

Telemedicine for Allergy Services to Rural Communities



Luisa Taylor, RN, Morgan Waller, RN, and Jay M. Portnoy, MD *Kansas City, Mo*

Telemedicine (TM) involves the use of technology to provide medical services to patients who live at a distance. It can be used asynchronously for interpretation of test results (spirometry, skin tests imaging studies), and for communication of information when the simultaneous presence of provider and patient is unnecessary. Synchronous encounters can either be unscheduled and initiated on demand by patients or be facilitated substitutes for in-person visits. The latter results in asthma outcomes that are as good as those for in-person visits while reducing the cost and inconvenience of travel from rural communities to urban centers. Facilitated visits can be done in the ambulatory and emergency department settings, and they can be used for inpatient consults when allergy specialists are not readily available. Both patients and providers experience high degrees of satisfaction with this type of visit. In addition, virtual visits performed using TM are cost-effective. TM offers a solution to the shortage of specialty care that is present in rural communities. © 2019 American Academy of Allergy, Asthma & Immunology (J Allergy Clin Immunol Pract 2019;7:2554-9)

Key words: Telemedicine; Direct-to-consumer; Facilitated visits; Synchronous visits

INTRODUCTION

According to the US Census Bureau, the term *rural* refers to areas that are not *urban*. There are 2 kinds of urban areas: urbanized areas and urban clusters. *Urbanized areas* have a core population of at least 50,000 people, and *urban clusters* have a core population of 2,500 to 50,000 people.¹ Urbanized areas tend to have a population density of at least 500 people per square mile, or fewer than 1 person per acre.

Ever since 1900, the proportion of the US population that lives in rural areas has been steadily declining. Between 2000 and 2010, most of the population growth in the United States has been in urban areas. According to the 2010 Census, less than

20% of the US population resides in rural areas.² Although more than 80% of the US population lives on less than 5% of the total land area, about 60 million people still live in rural areas.

A significant challenge facing these rural residents is the uneven distribution and relative shortage of health care providers and, in particular, specialists.³ In addition, residents of rural communities tend to be older, have lower incomes, and have higher rates of certain chronic diseases. In response, programs have been developed specifically to address the issue of provider shortage in rural communities.⁴ By reducing the geographical distance barrier, telemedicine (TM) has the potential to aid in addressing this challenge. Although it is likely that TM will be most helpful for patients who live in large rural states, underserved urban areas may also benefit from the technology.

Although many patients are willing to be seen by TM, others are not so sure. In a survey of 3512 rural patients, 5% were interested in being seen by TM regardless of circumstance and 23% were comfortable with TM if its use improved convenience. Another 29% who were uncomfortable using TM would see a provider using the technology if it provided a significant benefit. Interestingly, 43% were equivocal toward TM even if it were more convenient than an in-person visit. The best indicators of willingness to be seen by TM in this survey were previous internet use, rural residence, and higher education.⁵

The use of TM has been shown to improve the efficiency of care by providing treatment in locations that are more convenient for patients such as local medical offices and community hospitals.⁶ Patients who are seen by specialists using TM are more likely to receive care that adheres to evidence-based guidelines.⁷ In addition, both providers and patients are more satisfied with the care, its quality is measurably improved, and overall costs are reduced.⁸ By providing allergy care to rural communities using TM, health inequities that occur because of geographic maldistribution of specialists can be overcome.

For management of adult patients with allergy, TM has been suggested as a way to reduce the distance needed to travel to see an allergy specialist. Although the lack of physical presence can limit procedures that can be done, it is possible to take an extensive history, perform a physical examination, perform allergy testing (using *in vitro* tests) to determine whether allergy immunotherapy is indicated, and follow a patient's response to treatment. The use of TM also can improve access for those with limited mobility or who live far away from a specialist.⁹

TYPES OF TM

TM has the potential to connect providers with patients who are separated both by distance and by time. Temporal distance can be bridged using either asynchronous visits (provider and patient are not online at the same time) or synchronous visits (provider and patient are together in real time). Geographic

Division of Medical Informatics and Telemedicine, Children's Mercy Hospital, Kansas City, Mo

Conflicts of interest: J. M. Portnoy has received consultancy fees from Kaleo and TEVA unrelated to this study; and is a speaker for Boehringer-Ingelheim and Thermofisher, all outside the current work. The rest of the authors declare that they have no relevant conflicts of interest.

