

School-Based Telemedicine for Asthma Management



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Learning objectives:

1. To identify how school-based telemedicine is a feasible option for managing asthma in children.
2. To identify how school-based telemedicine can effectively reduce morbidity, health care use, and absenteeism for children with asthma.
3. To briefly discuss barriers that could impact successful implementation of a school-based telemedicine program for asthma.
4. To recognize successful programs offering school-based asthma management via telemedicine.

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Asthma affects 10% of school-age children in the United States. These numbers nearly double in high-risk populations such as low-income and minority populations. Patients in these populations frequently live in communities that are medically underserved, with limited resources to implement comprehensive asthma interventions. It is important for researchers and clinicians to explore avenues to reduce the burden of illness in this population. Incorporating innovative strategies such as school-based telemedicine programs can potentially reduce morbidity, health care utilization, work absenteeism for caregivers, and school absenteeism for children

with asthma. The aim of this review is to discuss the potential benefits of school-based asthma telemedicine programs, explore potential implementation models, and provide a comprehensive review of the literature including programs that use telemedicine in schools to assist with the management of asthma.

Telemedicine is a feasible approach to increasing access to primary and specialty asthma care; however, there is a need for future randomized trials to establish best practices for implementation of telemedicine programs to aid in the care for children in school settings. © 2019 American Academy of Allergy, Asthma & Immunology (*J Allergy Clin Immunol Pract* 2019;7:2524-32)

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INTRODUCTION

Asthma affects 10% of school-age children in the United States.^{1,2} In high-risk populations such as low-income and minority children, prevalence rates are nearly double the reported national rates.³ Thus, the burden of asthma for school-age children, especially children in high-risk communities, is significant. Uncontrolled asthma contributes substantially to costs associated with health care utilization, work absenteeism for caregivers, and school absenteeism for students.⁴⁻⁶ Rates of

Abbreviations used

ED- Emergency department

PCP- Primary care provider

SB-TEAM- School-Based Telemedicine Enhanced Asthma Management

SBTM- School-based telemedicine

SFD- Symptom-free day

QOL- Quality of life

UC- Usual care

school absenteeism have been reported to be as high as 59% for children with asthma, and asthma-related absenteeism has been linked to poorer academic performance and significant achievement gaps especially among minority children.⁷⁻⁹ Improving school attendance and academic achievement are inherently shared objectives of parents, clinicians, and school officials, and this common goal should serve as motivation for implementation of innovative strategies to improve asthma outcomes. School-based telemedicine (SBTM) programs have the potential to assist in the management of asthma care while allowing students to remain in school. The purpose of this review was to explore the use of telemedicine for asthma management in school-based settings. This review will discuss the rationale for the use of telemedicine in a school-based setting. The review will examine outcomes such as increased school or work absenteeism and inadequate provider access. Implementation models and tools to successfully execute an asthma SBTM program will be explored. Finally, a review of current research on the use of telemedicine in school-based settings will be explored.

SCHOOL AND WORK ABSENTEEISM DUE TO ASTHMA

School absenteeism

More than 13 million school days were missed because of asthma-related illness among US children in 2013.¹⁰ Children with asthma miss school because of acute illness, chronically uncontrolled symptoms, and regularly scheduled doctor's appointments. Hsu et al¹¹ reported modifiable factors for asthma-related school absenteeism in a nationally representative sample of Behavioral Risk Factor Surveillance Child Asthma Call-back respondents. This national sample included only children with current asthma who attended school in the past 12 months. One of the key modifiable factors associated with missed school due to asthma was the child's inability to see a provider. Missed school was associated with the inability to see a primary care doctor (prevalence ratio, 2.0; 95% CI, 1.26-3.19) and inability to see an asthma specialist (prevalence ratio, 2.97; 95% CI, 1.68-5.24). School absenteeism among pediatric asthma populations has also been associated with lower income and uncontrolled asthma.^{12,13} Children spend most of their wakeful hours at school. Thus, it is not only reasonable but also practical to implement school-based interventions for one of the most common childhood illnesses that significantly contributes to student absenteeism.^{5,6,9} Using a chronic disease management model, an asthma SBTM program has the potential to improve asthma outcomes as a result of improved access to care. SBTM could also reduce school absenteeism for both acute and chronic care by allowing the child to stay in school for acute and regularly scheduled appointments, respectively.

