease unnecessary patient transports. The final aim of this model of care is that hospitalized children are more commonly able to receive treatment in their local communities, leading to less disruption to the family. Telemedicine has even approved effective in regions that already have access to pediatric subspecialty treatments (61). Attending practitioners at home can use telemedicine to help treatment for cases who are being managed by residents and fellows in teaching medical centers, allowing a quicker response time, backed up by attending practitioners coming into the hospital at night if the patient's problems cannot be treated completely via a telemedical connection. For infants, children, and cases who present to an emergency department that may lack pediatric expertise, telemedicine can be an effective technology to assist in the diagnostic workup, therapeutic choices, and decisions about disposition. Physical abuse cases provide an excellent model to approve the ability of telemedicine to improve emergency department assessment of pediatric cases (61). Currently, more than 15 telemedical programs in different centers throughout the United States are providing telemedicine visits to pediatric cases in remote emergency units. Similar to investigations in adult emergency medicine for acute stroke cases, investigations assessing this model of treatment for pediatric cases propose that telemedicine visits can lead to higher parent satisfaction, higher emergency department physician satisfaction, and higher quality of treatment. Results also suggest that this model of care leads to a decrease of unnecessary transports and an overall decrease in costs, given the lower rates of transport and less common use of helicopters. Telemedicine has also been shown to change newborn referral patterns and reduce infant mortality statewide (24, 60, 62).

### 9.3 Outpatient

Teleconsultation can be applied for common, less time-critical visits. Such visits can occur via a live AV link or through store-and-forward technology. Although telemedicine can be applied to provide outpatient teleconsultations for any subspecialty, pediatric dermatology provides a clear and well-documented example of the application of both live and store-and-forward visits. Less urgent teleconsultations provide many of the same benefits as emergency and urgent critical care visits. cases can receive these visits in their own medical home, thus increasing its utility and significance. Because local access to visit makes appointments easier to keep, the consultant has less difficulty with cases who fail to keep their appointments, and local care providers can be included in the consultations, increasing opportunities for care coordination and collaboration (60, 62).

## 10. Role of Telemedicine in the Management of Gynecological and Urologic Diseases

### 10.1 Well Woman's Visit and Preventive Care

Important Characteristics of a well-woman consultation are a discussion of reproductive plans, care for women across her lifespan, and regular treatment for the perimenopausal and postmenopausal woman. The well-woman consultation consists of a monitoring for underlying medical conditions, maintenance of healthy life with preventive care, treatment of women at reproductive age with preconception care (PCC), and referral to another specialist as required. Indications for referral would include medical problems that need screening, history of pregnancy-related complications, and infertility (63, 64). PCC is an excellent opportunity to counsel the case on how to maintain a healthy lifestyle, improve her overall well-being, and provide preventive cares. A head-to-toe physical evaluation was traditionally needed during the well-woman visit. There are different instances whereby telemedicine can be an effective adjunct to the traditional physical evaluation. For example, the patient's history and review of system (ROS), follow-up of blood work, and additional monitoring exams are ideal for telemedicine. A comprehensive history and ROS, including the gynecologic evaluations, will give more data to determine if the patient requires certain parts of the physical evaluation, such as a breast or pelvic evaluation. According to a recent American College of Obstetricians and Gynecologists (ACOG) committee opinion and a practice bulletin, pelvic and breast evaluations are suggested only when indicated by medical history or manifestations. A pelvic evaluation should be carried out only after a thorough review of the patient's situation followed by a detailed discussion about risks and benefits of the evaluation between the health care provider and the case (63, 64). There have been different opinions among the major groups that indicate guideline suggestions for breast cancer monitoring. ACOG's suggestions emphasize a shared decision making in selecting between the range of options suggested within different protocols. The 2018 ACOG committee opinion on the annual well-woman evaluation suggested that the annual evaluation should include the woman's vital signs, body mass index (BMI), and evaluation/management of the patient's health by monitoring, counseling, and immunizations based on the woman's age and risk factors. Obstetrics and Gynecology (OB-GYN) practitioners should be playing an important role in engaging cases in shared decision making, encouraging healthy lifestyles, and counseling about effective preventive health practices. Obtaining a family history is critical in assessment of a patient's risk profile by finding women at an increased risk for familial malignancies. This early detection is crucial for optimal genetic evaluation and counseling; not uncommonly, there are some conditions when it may not be possible to complete all of the suggested services in 1 visit or with 1 health care provider. Telemedicine and telehealth with team-based care, including the OB-GYN practitioners, physician assistant (PA), nurse practitioner (NP), and other health care providers may facilitate visits the needs of medical care for these cases (65, 66).