Received for publication May 20, 2019; revised June 5, 2019; accepted for publication June 6, 2019.

Available online June 22, 2019.

Corresponding author: Jay M. Portnoy, MD, Division of Medical Informatics and Telemedicine, Children's Mercy Hospital, 2401 Gillham Rd, Kansas City, MO 64108. E-mail: jportnoy@cmh.edu.

2213-2198

© 2019 American Academy of Allergy, Asthma & Immunology

<https://doi.org/10.1016/j.jaip.2019.06.012>

Abbreviations used
DTC- Direct-to-consumer
ED- Emergency department
TM- Telemedicine

distance can be bridged using 2-way digital and video communications in ambulatory, emergency, and inpatient settings (Table I).

Asynchronous TM

Asynchronous TM consists of interactions in which the provider and patient are not online simultaneously (Table II). An example of this type of interaction is store and forward, in which information about a patient (eg, imaging studies, laboratory results, and pictures of rashes) is captured and forwarded to the provider for subsequent review.¹⁰ A common use of this in allergy is when pulmonary function tests are performed in a laboratory and the results are forwarded for interpretation. Allergy skin or blood tests can be performed, and the results can be subsequently interpreted by an allergist. Because test result interpretation does not necessarily occur when the patient is present, the results can be forwarded to the patient via patient portals. The advantage of this is that it eliminates the need for simultaneous availability of patients and providers. In addition, unlike unscheduled telephone calls that are ad hoc, both sides of the interaction have time to think about the information, leading to a more thoughtful exchange of ideas.

Another example of asynchronous TM is remote monitoring. Although this has become common for chronic conditions such as congestive heart failure and diabetes, remote monitoring can also be done with patients who have asthma or allergic rhinitis.¹¹ One study evaluated a smartphone-based app to optimize asthma outcomes in 72 pregnant women.¹² The app consisted of an interactive asthma action plan combined with a handheld respiratory device. After 6 months, the intervention group had significantly better asthma control and quality of life though other outcomes such as lung function, unscheduled visits, and use of oral steroids did not differ.

Access to high-quality pediatric spirometry can also be improved in rural communities using TM. One study in Arkansas involved the use of respiratory therapists in rural areas to improve the quality of spirometry. Patients were able to complete the maneuver with an 84% rate of interpretation by a pulmonologist to whom the results were forwarded. This was an improvement over the 25% to 50% interpretation rate reported in rural primary care settings and was similar to the 80% interpretation performance of spirometry at the tertiary center.¹³

Although the use of respiratory therapists using store and forward is one approach to improving spirometry in rural areas, another approach would be to train primary care providers to do the procedure correctly. In a study, 36 nurses and medical assistants from 14 rural primary care practices were trained to perform spirometry using a series of interactive webinars. Initially, 15% of spirometry procedures performed were interpretable. After the intervention, the interpretable rate improved significantly to 45%. In addition, the practices were more likely to categorize asthma severity and to prescribe controller medications to patients with persistent asthma.¹⁴

Synchronous TM in the ambulatory setting

Synchronous interactions occur when the provider and patient are online at the same time. This can be done with audio-only (telephone) communication or with a 2-way video interaction. Both types of interaction have current procedural terminology codes that permit reimbursement by health plans. Although coordination is necessary to set up a real-time connection, the advantage of this type of visit is that it helps to establish a provider-patient relationship and is helpful when addressing sensitive issues. Synchronous TM can be divided into direct-to-consumer (DTC) and facilitated visits.