Work absenteeism

In addition to school absenteeism for children with asthma, caregivers often miss work as a result of their child's asthma-related illness and routine health care visits. In a nationally representative sample, Sullivan et al⁵ reported that caregivers of school-age children with asthma missed 1.16 times more work-days annually compared to caregivers of school-age children without asthma. For children with poorly controlled asthma, parental annual work absenteeism increased by 1.2 days for parents of children with an exacerbation in the previous 12 months and by 1.8 days for parents of children who had an emergency department (ED) or inpatient visit for asthma.⁶ An asthma SBTM program has the potential to reduce caregiver work absenteeism, particularly for nonemergency and chronic asthma management. By providing pediatric primary or specialty care for asthma, SBTM programs using a chronic disease management model can offer caregivers the option of joining remotely^{14,15} from their workplace, thus eliminating the need for missed work for routine or nonurgent asthma care. The economic impact of caregiver missed workdays due to pediatric asthma is substantial,⁶ and a school-based asthma telemedicine program could potentially alleviate this significant burden on caregivers.

ACCESS TO ASTHMA PROVIDERS

Several barriers to optimal asthma care can potentially be addressed through an integrated SBTM program. Barriers have been reported, especially among high-risk pediatric asthma populations, such as disparities in the number of asthma visits per year,¹⁶ receipt of a written asthma plan,¹⁶ and use of preventive asthma medications.¹⁷ These known disparities are further compounded in rural environments by inadequate access to primary and specialty care, transportation limitations, and lack of tailored interventions for rural children.¹⁸⁻²⁰ Although it is commonly thought of as a problem that primarily impacts inner-city youth, Keet et al³ revealed in a national survey that race, ethnicity, and lower household income were predictive of asthma prevalence, not residence in an inner-city. Telemedicine offers the potential to overcome many barriers to asthma care, particularly those related to provider access and travel/transportation, especially if done in a place where children are inherently present such as schools.

CAN TELEMEDICINE BE INTEGRATED INTO SCHOOL-BASED INTERVENTIONS?

There have been a number of programs and resources created to assist schools and providers in implementation of school-based asthma programs.²¹⁻²⁶ These school-based programs have been endorsed by patient advocacy groups as well as national nursing and provider organizations such as the American Academy of Allergy, Asthma & Immunology, the American College of Allergy, Asthma, and Immunology, the American Lung Association, and the National Association of School Nurses. These programs use various elements including education, medication management, directly observed therapy (DOT), and care coordination. Investigations of school-based asthma programs have suggested that school-based asthma interventions are effective in improving outcomes and quality of life (QOL) for children with persistent asthma.²⁷ On-site asthma care through school-based health centers has been associated with fewer

hospitalizations,^{28,29} school absences,²⁹ and ED visits.²⁸ The Breathmobile program was one of the first comprehensive mobile programs delivering specialty asthma care directly to students through the use of a van that traveled to their schools.^{25,26,30} The program, implemented in urban schools, improved asthma symptoms and reduced health care utilization and school absenteeism by shifting asthma care from acute and episodic to preventive.^{25,30} Although cost-effectiveness has been demonstrated in the inner-city Breathmobile programs in Los Angeles³¹ and Baltimore,²⁶ programs rely heavily on philanthropic support and long-term sustainability is difficult. Furthermore, demonstrating feasibility and cost-effectiveness of mobile clinics outside of inner-city environments will require additional investigation because it is anticipated that additional travel expenses and added resources would be needed to reach children in sparsely populated rural regions.

Although telemedicine is not widely integrated in school-based programs at this time, it could be incorporated in new and existing programs such as Breathmobile or school-based health centers for at-risk populations. Providing specialty care in schools via telemedicine has the potential to mitigate or reduce the impact of modifiable risk factors such as access to providers and financial constraints related to travel/transportation on families in rural regions.³² Similarly, telemedicine can be used in urban regions where at-risk children often overuse emergency and acute care settings, underuse asthma specialists, or have social hardships (ie, lack of transportation) that interfere with optimal asthma management.^{33,34}