### 10.2 Preconception Counseling

A significant component of the well-woman consultation for a reproductive-aged woman is a discussion about her life plan on reproduction. The case can undergo monitoring and evaluations depending on her history, manifestations, and risk factors. This time is the ideal time when PCC, infertility evaluation, health care related to sexually transmitted disorders, and a discussion on the full range of contraceptive choices that are available can take place. The aim of PCC is not just to help a case gain pregnancy but to establish a favorable pregnancy outcome with a healthy mother and a child (65, 66).

PCC is an extension of a well-woman consultation. A detailed discussion on lifestyle habits, body weight and nutrition, monitoring examinations for antibody condition that need vaccination as well as monitoring for a medical situation should be conducted in addition to common gynecology evaluation. When something is identified or if the case has known chronic medical situations, these require to be addressed, controlled, and assessed. Reproductive history, including recurrent pregnancy loss (RPL), previous stillbirth, history of delivery of an infant with congenital anomalies, history of preterm labor, gestational diabetes, or preeclampsia, is meaningful data. Genetic visit and monitoring can be offered to cases with increased risks of genetic disease. Initial PCC using telemedicine and telehealth can be either performed with a general OB-GYN doctor, primary care physician (PCP), NP, or PA; then, if something abnormal is identified, the case can be referred for specialist visit using the TM/TH system. Ideal candidates for these visits are women with known medical problems, for example, seizure diseases, blood clotting diseases, thyroid disease, chronic hypertension, diabetes, history of pregestational diabetes, poor obstetric history, and RPL. Evaluation of body habitus can be performed by measuring the BMI. Depending on BMI, the case can be referred for visiting by a nutritionist and/or referral for bariatric management if adequate. Telemedicine and telehealth can be applied not only for specialist visit but also for general PCC. Lifestyle changes, like smoking, alcohol, and recreational drug cessation, are a crucial component of PCC and can be performed using telemedicine and telehealth (63, 65).

## 11. Role of Telemedicine in the Rehabilitation Department

### 11.1 Neurologic Telerehabilitation

The application of telemedicine in acute stroke has approved the proof-of-concept that specialized services can be delivered virtually when they cannot be easily provided face-to-face. Several teleneurology applications have been suggested to manage cases with chronic neurologic diseases where impaired mobility hinders access (67, 68).

### 11.2 Stroke

Research has revealed that more time spent on exercise treatment in the first weeks to months following stroke results in better functioning. Under the present health care system, transitional care managements are insufficient to address the barriers preventing community stroke survivors from finding their highest potential, resulting in hospital readmission, poorer outcome, and permanent disability. Several randomized controlled studies have used alternative choices to provide and/or supplement treatment in the patient's home after discharge. Caregiver-delivered rehabilitation services have been assessed to augment intensity of practice. A Cochrane review revealed that caregiver-mediated exercises (CME) administered alone or in combination with standard treatment have no considerable effect on basic activities of daily living (67, 69). However, CME considerably improved patients' standing balance and quality of life with no considerable effects on caregiver strain. A more recent review revealed that telerehabilitation interventions were correlated with significant improvements in improvement after motor deficits, higher cortical dysfunction, and depression in the intervention groups in all investigations evaluated. Modalities applied included tele-supervision, virtual reality, game-based virtual reality, and interactive mobile phone applications. Ongoing investigations promise to provide more definitive findings on CME and to evaluate the utility of tele-visits by the interdisciplinary team using more rigorous modalities (70). Approximately one-third of all cases with stroke suffer from depressive manifestations, using more health care options and increasing costs. Moreover, the existence of depression is correlated with poor functional outcomes after stroke. Telerehabilitation has been successfully used to address motor and nonmotor domains assessed by the Stroke Impact Scale in an investigation comparing the effects of homebased robot-assisted rehabilitation coupled with a home exercise program versus home-based exercise alone. The investigators were not able to indicate why the quality-of-life and depression outcomes improved. They hypothesized that the positive trend could be related to the intervention per se, the resulting modest motor improvement, or the weekly interaction between the cases and the health care providers (69, 70).