DTC visits. Synchronous DTC encounters usually are initiated by patients on demand when they want to speak with a health care provider (see Table II and review by Elliott and Yopes in this issue).¹⁵ For that reason, this type of visit usually is not scheduled in advance because it requires a provider to be available on-call. The patient can be located almost anywhere when they initiate this type of visit including their home, school, or workplace or even when they are traveling. The only requirement is that the patient needs to have access to digital equipment that permits real-time videoconferencing such as a smartphone, tablet, or computer that has internet capability. Although some DTC services permit telephone encounters, current reimbursement requirements are more favorable if videoconferencing is used. The use of video also improves the quality of the interaction because body language can be seen and visible signs such as rashes can be examined if necessary. The primary requirements for the internet connection are that it needs to have sufficient bandwidth to avoid latency issues and that it should be secure enough to protect confidentiality.¹⁶

DTC visits are commonly used for evaluation of conditions that do not require a physical examination, or that can be evaluated using the low-quality imaging that is available using devices that the patient has. Disorders that are appropriate for DTC care include rashes and respiratory infections. DTC care also includes consultations regarding issues that are not currently active such as a history of food allergy, urticaria, allergic rhinitis, and asthma. In addition, common tasks such as preseason checkups, medication refills, review of laboratory results, and interval discussion of immunotherapy are ideal candidates for a DTC visit. DTC also could be offered to patients who simply do not want or physically cannot come to a medical office and who have uncomplicated conditions. Because procedures such as spirometry and allergy tests cannot be performed using DTC, patients who need them generally require a referral to a center where the procedures can be performed.

Because of the lack of a physical examination, most health plans do not reimburse for DTC visits. For that reason, a common model is for patients to pay a flat fee before being connected to the provider. In some cases, health plans will subsidize the cost of these visits to encourage covered individuals to use this less expensive health care option. Patients should be encouraged to check with their health plan to determine whether DTC services are covered. Some practices use DTC platforms to provide night call. This can be done using providers from the practice, or providers who work for the DTC platform also can serve this function.

Facilitated visits. Synchronous facilitated encounters require a patient to travel to a medical facility where they can see the

TABLE I. Features of TM visit types in the ambulatory, emergency, and inpatient settings

Clinical setting	Application	Example(s)
Ambulatory care	Facilitated visits	Live, synchronous scheduled virtual visits
	DTC	Live, synchronous patient-initiated videoconferencing visits
	Chronic disease monitoring	Serial monitoring of PFTs, weight, glucose, blood pressure
	Community care visits	School-based multipresence visits for conditions such as asthma, food allergy, and rhinitis
	Personal health management	Activity trackers, ACT and symptom tracking apps
	Reminder systems	SMS (text) and smartphone apps
Emergency/urgent care	Professional development	Distance education, project ECHO, case conferencing
	Live emergency consults	Outpatient consultation to treat patients in the ED
Inpatient care	Remote specialty consults	Remote specialty evaluation and treatment of hospitalized patients including high-risk patients with asthma
	Efficient use of tertiary care resources	Reduced need for transfers to obtain specialty services
Other	Asynchronous store and forward	Interpretation of PFT results, other test results

ACT, Asthma control test; ECHO, Extension for Community Healthcare Outcomes; PFT, pulmonary function test.

provider from a TM room with the help of a facilitator (usually a nurse or respiratory therapist) (Table II). In a sense, this type of visit serves as a substitute for an in-person encounter. The advantage to the patient of this type of visit over an in-person visit with the provider is that the facility is usually closer to where they live than where the provider is located, which reduces their travel time. Rural residents can avoid long drives to urban centers. To enable a facilitated visit, the clinic should have a TM cart with 2-way video capability and an adequate internet connection. A physical examination can be performed using digital examination equipment including a stethoscope, otoscope, and high-resolution camera. Clinics also should be equipped with the ability to perform spirometry and venipuncture.

Facilitated visits permit evaluation of almost any condition that could be managed with an in-person visit including rashes and rhinitis, asthma, and food allergy. Common low-risk procedures can be performed including spirometry and allergy testing (using *in vitro* tests); however, procedures that require the physical presence of a provider such as skin tests, allergy shots, and drug, food, or bronchial challenges should be performed only if a provider who is willing to be responsible for treating a systemic reaction is available to supervise them. When one of these procedures is indicated in a facility that does not offer it, a new visit can serve to triage patients for testing at another facility. Because a physical examination can be performed, a facilitated visit usually is reimbursable by health plans using current procedural terminology codes with appropriate TM modifiers. The extent of this depends on the TM laws governing the state in which the patient is seen.