ASTHMA MANAGEMENT AND EDUCATION VIA TELEMEDICINE

In a recent study, an outpatient telemedicine clinic was found to be as effective as in-person visits for asthma follow-up care.³⁵ Telemedicine has also been shown to be useful in conducting remote spirometry testing for pediatric patients with asthma.³⁶ Both clinical visits and spirometry testing conducted via telemedicine have the capability of delivering pediatric-trained personnel and specialty services to areas where pediatric specialty care is scarce. The methods used in these studies can potentially be replicated in the school environment to improve access in rural and underserved areas as well as areas with high concentrations of at-risk children with asthma. A recent Cochrane review³⁷ examined methods of 21 randomized controlled trials using telemedicine interventions for asthma. Although the meta-analysis did not show improved QOL or reduction in ED visits, it did show a reduction in hospital admissions. If an effective SBTM asthma program achieved reductions in health care utilization, the intervention would prove meaningful to parents, clinicians, and school personnel because this potential benefit could translate into fewer school days missed and potentially improved academic performance.

Acute and chronic asthma care

SBTM offers potential models of asthma care for both acute and chronic asthma management. Both models offer favorable opportunities for students, caregivers, and school personnel. Schools are often faced with limited nursing coverage and few resources to assist in the management of acute asthma.^{38,39} An SBTM clinic offering acute asthma visits would provide an opportunity for school nurses and/or staff to receive real-time advice from the child's provider, thus preventing inappropriate

triage to the ED or other acute health care settings.^{40,41} Likewise, acute advice during an exacerbation could potentially expedite appropriate initiation of Emergency Medical Services and/or transfer to the ED when necessary.

For chronic management of asthma, telemedicine offers an opportunity to improve access to both primary and specialty asthma care. In particular, children in high-risk communities often lack convenient access to specialists or lack transportation or have other barriers to care.^{18,33,34,42} A SBTM asthma program has the potential to alleviate some of these important barriers. In addition to chronic asthma management, an SBTM model could support better educational opportunities for school nurses through interactions with asthma providers as well as encouraging participation in educational resources such as webinars, videoconferences focused on asthma care in schools, and other continuing education opportunities.¹⁴ These opportunities are important because urban-rural differences in school nurse training have been identified as a barrier, with rural nurses receiving fewer opportunities for engagement in asthma education programs.³⁸

Both synchronous and asynchronous telemedicine⁴³ can be used in the school setting. Synchronous telemedicine uses a live, interactive audiovisual connection between a patient at an originating site such as a school or clinic and the provider at a distant site. Synchronous telemedicine is used most frequently in the school setting^{40,44,45} and for other acute pediatric health care models.^{14,46} Asynchronous telemedicine uses recorded video, often accompanied by a detailed medical history form and imaging when appropriate. Asynchronous telemedicine is more appropriate for chronic disease management and has been successfully used by Halterman et al⁴⁷ for asthma in the school setting. Both synchronous and asynchronous telemedicine visits typically use trained personnel, often referred to as telepresenters, to facilitate the visit. The telepresenter provides assistance to the patient during the visit, ensures lighting and telemedicine equipment are functioning properly, and facilitates the patient examination with the use of peripheral devices such as the examine camera, stethoscope, and otoscope.⁴⁸

Education

Education delivered via videoconference, often referred to as teleeducation, is commonly used in school settings for academic purposes. It has also been found to be a feasible method of providing chronic disease education and training,^{49,50} including asthma education for high-risk populations.^{51,52} Patients, caregivers, and school health care professionals can benefit from health care education via distance learning. This is particularly valuable in rural areas where providers and patients have few opportunities to attend chronic disease management programs locally or attend continuing education professional conferences or have limited funds and/or time to travel to conferences. In addition to continuing education opportunities, school-based programs may potentially use a teleconsultation model to provide asthma education and case management. One such telemedicine model, the project Extension for Community Healthcare Outcomes (ECHO) program, has been used to connect rural primary care providers (PCPs) to specialists at academic health centers.⁵³⁻⁵⁶ An ECHO style model has been used for a number of chronic diseases in community settings including school-based models.⁵⁷ This innovative model could potentially be used to provide asthma education and teleconsultation to rural

health care providers at school-based health centers and school nurses.