### 11.3 Multiple Sclerosis

Cases with multiple sclerosis (MS) are at risk for developing long-term problems. Rehabilitation provides treatments and managements to reduce the impact of disability and improve function; however, access to those services is difficult by limited mobility, fatigue, and related issues. It has been revealed that subjects with MS are willing to receive rehabilitative services through telemedicine. However, cases with moderate-to-severe disability may experience technical difficulties due to cognitive and physical disability. Charvet and colleagues have applied an adaptive online cognitive improvement program to train cases with MS at home (67, 71). The cases were randomly assigned to either a common adaptive cognitive improvement program or an active control of ordinary computer games. This telerehabilitation technology provided modest improvement in cognitive efficacy as assessed by changes in a composite of neuropsychological duties. Khan and colleagues performed a systematic review of the application of telerehabilitation to provide or supplement treatment to subjects with MS. The investigations assessed included multiple delivery modalities, some complex, with more than one rehabilitation component and included physical activity, educational, behavioral, and manifestation management programs. With such heterogeneous methodology, it was concluded that there is limited findings on the efficacy of telerehabilitation in improving functional activities, fatigue, and quality of life in cases with MS (72). The review also showed that evidence supporting telerehabilitation in the longer term for improved function, impairment, quality of life, and psychological outcomes is poor. A very recent randomized clinical study provides higher-quality evidence that telerehabilitation is technically feasible, desirable, and effective in improving gait and other outcomes in cases with MS. An ongoing investigation is assessing the delivery of complementary and alternative medicine sessions at home to rural and low-income cases with MS versus the same intervention delivered in the clinic by a health care provider (71, 72).

## 12. Role of Telemedicine in the Imaging and Radiological Department

### 12.1 Clinical Environment

There is a wide variety of conditions in which teleradiology can be applied:

• A well-known example of the application of teleradiology is receiving expert or second opinions. In Tirol in Austria a teleneuroradiology-network was provided between three rural medical centers and a university medical center for triage of acute neuropatients. Between October 2007 and March 2008 there were 744 teleradiology cases. The seen teleneuroradiology network approves Tyrolean healthcare-providers to diagnose and manage cases with acute neurological manifestations in a time period off less than one hour (73, 74).

• From the initiation of the military has been a great developer and driving force of teleradiology. During the Balkan war in the midnineties a deployable teleradiology modality was used. From 1995 to 1997 more than 20.000 digital diagnostic evaluations were conducted, transferred and archived using this technology (73, 74),

• Teleradiology can also play a critical role in humanitarian and disaster-relief surgeries. Likewise, as there is a wide variety in uses for teleradiology, many different service and business models exist, for example: after hours 24/7 coverage, radiology assistances in remote regions, and subspecialty readings or expert readings, e.g. cardiac imaging and virtual colonoscopy. Causes to make use of teleradiology services can be a growing or changing workload, a structural or temporary shortage of radiologists, and a shortage of expertise. In some conditions teleradiology is also applied for educational aims. Teleradiology in its 'purest' form is simply transmitting images from one location to another (74). This can be limited to intra-mural uses in a given situation:

• teleradiology 'integrated' in a medical center with or without different locations,

• point-to-point (hospital to radiologist's home),

• regional hospital networks (e.g. Scandinavia and Spain). When applied for extra-mural applications, images are transmitted to:

• an accredited (international) teleradiology reading medical center, possibly even in a different time zone, e.g. 'Nighthawk services',

• to radiological experts for specialized reading services, not available in the medical center (e.g. virtual colonoscopy),

• another hospital, academic (tertiary) center or diagnostic center (for second opinion),

• an expert center for training aims, giving support during the start-up phase of a new technology (e.g. virtual colonoscopy). In the United States almost 70% of all radiology practices reported using teleradiology. In 2003 primarily academic conditions were less likely to use teleradiology than private radiology conditions. According this study, the most frequent aim of teleradiology is to transmit images to radiologists at home; about a quarter of the users sent images to outside specialists. A considerable increase of teleradiology was observed in the rate of PACS (75). Although no published results are available, it is likely that in Europe the increasing availability of PACS in medical centers has similarly resulted in the possibility to transmit images to the radiologists' homes, to easy the burden of being on-call. In the Netherlands a number of academic centers are also using teleradiology due to staff shortages. Several commercial teleradiology companies are currently active within the EU, but the existence of different healthcare and legal systems in the EU member states make the condition much more complex than in the US. These extra-mural uses can be very complex, because often integration of different data systems is needed. Not only the PACS systems of different regions have to communicate, but also the data coming from the different RIS and HIS systems has to be integrated. Also aspects such as confidentiality and information integrity have to be taken into account (73, 75).