Although the primary advantage of a facilitated visit is proximity, the patient still needs to travel to a clinic and facilitators need to be trained to operate the equipment and perform the physical examination using digital equipment. Scheduling of patients is similar to that for in-person visits; however, the schedule should consider that it usually takes slightly less time to see a patient by TM. This is because documentation in the electronic medical record can be done at the same time as other tasks such as doing a physical examination and because patients tend to ask fewer questions during a TM visit. In addition, there tends to be less “chit-chat” during a TM visit.¹⁷ Despite the shorter more problem-oriented visits, satisfaction surveys show

that patients report 95% to 100% satisfaction rate in comparison to traditional, in-person appointments.¹⁸ Patients seen by TM can be scheduled in half- or full-day blocks or they can be intermixed with in-person visits. Our experience has been that the former works better because otherwise scheduling of resources become unpredictable in different locations.

Factors influencing the adoption of TM in the emergency department (ED) include perceived usefulness of the service, ease of use, and whether the user believed that TM offered an advantage over an in-person visit. Strategies to improve adoption of TM include the availability of patient-specific education, clinical protocols for use of TM, reduced response times, and simplification of the technology.¹⁹

AMBULATORY USES OF TM

A growing use of TM has been in the military where bases are often located distant from access to specialists. In a series of studies by Waibel et al,²⁰ facilitated TM care was provided to 423 patients with allergy located at 13 military bases across Europe. This represented 13% of all new and 10% of all follow-up ambulatory visits at these facilities during a 2-year interval. The most common diagnoses were allergic rhinitis, asthma, and food allergy. After the TM visits, 23% of new and 10% of follow-up patients needed an in-person visit. In addition, new patients were more likely to have medication prescribed than follow-ups (64% vs 49%). The authors estimated that patients saved an average of \$485 in travel expenses, 438 driving miles, and 2.3 days of work or school per visit.²⁰ Anonymous surveys of patients who completed a TM visit found an average satisfaction of 4.8 on a 5-point scale.²¹

Because patients are reimbursed for travel expenses, the Veterans Affairs health care system evaluated savings with TM due to avoidance of travel between 2005 and 2013. On average, TM saved 145 miles of travel and 142 minutes per visit. By the final year, TM resulted in savings of more than \$63,000 per year.²²

Perhaps the ideal location for children with asthma to be seen would be their school. In a school-based program that was developed in Rochester, NY, Halterman et al²³ showed that patients with asthma who were seen by TM had better outcomes than those seen in-person. In this study, 300 children were assigned to a control group or an active group in which controller

TABLE II. Comparison of asynchronous with synchronous DTC and facilitated visits

Consideration	Asynchronous	Synchronous (DTC visit)	Synchronous (facilitated visit)
How initiated	Patient generates results for later review by provider	Usually initiated on demand by the patient	Scheduled visit between patient and provider
Location	Monitoring at home or tests at a medical facility	Patient can be almost anywhere including home	Patient travels to a medical facility with a facilitator
Equipment	Uses patient's equipment or equipment in a facility	Uses the patient's equipment (eg, smartphone, tablet, or computer)	Uses the facility's equipment (eg, TM cart)
Timing	Can be intermittent	Dependent on patient's internet connection	The facility provides the internet connection
Examination	NA	No or limited physical examination	Physical examination performed using digital equipment (eg, stethoscope, otoscope, and high-resolution camera)
Conditions	Rashes, conditions for which a test is available, imaging studies	Restricted types of conditions can be seen	Almost any condition can be evaluated and managed
Procedures	Low-risk procedures for subsequent interpretation	Few procedures can be done	Most procedures are available except those with an increased risk of a reaction (eg, allergy shots, skin tests, and challenges)
Advantages		Convenient on demand Avoids travel Avoids overhead costs Improved access to patients with limited travel ability No or limited examination Reimbursement depends on state rules	More convenient than traveling to where the provider is Physical examination can be done, teaching and instructions provided Reliably billable using CPT codes with g-modifier
Disadvantages			Requires some patient travel Facilitator needs to be trained Overhead cost of the clinic and equipment

CPT, Current procedural terminology; NA, not applicable/available.