SPECIAL CONSIDERATIONS FOR SBTM

With the exception of school-based health centers, schools are not usually considered health care centers, and any provider or health care system offering SBTM services has to consider several regulatory and legal factors before implementation. Because the legal and other regulatory aspects of an SBTM program vary on the basis of state laws and school district regulations, a full discussion regarding these aspects of an SBTM program is beyond the scope of this review. However, there are a few universal guidelines that should be applied to any SBTM program. All programs must comply with the Health Insurance Portability and Accountability Act and Family Educational Rights and Privacy Act regulations for all telehealth encounters.¹⁵ Specific policies and contractual agreements between the provider and the local school system should be developed to comply with state regulations and school policies regarding confidentiality and privacy. Parity in coverage and reimbursement is not currently mandated, so reimbursement rules and state laws regarding telemedicine vary significantly from state to state. This is further complicated by the fact that some state laws and insurance policies may not recognize schools as health care sites or may have specific limitations on reimbursement of telehealth services at schools. Because of this variability and inconsistency among payers, stakeholders of SBTM programs must be well versed in their current state laws and regulations for telemedicine care. The American Academy of Allergy, Asthma & Immunology recently published a toolkit specifically aimed to aid the practicing allergist/immunologist in learning about the complexities of providing care via telemedicine.⁵⁸ Also, the Center for Connected Health Policy has an interactive state map that will help providers stay informed about telehealth laws and regulations in their state.⁵⁹

Administrative support, telepresenter personnel, equipment, and funding are program specific and can be directly or indirectly impacted by state and/or school regulations and policies. Telemedicine implementation is contingent on the availability of these factors as well as stakeholder buy-in. In a national survey of pediatric telemedicine programs, it was demonstrated that most telemedicine programs in the United States are currently funded by philanthropy, grants, or institutional support, and lack of reimbursement was cited as one of the main barriers to program expansion.⁴⁶ If long-term feasibility and cost-effectiveness are proven, stakeholders will need to secure sources of funding, including reimbursement by payers, to ensure long-term sustainability of SBTM programs to support equipment, operational costs, and staffing needs.

Other practical considerations for the implementation of an asthma SBTM program include involvement and collaboration with caregivers, PCPs, and schools. All children seen and treated via telemedicine in the school setting should have the written informed consent of their caregiver/legal guardian before the telehealth encounter, and caregivers should be invited to join the telemedicine visit either remotely or onsite at the child's school when feasible. In an attempt to avoid fragmentation of the patient's care, telehealth encounters not conducted by the child's PCP should include documentation of the visit in the patient's medical record with direct communication shared between the telemedicine provider and the PCP.^{14,15} Finally, infrastructural

needs add to the complexity of implementation of SBTM programs. Significant investment in infrastructure include costs for telemedicine equipment with peripheral devices that allow for physical examinations, reliable Wi-Fi and adequate internet bandwidth to support live audiovisual connectivity, and staffing such as a telepresenter to facilitate the visit and troubleshoot any technical difficulties during the telemedicine encounter. In addition to financial investment, SBTM programs require coordination with schools to ensure that there is no interference with the school's primary objective of educating children. Thus, it is imperative that SBTM activities be coordinated with the school's schedule and major activities such as standardized testing and student holidays.

REVIEW OF SBTM ASTHMA PROGRAMS

SBTM programs designed for pediatric asthma management are limited, and only a few trials have been conducted to examine the effectiveness of SBTM for asthma management (Table I). Overall, findings of available literature supports telemedicine as a feasible method to connect children with primary care and specialists in the school setting; however, findings suggestive of improved asthma outcomes were variable.

Rural schools

Perry et al⁵¹ conducted a cluster randomized trial comparing a telemedicine asthma education intervention to usual care (UC). The trial included 393 children aged 7 to 14 years with provider-diagnosed asthma in the Arkansas Delta, a rural and impoverished region of the state. The intervention included 5 age-appropriate asthma education sessions conducted via telemedicine, and recommendations for asthma treatment and management were sent to the child's PCP from an asthma specialist. Recommendations were based on National Asthma Education and Prevention Program guidelines⁶⁰ in response to caregiver- and child-reported symptoms, medication use, and lung function testing. In addition, asthma education was delivered via telemedicine to the caregivers of enrolled participants (2 sessions) and school nurses (1 session) at participating intervention schools. All telemedicine sessions were conducted via live, interactive video and followed a standardized format. The sessions were completed over a 5- to 9-week period with an asthma specialist, a respiratory therapist, and a trained asthma educator. Eighty-eight percent of children and 61% of caregivers completed the education sessions. The primary outcome was change in the number of symptom-free days (SFDs) compared with baseline. Secondary outcomes included Children's Health Survey for Asthma score, QOL, asthma knowledge, medication use, self-efficacy, and prescription refills for preventive and rescue asthma medications. Investigators found no significant difference in SFDs for the intervention group or the UC group. Intervention participants had some evidence of behavior change including higher use of peak flow meters to monitor asthma and reported medication use but there were no other significant differences in secondary outcomes between groups. Investigators concluded that the education intervention was inadequate to overcome the significant morbidity experienced by participants and that an intervention encouraging better engagement with caregivers and PCPs may be more effective.