## 12.2 Commercial International Teleradiology

In the future there will be no difference between PACS and teleradiology. Virtual imaging organizations will become reality. The following question will be created: Will teleradiology significantly change the way we manage our profession? Can radiology services almost completely be outsourced when we keep in mind that less than 10% of the total radiology imaging, namely vascular and interventional radiology, is exempt from outsourcing? Theoretically yes, but more possibly no. Radiologists have many other duties besides reporting images such as: justification of need, ad hoc problem solving, optimizing and tailoring individual evaluation methods, conferencing in multidisciplinary groups, organizing workflow and quality control (76, 77). On the other hand in many centers there is a growing tendency towards overflow of workload, which can be clarified by the increasing demand for imaging interventions throughout Europe. This overflow could be managed by teleradiology. Teleradiology should be regarded as a valuable choice for managing this type of overflow problems. Introducing teleradiology however is not plug-and-play (77). Before initiating to send images using teleradiology the stakeholders require to formulate a clear agreement about the following aspects:

• How the clinical data is transmitted and integrated?

• How the previous images/interventions and the records are made available?

• How quality assurance is organized?

• Is single or double reading needed?

• What turn around time is required?

• What language is applied in the condition of cross-border teleradiology?

• What legislation is involved in the country of the case?

• What about privacy and integrity of information?

• How the communication between referring practitioners and radiologists is assured?

• How are all these processes validated?

• What medico-legal aspects are to be dealt with?

In the last decade several commercial cross-border teleradiology centers have been working in Europe. These centers can develop an unmatched concentration of expertise and industry-level quality controls. Also in the field of mass-monitoring programmes these centers can play a significant role. At the moment in several European regions mass-monitoring programmes are put out to tender. It is expected that the role of teleradiology will increase and that teleradiology centers will take up their role in the delivery of imaging services (76, 77).

## 13. Role of Telemedicine in the Orthopedic and Sports Medicine Departments

### 13.1 Advantages of Teleorthopedics

It has been shown that teleorthopedics in an outpatient condition is safe and without serious problems. Teleconsultation services were originally reported to decrease cost, improve efficiency, and increase quality and access to healthcare services. During the COVID-19 pandemic, the main trigger for its use has been to provide continuity of care while maintaining physical distance. Teleorthopedics has been successful in maintaining physical distance between cases and orthopedic specialists (78, 79). By comparing the cost of implementing and running a teleconsultation service to the cost savings correlated with the case not having to travel and miss work to consult a practitioner, the break-even point has been received after 151 teleconsultations per year. A research group showed that first-time case visits to a tertiary orthopedic oncology center saw a decrease in costs between 12.2 and 72% when telemedicine was applied for the visit. Overall, cases seem to be similarly satisfied with a teleconsultation than with an in-person visit and follow-up rates increase when barriers to accessibility such as travel distance and related costs are removed (79, 80). Physical evaluation is a critical component of the orthopedic assessment. Teleconsultations do not allow the clinician to evaluate the patient. However, investigations have investigated the precision and reliability of a virtual physical evaluation and this is conducted by having the case go through a series of range of motion and by investigating mobility with a virtual goniometer. A recent study investigated healthy control cases who underwent elbow range-of-motion evaluations in person, through teleconference, and with still photography (81). The investigators stated high inter-method reliability between teleconference-based goniometry and in-person evaluations. Similar accuracy and greater precision in investigating shoulder abduction and internal rotation, elbow flexion, hip abduction, and knee extension have been shown with virtual goniometry compared to visual evaluation. The future of virtual physical evaluation and telerehabilitation is promising and will likely incorporate augmented reality, artificial intelligence, and sensor-based technologies with success of this method already being reported by a group in Denmark already using this to guide rehabilitation following knee surgery (80, 81).