medications were given at the school and children were monitored with 3 TM visits for prescriptions and follow-up care. Facilitators at the school site obtained histories and performed examinations. A provider reviewed this information and provided instructions to the facilitators regarding each patient. After 4 years, 400 children participated in the study (196 in the active group). Although both groups were similar at baseline, children in the active group had more symptom-free days (11.6 vs 11.0) and were less likely to have an ED visit or hospitalization (7% vs 15%).²³

In another prospective cohort study in 3 urban California schools, students seen virtually by an asthma expert experienced a significant improvement in family social activities and in the number of asthma exacerbations. In addition, more than 90% of the students rated the program as good or excellent.²⁴

INPATIENT TM SERVICES

Another area that TM can facilitate access to allergy specialists is inpatient consults (Table I). The utility of this was demonstrated in a study of 50 patients with a history of penicillin allergy who were admitted to a community hospital.²⁵ Allergy skin tests were performed by a physician assistant, with subsequent review of an allergy specialist using TM. The average time to complete the consultation was 82 minutes plus 46 minutes required for the physician assistant to travel to the hospital. Physician time averaged 5 minutes. Of the 46 patients with negative skin test results, 33 could be treated with a β -lactam, reducing the cost of care by \$30,000.

Because most allergists practice outside of the hospital setting, they have a limited ability to see a hospitalized patient during the day because of the need to leave a busy practice and travel to the hospital. Consequently, most inpatient consults are performed before or after the workday. Hospitals that provide an origination site for TM could permit an allergist to see a patient during the workday, leading to faster treatment and possibly to earlier discharge. In a study, rural hospitals were found to be more likely than urban hospitals to report higher rates of TM knowledge and many were planning for or implementing TM services.²⁶

OTHER CONSIDERATIONS

Because it is a relatively new technology, TM has been subjected to various regulatory issues that vary by state. Early on, the Center for Medicaid & Medicare Services required patients to live a certain distance (usually 50 miles) from the provider before they could be seen using TM. In addition, restrictions were placed on where patients could be when seen. More recently these restrictions have been removed. Currently, TM visits originating at home are legally permitted in all 50 states. In addition, most health plans cover TM services, though not all reimburse at the same rate as in-person services. Although 29 states and the District of Columbia have laws requiring insurance companies to reimburse for TM services, the amount of reimbursement differs by state and medical specialty.²⁷

LICENSURE

With few exceptions, a provider needs to be licensed in the state where the patient is located to see a patient either by TM or in-person. This can create significant barriers for TM because the technology permits care to be provided independent of distance.

Providers generally are unwilling to apply for and maintain medical licensure in numerous states.

To address this issue, the Interstate Medical Licensure Compact has been formed.²⁸ The Interstate Medical Licensure Compact is an agreement between 29 states, 1 territory, and 39 medical and osteopathic boards to permit physicians (other advanced practice professionals have different requirements) to practice medicine across state lines in states that are members of the compact if they meet agreed-upon eligibility requirements. The compact used the “driver’s license” model in that if a provider is qualified to practice in one member-state, the other states would agree to allow that provider also to practice in their state using TM.

CONSIDERATIONS FOR TM PROVIDERS

Advances in TM technology have important implications both for the cost of health care services and for the availability of health care providers in remote areas. Such advances also create a need for training of health care providers so that they can acquire proficiency in deploying and using the new technology.²⁹

When setting up a TM service, it is important to ensure that providers and facilitators are properly trained to use the software and equipment. In addition, providers should practice connecting to the origination site and using the software to control the camera and digital equipment before seeing patients. It is also helpful to have a backup plan in case there is a technology failure. Providers should also connect with enough time before the first visit to address connectivity issues should they occur.

Among general practitioners, barriers to adoption of TM include ignorance of the technology, concerns about payment, legal issues, and a resistance to changing medical practice. Despite these concerns, TM is increasingly recognized as a solution for provision of specialty care in medically underserved areas.³⁰

TM visits tend to be more efficient than in-person ones. In a study of 14 rural hospitals and 128,000 ED visits, the time to be seen by a provider was 6 minutes less for patients seen by TM and the length of stay in the ED was 22 minutes shorter. This was because 42% of the time the TM provider was the first person who saw the patient as opposed to in-person visits in which other personnel spent time with the patient first.³¹

DOES IT WORK?