Romano et al⁶¹ conducted a longitudinal assessment of 17 rural children aged 5 to 18 years with persistent asthma who received specialty follow-up care via telemedicine at weeks 4, 12,

TABLE I. Use of telemedicine in school-based asthma programs

Author, year	N	Rural or urban	Study population	Intervention	Main outcomes	Limitations
Halterman et al, ⁴⁷ 2018	400	Urban	3-10-y-olds with physician-diagnosed persistent asthma; enrolled in Rochester City School District, Rochester, New York; 57.5% blacks	Randomized controlled trial with participants stratified by preventive medication use at baseline. DOT of preventive asthma medications plus 3 telemedicine assessments with PCP for asthma management and follow-up care	Primary outcome: Increase in the mean number of SFDs among intervention participants compared with enhanced UC Secondary outcomes: Reduced activity limits, reduced airway inflammation, and fewer ED visits and hospitalizations. Intervention participants were more likely to be prescribed a preventive medication	Feasibility of supervised DOT by school nurses may not be generalizable to smaller or resource-limited schools 18% of the intervention group did not receive DOT
Perry et al, ⁵¹ 2018	393	Rural	7-14-y-olds with physician-diagnosed asthma; enrolled in public schools in the rural Delta region of Arkansas; 81% blacks	Clustered randomized trial with child, caregiver, and school nurse education delivered via telemedicine by asthma specialist, respiratory therapist, and asthma educator. PCP notified of asthma assessment and provided with treatment recommendations based on caregiver- and child-reported asthma symptoms, medication use, and health care use	Primary outcome: No change in SFDs among intervention participants compared with UC Secondary outcomes: Improved peak flow monitoring and reported medication use. No changes in QOL, self-efficiency, asthma knowledge, or lung functioning	The comparison group had modest improvement in SFDs, suggesting possible bias through study participation Specialist provided treatment recommendations to PCP but compliance with recommendations was not required to participate in the intervention Low participation rate, with 61% of caregivers attending all sessions and 27% failing to complete any sessions
Bergman et al, ⁶² 2008	83	Urban	5-12-y-olds with reported asthma diagnosis or positive ISAAC; enrolled in 3 inner-city elementary schools in San Francisco, California; 71% blacks	Single-arm, prospective trial with 4 telemedicine visits with an asthma specialist (weeks 0, 8, 16, and 32). PCP notified of asthma assessment and provided with treatment recommendations from the specialist. In-person asthma education at week 16 using the Open Airways for Schools curriculum	Outcomes: Significant improvement in the physical and social domains of the CHSA, child knowledge, and parent knowledge. No spirometry or health care use. Reported parent satisfaction was high	Specialist provided treatment recommendations to PCP but compliance with recommendations was not required to participate in the intervention. Small sample size No comparison group

(continued)

TABLE I. (Continued)