### 13.2 Limitations of Telemedicine

Telemedicine has many good benefits regarding increasing efficiency and decreasing costs, but limitations have been highlighted with the lack of in-person physical evaluations, barriers to accessibility, and the validity of the virtual evaluations, especially in acute and complex situations. According to an online survey of 781 cases that experienced telemedicine, the main benefits are the lack of hands-on care, the lack of intimacy, and technical difficulties. The main aim of telemedicine is to improve accessibility of professional expertise to the case. The opposite effect was seen when trying to implement such a system with the elderly subjects due to their limited access to the instrument or technical data necessary to participate in teleconsultations. For this reason, a lot of surgeons opted to use standard telephone visit to alleviate this issue (79, 82). In-person physical communication and evaluations are a crucial part of the visit as it can directly express care, compassion, and comfort. Teleorthopedics does not allow this type of interaction which might affect the doctor-patient relationship and result in sub-optimal treatment. Investigations on the virtual physical evaluation have approved the ability to assess the range of motion in healthy subjects. With the current technology, it is not possible to remotely evaluate the temperature, to palpate, or to physically stress and examine joints. In that sense, the virtual physical evaluation provides very limited information and an incomplete clinical picture (81, 82). Evidence to determine the role of teleconsultation in an acute manifestation or complication does not exist. Investigations assessing case satisfaction with telemedicine may underestimate the role that in-person visits have in breaking social isolation and detecting child, elder, or domestic abuse and violence. In fact, one in six female cases presenting to an orthopedic fracture medical center is a victim of domestic abuse and almost 2% are presenting as a direct consequence of physical abuse. Orthopedic surgeons have a significant role and opportunity in detecting these patients. Telemedicine limits the ability to take a clear history and does not always provide the condition necessary for such disclosures or observation of interactions with their partner (78, 83).

## 14. Role of Telemedicine in the Pharmaceutical Consultations

### 14.1 Advent of Telepharmacy

Pharmacies are critical parts of the health systems and can offer health services in a capillary way due to their wide diffusion at least in industrialized regions. Qualified health professionals such as pharmacists, besides dispensing medicinal products, can give advice to cases on drug assumption regimens and can also offer pharmacovigilance services. In spite of the relevant role of pharmacies as first level health care points, an uneven distribution of these structures is considerable also in developed regions, with shortage in their distribution at a regional level and across urban and rural regions. These problems can become more relevant in the near future in view of the expected reduction in the number of pharmacists (84). Application of the data and communication technologies (ICTs) to the health sector can open new perspectives in the delivery of health services and can have a role in limitation of the problem of reduced availability of health professionals. One opportunity can be represented by telepharmacy services. Telepharmacy is known as "the provision of pharmacist care by registered pharmacists and pharmacies through the application of telecommunications to cases located at a distance". Telepharmacy services already developed include treatment selection, order review and dispensing, patient counselling and screening, and provision of clinical service (85, 86). A typical characteristics of a telepharmacy service is that the pharmacist is not physically present at the point of pharmacy operations or patient care. Benefits of telepharmacy services are represented by a wide coverage of the pharmaceutical service also in regions underserved due to economic or geographic problems. A reduced human interaction between health professionals and cases, problems in the assessment of drug dispensing, and an increased risk for security and integrity of case information represent some potential benefits of telepharmacy. Telepharmacy experiences are available in some regions such as the United States, Spain, Denmark, Egypt, France, Canada, Italy, Scotland, and Germany as stated in this review. The present work has analyzed the main investigations reporting telepharmacy experiences with particular attention to those in some way different to the conventional pharmaceutical service. This to detect new regions in which telepharmacy could increase availability of health services. Benefits and still unsolved limitations of telepharmacy practice were also discussed (86-89).

### 14.2 Pharmaceutical Counselling Activity

Home drug delivery (HDD) is a recently developed way of medicines delivery consisting in dispatching medicinal agents directly at home or at the workplace of cases. This allows time and money saving, especially for cases under chronic pharmacological management and going often to a pharmacy or a hospital to get their medicines. HDD is of great interest and utility primarily in rural or in regions with relevant geographic dispersion (85). In Spain, this service was suggested to Human Immunodeficiency Virus (HIV) cases and was managed by hospital pharmacists. An in part similar initiative was developed in Denmark. This consisted in provision of remote pharmacist counselling for cases who obtained drugs via Internet or received them home. This counselling was provided commonly via telephone or video calls by community pharmacists. Both experiences reached the aims of guaranteeing appropriate management of cases. Not negligible findings were money and time saving and subject satisfaction (84, 90).