Although TM has been shown to improve access to allergy care in rural communities, it is important that this does not come at the cost of worse outcomes. To compare asthma control between patients seen by TM and those seen in-person, children with asthma residing in 2 rural communities were offered the choice of an in-person visit or a facilitated TM visit in a controlled study.³² Both groups were assessed initially, after 30 days, and at 6 months using validated tools. A total of 34 in-person and 40 TM patients completed all 3 visits. Patients in both groups experienced a small improvement in asthma control over time. TM was found to be noninferior to in-person visits with an 80% confidence.

In addition to providing access without sacrificing quality, TM is a cost-effective alternative to in-person visits for rural populations. In a study of TM at a Wisconsin Veterans Affairs hospital among pulmonary patients, physicians were able to rely on medical history and radiology to manage various patients with

complex pulmonary conditions by using a facilitator at the remote site.³³ In this study, TM was found to be more cost-effective (\$335 per patient/y) when compared with in-person care (\$585 per patient/y) and care delivered on site if the specialist traveled (\$1166 per patient/y). This was related to 3 major factors: sharing of TM infrastructure among various clinical users, effectiveness of TM to achieve successful clinical consultations, and decreasing indirect cost of lost productivity.³⁴

An economic evaluation of the cost, effectiveness, and return on investment of TM consultations for acutely ill and injured children in rural EDs found that the average cost for a TM consultation was \$3641 per child/ED/y in 2013 US dollars. TM consultations resulted in 31% fewer patient transfers when compared with telephone consultations, leading to a cost reduction of \$4662 per child/ED/y. TM consultations were less costly than telephone consultations in 57% of simulation iterations. The authors estimated that treatment of 10 acutely ill and injured children with TM resulted in an annual cost-saving of \$46,620 per ED.³⁵ In addition to reducing transfers, the overall admission rate among children who have consults by TM has been found to be lower than that of children who have telephone consultations (59.5% vs 87.5% in a study).³⁶

TM also has the potential of reducing medication errors. A chart review of 234 seriously ill children presenting to 8 rural EDs found that 73 received TM consultations, 85 received telephone consultations, and 76 received no specialist consultations. Patients who received care by TM had significantly fewer physician-related medication errors than patients who received telephone consultations or no consultations (3.4% vs 10.8% and 12.5%, respectively).³⁷

The University of California-Davis health system found that TM reduced patient travel distance by more than 4 million miles during a 7-year interval, saving 8.9 years of driving and \$2.8 million.³⁸ On average, patients drove 278 miles less per visit, saving 245 minutes and \$156. The overall reduced travel was estimated to have decreased CO₂ emissions by 50 metric tons, which is equivalent to the amount produced by 271 four-member households.³⁹

PATIENT AND PROVIDER SATISFACTION

A 2016 study of adult patients seen by TM in a MinuteClinic found that 98% of patients were very satisfied with TM visits, 95% would use TM again, and 95% would recommend TM to others.¹⁸ Predictors of liking TM included female sex, quality of care received, convenience, and liking the technology. Patients without medical insurance tended to prefer TM because of its lower cost.

Another study of patient satisfaction in an academic center found that most patients who completed an encounter by TM were satisfied and most would continue to use video visits as an alternative to in-person ones. The most common benefits included convenience and reduced cost. Some patients felt more comfortable being seen by TM because they could be in their own environment when seen, which was perceived as more supportive than a provider office. They were concerned about the possibility of coworkers overhearing the visit and the lack of a physical examination.⁴⁰

CONCLUSIONS

TM offers a solution to the shortage of specialty care for allergic conditions and management of asthma that is present in

rural communities. By receiving a combination of asynchronous and synchronous DTC and facilitated visits, residents of rural communities can benefit from specialty care that is as effective as in-person care at a lower cost and greater convenience. Hospitals in rural areas are already preparing to facilitate inpatient consultations. With continued advances in the technology along with updates in regulations, TM can bridge the gap and reduce the medical inequality that rural residents currently experience. Allergy/asthma specialists also can benefit from easier access to patients and payers can benefit from lower costs. It is a win-win situation for everyone concerned.