Author, year	Rural or urban	Study population	Intervention	Main outcomes	Limitations
Romano et al. ⁶¹ 2001	17 Rural	5-18-y-olds with persistent asthma enrolled in Hart Independent School District, Hart, Texas; 71% Hispanic	Single-arm, prospective trial with an initial in-person visit followed by telemedicine follow-up care with an asthma specialist at 4, 12, and 24 wk. Participants received in-person asthma education, vinyl mattress and pillow covers, and spacer devices as a part of the intervention	Outcomes: Significant improvement in SFD at 24 wk compared with baseline. Improved symptom scores, spirometry, and QOL were reported	Intervention included extensive in-person education and tools to assist with home allergen reduction and medication delivery (spacers); thus, impact of telemedicine aspects of the intervention is difficult to determine
					Small sample size
					No comparison group
Lowe et al. ⁶⁴ 2016	234 Urban	Elementary age children with asthma; enrolled in Tucson Unified School District, Tucson, Arizona; predominantly Hispanic	Prospective randomized trial evaluating the effectiveness of DOT. Telemedicine was not considered part of the primary intervention but was used to conduct assessment of some enrolled participants throughout the DOT intervention	Outcomes: Clinician and staff report that telemedicine system was easy to use and that they felt confident in their ability to make a diagnosis. The average clinic visit time was 12.9 min, and clinicians did not feel that the visit was longer than an in-person visit. Inadequate internet connectivity was reported at some schools	Telemedicine was not used as an intervention tool but was used to complete asthma assessments in the context of a primary DOT intervention
					Unclear how many visits were completed via telemedicine vs in-person

CHSA, Children's Health Survey for Asthma; ISAAC, International Survey of Allergy and Asthma in Children.

and 24 after an initial in-person visit at a rural school-based health clinic. Patient outcomes included SFDs (primary), spirometry, and caregiver and patient QOL. At the initial in-person visit, all participants received prescriptions for preventive asthma medications, asthma and allergy trigger reduction education, vinyl mattress and pillow covers as well as spacer devices if they were prescribed a meter-dose inhaler. Follow-up telemedicine visits were conducted to reassess the asthma, and outcomes were measured at week 24. Investigators found an 83% improvement in SFD per week (2.35 days vs 4.31 days) at week 24 compared with baseline. A significant reduction in mean symptoms scores and improvements in spirometry and QOL were reported. The in-person intervention components were quite extensive, so it is difficult to determine the treatment effects related to telemedicine versus the other intervention components. The small sample size and lack of a comparison group were additional limitations.

Urban schools

In the School-Based Telemedicine Enhanced Asthma Management (SB-TEAM) trial, Halterman et al.⁴⁷ randomized 400 urban children aged 3 to 10 years with poorly controlled or persistent asthma to receive DOT with preventive medications at school and telemedicine visits for asthma management. SB-TEAM trial's intervention included 3 SBTM visits and used

a combination of synchronous and asynchronous telemedicine visits. All 3 virtual visits were conducted with the aid of a telepresenter who either assisted with the completion of a live telemedicine visit with the PCP (synchronous) or recorded a standardized asthma assessment including a physical examination that was later (within 3 days) viewed by the PCP (asynchronous). During the first telemedicine visit, participants had an initial asthma assessment and the preventive medication dose to be given as DOT was determined by the PCP. Two subsequent follow-up telemedicine visits were conducted for medication management. Students were enrolled in SB-TEAM for 1 school year, and the primary outcome measure was the number of SFDs compared between the intervention group and an enhanced UC group. Secondary outcomes included day and nocturnal symptoms, school absence, airway inflammation, rescue medication use, and health care utilization. SB-TEAM intervention participants had significantly fewer SFDs, with a difference of 0.85 SFD per 2 weeks compared with enhanced UC. Intervention participants also had less activity limits, reduced airway inflammation, and fewer ED and hospitalizations. Notably, children in the intervention group were more likely to be prescribed a preventive asthma medication (odds ratio, 8.67). This increase was likely due to the intervention's design that connected the participants with his or her PCP and allowed for longitudinal assessment and medication

management through the use of telemedicine. One study limitation included the fact that 18% of intervention participants did not receive DOT. Also, the comparison group had a modest improvement in SFD, thus suggesting bias related to study participation.