## 15. Role of Telemedicine in the Nursing Cares

### 15.1 Telemedicine in Advanced Nursing Practice

Advanced practice nurses (APNs) are not new to telemedicine. In 1977, bidirectional cable television made backup for nurse practitioners (NPs) treating sick and well children in a small primary medical center. The system allowed pediatric NPs to function without on-site practitioner coverage 40% of the time. Recently, an NP followed female cases in domestic violence shelters using teleconferencing (91). At the study's conclusion, most of the women reported they would be comfortable receiving both episodic and chronic therapeutic services from an NP by the Internet and were willing to learn to use a computer to perform so. Research outcomes are approving how telemedicine advances the primary care nursing practice by expanding health services, complementing the professional APN role, and enhancing reimbursement choices (91).

### 15.2 Improved Patient Monitoring

The remote treatment of chronic diseases can also be conducted in a convenient and cost-effective manner and is predicted to increase. An annual e-health forecast estimated an increase of home screening modalities in the next few years that will evolve into more streamlined agents. One home screening investigation managed by an APN and a cardiologist followed and managed heart failure cases at home with fewer readmissions with shorter hospitalization for heart failure than traditional outpatient consultations (92). The application of telehealth technology was shown to significantly improve heart failure treatment while decreasing the cost of care. In Japan, an asthma telemedicine investigation used a nurse under physician supervision to follow patients' medication compliance and peak flow values at home. Exacerbations were found earlier and managed with a zone-controlled plan that led to an 83% decrease in hospitalizations (93).

### 15.3 Preventative Services

Achievement of an annual monitoring for diabetic retinopathy is often logistically difficult for isolated and high-risk cases such as Native Americans on tribal lands. Digital imaging of the retina can be carried out by APNs and e-mailed for ophthalmologist interpretation at a distant monitoring center. Access to ophthalmological visit and referrals are improved while removing the waiting times, travel, and fees. Furthermore, the earlier retinal monitoring using telemedicine moves diabetic retinopathy subjects away from acute care and back to the realm of preventative medical center (94).

### 15.4 Role Complement

Increased independence can enrich the practice experience for both the case and health care provider. A nurse-led telemedicine service to the elderly in a rural Scottish village showed that combining a referral strategy with televideo visit was effective to cases, nurses, and practitioners alike. The cases were satisfied with its convenience and appreciated the nurses' role in clarifying points that they had not find out during the visit. Furthermore, the numbers of cases managed solely by the community health nurse increased considerably, while fewer cases required referral to a practitioner (95). Another investigation compared APNs using telemedicine in three rural Missouri regions with APNs who did not use telemedicine. The APNs with the technology showed improved professional development and peer connectedness, citing both formal and informal learning choices, while those without it viewed the telemedicine capability as potentially supportive of increased patient care and professional satisfaction. The investigation concluded that the technology supports telemedicine in augmenting the role of the APN in different of rural regions (95, 96).

## Conclusion

Although distant medical visit has been around as long as the telephone, modern telemedicine is characterized by far more than telephone conversation. While early telemedicine simply delivered astronauts' vital signs in the 1950s, today the technology rapidly exchanges large amounts of detailed images and information in virtually all aspects of healthcare provision. Recently, more practitioners such as dermatology, ophthalmology, critical care, and cardiology have begun visiting using telemedicine. Services commonly performed by acute care hospitals during face-to-face outpatient visits can now be delivered to the underserved by telemedicine in community clinic conditions. For example, case presentation information and digital images such as dermatological or wound photographs can be sent to the visit by e-mail, while more elaborate telemedicine technologies enable live interactive video visit. Modern telemedicine technologies can send records, charts, ultrasound, computed tomography, pathology/cytology results, and x-rays over most types of communications, including conventional telephone lines.

## Declarations

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### *Author Contribution*

Robert S Fisher: Study design, data collection, writing draft of study.

Jialing Liu: Study design, data collection, writing draft of study.

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### *Conflict of interest*

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### *Data Availability*

Data sharing not applicable to this article as no datasets were generated or analysed during the current study.

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