REFERENCES

1. Rural Health Information Hub. What is Rural? 2018. Available from: <https://www.ruralhealthinfo.org/topics/what-is-rural>. Accessed February 19, 2019.
2. United States Census Bureau. 2010 Census urban and rural classification and urban area criteria; 2010. Available from: <https://www.census.gov/geo/reference/ua/urban-rural-2010.html>. Accessed February 19, 2019.
3. Hart LG, Salsberg E, Phillips DM, Lishner DM. Rural health care providers in the United States. *J Rural Health* 2002;18:211-32.
4. Rabinowitz HK, Diamond JJ, Markham FW, Santana AJ. Increasing the supply of rural family physicians: recent outcomes from Jefferson Medical College's Physician Shortage Area Program (PSAP). *Acad Med* 2011;86:264-9.
5. Call VR, Erickson LD, Dailey NK, Hicken BL, Rupper R, Yorgason JB, et al. Attitudes toward telemedicine in urban, rural, and highly rural communities. *Telemed J E Health* 2015;21:644-51.
6. Marcin JP, Shaikh U, Steinhorn RH. Addressing health disparities in rural communities using telehealth. *Pediatr Res* 2016;79:169-76.
7. Gagnon MP, Duplantie J, Fortin JP, Landry R. Implementing telehealth to support medical practice in rural/remote regions: what are the conditions for success? *Implement Sci* 2006;1:18.
8. Dharmar M, Romano PS, Kuppermann N, Nesbitt TS, Cole SL, Andrada ER, et al. Impact of critical care telemedicine consultations on children in rural emergency departments. *Crit Care Med* 2013;41:2388-95.
9. Krishna MT, Knibb RC, Huissoon AP. Is there a role for telemedicine in adult allergy services? *Clin Exp Allergy* 2016;46:668-77.
10. Scholl J, Lambrinos L, Lindgren A. Rural telemedicine networks using store-and-forward Voice-over-IP. *Stud Health Technol Inform* 2009;150:448-52.
11. Kagen S, Garland A. Asthma and allergy mobile apps in 2018. *Curr Allergy Asthma Rep* 2019;19:6.
12. Zairina E, Abramson MJ, McDonald CF, Li J, Dharmasiri T, Stewart K, et al. Telehealth to improve asthma control in pregnancy: a randomized controlled trial. *Respirology* 2016;21:867-74.
13. Berlinski A, Chervinskiy SK, Simmons AL, Leisenring P, Harwell SA, Lawrence DJ, et al. Delivery of high-quality pediatric spirometry in rural communities: a novel use for telemedicine. *J Allergy Clin Immunol Pract* 2018;6:1042-4.
14. Stout JW, Smith K, Zhou C, Solomon C, Dozor AJ, Garrison MM, et al. Learning from a distance: effectiveness of online spirometry training in improving asthma care. *Acad Allergy Asthma Rep* 2012;12:88-95.
15. Elliott T, Yopes MC. Direct-to-consumer telemedicine. *J Allergy Clin Immunol Pract* 2019;7:2546-52.
16. Baker J, Stanley A. Telemedicine technology: a review of services, equipment, and other aspects. *Curr Allergy Asthma Rep* 2018;18:60.
17. Bulik RJ. Human factors in primary care telemedicine encounters. *J Telemed Telecare* 2008;14:169-72.
18. Polinski JM, Barker T, Gagliano N, Sussman A, Brennan TA, Shrank WH. Patients' satisfaction with and preference for telehealth visits. *J Gen Intern Med* 2016;31:269-75.
19. Ray KN, Felmet KA, Hamilton MF, Kuza CC, Saladino RA, Schultz BR, et al. Clinician attitudes toward adoption of pediatric emergency telemedicine in rural hospitals. *Pediatr Emerg Care* 2017;33:250-7.
20. Waibel KH, Bickel RA, Brown T. Outcomes from a regional synchronous teleallergy service. *J Allergy Clin Immunol Pract* 2019;7:1017-21.
21. Waibel KH, Cain SM, Hall TE, Keen RS. Multispecialty synchronous telehealth utilization and patient satisfaction within Regional Health Command Europe: a readiness and recapture system for health. *Mil Med* 2017;182:e1693-7.