A study by Bergman et al⁶² examined the effectiveness of telemedicine consultation with an asthma specialist among urban children aged 5 to 12 years with an asthma diagnosis or positive International Survey of Allergy and Asthma in Children. This single-arm, prospective intervention included 83 children who participated in 4 telemedicine encounters with an asthma specialist at baseline (week 0), and weeks 8, 16, and 32. The asthma specialist assessed each participant via live, interactive video. The baseline visit, facilitated by a telepresenter, included an interview between the specialist and patient/family as well as a physical examination. At the conclusion of the baseline visit, an asthma action plan and treatment recommendations were sent to each participant's PCP. Follow-up visits included reassessment for any needed changes in the treatment at 8 weeks, in-person asthma education using the American Lung Association's Open Airways for Schools curriculum at 16 weeks, and a final visit for data collection at 32 weeks. The outcomes of the study included the Children's Health Survey for Asthma, child and parent knowledge, spirometry, visit length, and parental satisfaction. At the end of the intervention, investigators found a significant improvement in the physical and social domains of the Children's Health Survey for Asthma, child knowledge, and parent knowledge. There were no other significant changes in asthma outcomes including spirometry or health care use. Parental satisfaction with the program was high, and specialists were able to assess 3.5 patients/h via telemedicine. Investigators concluded that only making medication recommendations to PCPs without effective partnerships between the PCP and specialists likely impacted the effectiveness of the program. This study also lacked a comparison group, so interpreting the significant changes from baseline may be attributed to factors other than the intervention itself.

In Tucson, Arizona, investigators used telemedicine in the Supervised Asthma Medicines in Schools study to facilitate clinical evaluations of participants. Details regarding the frequency of telemedicine visits versus in-person visits were not included in the primary study findings; however, the Supervised Asthma Medicines in Schools intervention included DOT of daily preventive asthma medication in children aged 6 to 10 years enrolled in Tucson Unified School District.⁶³ For the main study outcomes, investigators did not find differences in asthma control among students receiving DOT compared with UC. In a separate report, investigators described outcomes of accuracy, efficiency, and satisfaction with the telemedicine encounters of 234 children evaluated by 5 clinicians during the DOT intervention period.⁶⁴ On a 6-point Likert scale (range 1 = strongly disagree to 6 = strongly agree), findings suggested an overall satisfaction with the telemedicine visits. Clinicians and staff reported that the system was easy to use (4.69 ± 1.06 and 4.71 ± 1.37 , respectively). The average visit time for a telemedicine encounter was 12.9 minutes (range, 5.7-25 minutes). Clinicians reported feeling confident in their ability to make a diagnosis via telemedicine, with a score of 4.81 ± 0.69 , but they were less confident about the impact of telemedicine on patient rapport, 3.78 ± 1.04 . Inadequate connectivity was also reported at some schools during this study.

CONCLUSIONS AND FUTURE DIRECTIONS

The currently available literature reveals a wide range of variability in study design and outcomes measured. Although the reported studies all included children with asthma, the severity classification and level of control at enrollment varied. Furthermore, only 2 large-scale randomized controlled trials using telemedicine for asthma management have been reported.^{47,51} The urban study reported by Halterman et al⁴⁷ included DOT plus telemedicine visits with the child's PCP and showed improvements in SFDs; however, the rural asthma education telemedicine trial reported by Perry et al⁵¹ did not show improvement in SFDs. Differences in study design and lack of engagement with PCPs likely significantly impacted the negative findings in the rural study. Some weaknesses of the other trials include small sample size of participants and lack of inclusion of a comparison group; therefore, the overall impact of these interventions on asthma outcomes is difficult to determine. Thus, larger scale interventions will better assess the benefits of telemedicine for asthma management in children. One weakness cited in 2 of the studies with negative outcomes included lack of PCP engagement in the intervention. To maximize the impact of future SBTM programs, there should be collaboration between the PCP and the specialist. Engagement with the PCP will not only ensure continuity of care but also maximize effectiveness of the program. In the report assessing telemedicine efficiency and satisfaction,⁶⁴ the necessity for adequate internet connection was highlighted as an important factor for provider satisfaction with the SBTM program.

Second only to their homes, children spend most of their wakeful hours at school; therefore, opportunities exist to use telemedicine in school-based settings to aid in pediatric asthma management. Additional research, particularly randomized controlled trials, is needed. In addition to trials taking place in both rural and urban settings, trials conducted through collaborative networks such as Supporting Pediatric Research on Outcomes and Utilization of Telehealth^{46,65} will be important in establishing best practices for implementation of telehealth in various health care settings, including schools. Currently available literature suggests telemedicine as a feasible way to increase access to primary and specialty asthma care. Telemedicine providers will need to understand the available resources in their respective school systems, comply with state regulations and school policies, and be attentive to the need for collaboration between school personnel, specialists, and PCPs. Similar to other successful asthma interventions, SBTM asthma programs will need to provide coordinated care for the child with asthma to deliver a successful program.

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