22. Russo JE, McCool RR, Davies L. VA Telemedicine: an analysis of cost and time savings. *Telemed J E Health* 2016;22:209-15.
23. Halterman JS, Fagnano M, Tajon RS, Tremblay P, Wang H, Butz A, et al. Effect of the School-Based Telemedicine Enhanced Asthma Management (SB-TEAM) Program on asthma morbidity: a randomized clinical trial. *JAMA Pediatr* 2018;172:e174938.
24. Bergman DA, Sharek PJ, Ekegren K, Thyne S, Mayer M, Saunders M. The use of telemedicine access to schools to facilitate expert assessment of children with asthma. *Int J Telemed Appl* 2008;159276.
25. Staicu ML, Holly AM, Conn KM, Ramsey A. The use of telemedicine for penicillin allergy skin testing. *J Allergy Clin Immunol Pract* 2018;6:2033-40.
26. Martin AB, Probst JC, Shah K, Chen Z, Garr D. Differences in readiness between rural hospitals and primary care providers for telemedicine adoption and implementation: findings from a statewide telemedicine survey. *J Rural Health* 2012;28:8-15.
27. Center for Connected Health Policy. Current state laws & reimbursement policies; 2019. Available from: <https://www.cchpca.org/telehealth-policy/current-state-laws-and-reimbursement-policies>. Accessed May 10, 2019.
28. IMLC. Interstate Medical Licensure Compact; 2019. Available from: <https://imlc.org/>. Accessed May 13, 2019.
29. Institute of Medicine. The role of telehealth in an evolving health care environment: workshop summary. Washington, DC: The National Academies Press; 2012.
30. Durupt M, Bouchy O, Christophe S, Kivits J, Boivin JM. Telemedicine in rural areas: general practitioners' representations and experiences. *Sante Publique* 2016;28:487-97.
31. Mohr NM, Young T, Harland KK, Skow B, Wittrock A, Bell A, et al. Emergency department telemedicine shortens rural time-to-provider and emergency department transfer times. *Telemed J E Health* 2018;24:582-93.
32. Portnoy JM, Waller M, De Lurgio S, Dinakar C. Telemedicine is as effective as in-person visits for patients with asthma. *Ann Allergy Asthma Immunol* 2016;117:241-5.
33. Raza T, Joshi M, Schapira RM, Agha Z. Pulmonary telemedicine—a model to access the subspecialist services in underserved rural areas. *Int J Med Inform* 2009;78:53-9.
34. Agha Z, Schapira RM, Maker AH. Cost effectiveness of telemedicine for the delivery of outpatient pulmonary care to a rural population. *Telemed J E Health* 2002;8:281-91.
35. Yang NH, Dharmar M, Yoo BK, Leigh JP, Kuppermann N, Romano PS, et al. Economic evaluation of pediatric telemedicine consultations to rural emergency departments. *Med Decis Making* 2015;35:773-83.
36. Yang NH, Dharmar M, Kuppermann N, Romano PS, Nesbitt TS, Hojman NM, et al. Appropriateness of disposition following telemedicine consultations in rural emergency departments. *Pediatr Crit Care Med* 2015;16:e59-64.
37. Dharmar M, Kuppermann N, Romano PS, Yang NH, Nesbitt TS, Phan J, et al. Telemedicine consultations and medication errors in rural emergency departments. *Pediatrics* 2013;132:1090-7.
38. Dullet NW, Geraghty EM, Kaufman T, Kisse J, King J, Dharmar M, et al. Impact of a university-based outpatient telemedicine program on time savings, travel costs, and environmental pollutants. *Value Health* 2017;20:542-6.
39. US Environmental Protection Agency. Greenhouse gases equivalencies calculator—calculations and references; 2019. Available from: <https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references>. Accessed May 9, 2019.
40. Powell RE, Henstenburg JM, Cooper G, Hollander JE, Rising KL. Patient perceptions of telehealth primary care video visits. *Ann Fam Med* 2017;15:225-9.