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Telemedicine is as effective as in-person visits for patients with asthma

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ABSTRACT

Background: Access to asthma specialists is a problem, particularly in rural areas, thus presenting an opportunity for management using telemedicine.

Objective: To compare asthma outcomes during 6 months in children managed by telemedicine vs in-person visits.

Methods: Children with asthma residing in 2 remote locations were offered the choice of an in-person visit or a telemedicine session at a local clinic. The telemedicine process involved real-time use of a Remote Presence Solution (RPS) equipped with a digital stethoscope, otoscope, and high-resolution camera. A telefacilitator operated the RPS and performed diagnostic and educational procedures, such as spirometry and asthma education. Children in both groups were assessed initially, after 30 days, and at 6 months. Asthma outcome measures included asthma control using validated tools (Asthma Control Test, Childhood Asthma Control Test, and Test for Respiratory and Asthma Control in Kids) and patient satisfaction (telemedicine group only). Noninferiority analysis of asthma control was performed using the minimally important difference of an adjusted asthma control test that combined the 3 age groups.

Results: Of 169 children, 100 were seen in-person and 69 via telemedicine. A total of 34 in-person and 40 telemedicine patients completed all 3 visits. All had a small, although statistically insignificant, improvement in asthma control over time. Telemedicine was noninferior to in-person visits. Most of the telemedicine group subjects were satisfied with their experience.

Conclusion: Children with asthma seen by telemedicine or in-person visits can achieve comparable degrees of asthma control. Telemedicine can be a viable alternative to traditional in-person physician-based care for the treatment and management of asthma.

Introduction

Effective management of asthma requires ongoing monitoring by patients and health care professionals using a collaborative team approach. There is evidence that patients have better outcomes if there is involvement of medical professionals who specialize in managing asthma.[1] Unfortunately, patients with the greatest need for asthma specialists often live in underserved areas, such as rural or inner-city communities, where asthma specialists are not always available. This disparity in access to care presents an opportunity for remote asthma management using telemedicine.

Telemedicine is the use of computer-based technologies to manage a patient's health by exchanging medical information over a distance. When audio and video conferencing are paired with digital examination instruments, telemedicine can be used to facilitate health care encounters between patients and health care professionals regardless of distance. It was first used by Romano in 2001 in which follow-up specialty care was provided to 17 patients with persistent asthma. The investigators found reduced symptoms and improved quality of life. The usefulness of this report was diminished by the fact that it was an open, uncontrolled study.[2] In another uncontrolled study, Malone et al[3] described ongoing management of 7 children with asthma from Guam and Yakota, Japan, using digital equipment including spirometry.

Unfortunately, controlled studies of asthma outcomes using video conferencing and digital examination equipment have not been performed, which creates discomfort when deciding to offer this type of care to patients. Our hypothesis for this study is that patients seen by telemedicine using real-time video conferencing and digital examination equipment in place of in-person visits will have outcomes that are not inferior to a standard office treatment. To test this hypothesis, patients with asthma were recruited to be seen in-person or by telemedicine and the 2 groups were followed up for 6 months.

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Methods

Identification of Patients

The current study evaluated asthma outcomes between 2 groups of patients: a telemedicine group and an in-person group. After receiving approval from the Children's Mercy Hospital pediatric institutional review board, patients who scheduled an appointment to be seen for asthma in the Children's Mercy Hospital allergy clinic were identified if they resided near St Joseph, MO, or Wichita, KS. St Joseph is approximately 70 miles north and Wichita is 150 miles southwest of the Children's Mercy Hospital campus, where the telemedicine professional was located and where in-person clinic visits were completed. In addition to location, patients were selected if they had a previous diagnosis of asthma or if the reason for their visit included asthma. The diagnosis of asthma was confirmed at the visit if the patient met criteria for asthma included in the 2007 National Heart, Lung, and Blood Institute guidelines.[4]

Patients identified as potential participants were contacted by telephone and, after giving informed consent to participate in the study, were offered a choice of keeping their original appointment for an in-person visit or of changing it to a telemedicine visit. The in-person visit required that they drive to Kansas City as originally planned, whereas the telemedicine option involved a visit to a local clinic, where they would be seen by a telemedicine professional. This was a voluntary self-selected allocation, so there was no randomization or enforced allocation of patients to the study groups.

Telemedicine Process

The Telemedicine process involved the use of an InTouch Lite Remote Presence Solution (RPS) (InTouch Health, Goleta, California) at the patient end and a Dell Laptop running InTouch CS, version 20.31, software at the health care professional end. The system permits the health care professional to see and hear a patient in real-time and to pan and zoom a wide-angle camera located on the front of the RPS so that the patient can be tracked. The software also permits the health care professional to activate a digital stethoscope located on the RPS for listening to heart and lung sounds and to activate an s-video feed connected to a digital otoscope for examining a patient's ears and nose or a high-resolution camera that can be used to examine the throat and skin (Fig 1). In addition, pictures of the patient can be taken by the health care professional using any of the associated cameras.

At the access site, the RPS permits a patient to see and hear the health care professional in real-time and to see the images from the ancillary examination cameras. This particular RPS does not have arms and does not move around the facility independently.

The telemedicine sessions required a telefacilitator (either a registered nurse or respiratory therapist) at the access site to operate the RPS. This health care professional was also responsible for performing any procedures that were needed, such as spirometry, teaching inhaler techniques, and venipuncture if needed. Allergy testing was performed using in vitro testing. Patient instructions and educational materials were present in the remote clinic or the health care professional could print them at a printer in the remote clinic. Medication reconciliation and patient instructions were printed to the access site using an electronic medical record (Cerner, Kansas City, Missouri). Prescriptions were electronically sent to the patient's pharmacy using the same electronic medical record.

Outcome Measurements

Patients in both groups who enrolled in the study were seen 3 times: at the first visit, at 30 days, and at 6 months after the initial visit. Asthma control was measured at each visit using the Asthma Control Test (ACT) for patients 12 years and older, the Childhood Asthma Control Test (C-ACT) for patients aged 4 to 11 years, and the Test for Respiratory and Asthma Control in Kids (TRACK) for patients younger than 4 years. Differences in asthma control were evaluated for each age group using 1-way and 2-way repeated-measures analysis of variance.

Because the number of patients taking each of these tests was 10, 29, and 33, respectively, we combined the scores of ACT, C-ACT, and TRACK to increase statistical power. Because the ACT is measured on a 25-point scale, the C-ACT on a 27-point scale, and the TRACK on a 100-point scale, we used an adjusted asthma score (AAS), created by dividing the TRACK score by 4 to make statistical comparisons of treatment outcomes possible across all age groups. Because the ACT and C-ACT scales are nearly identical, we did not

Figure 1. Health care professional interface for telemedicine showing examinations of the oral cavity, examination of the tympanic membrane, and auscultation of a patient with a digital stethoscope.

modify them. Although this may not be a perfectly accurate transformation, this combination of 3 different tests scores was sufficiently accurate to make meaningful assessments and calculations of statistics across all 3 age groups. In addition, it did not alter comparisons within each age group.

Patient satisfaction was measured for the telemedicine group after the initial visit. Because the questions were specific to the telemedicine experience, telemedicine satisfaction was not measured in the control patients.

Statistical Analysis

Three statistical methods were used to investigate the equivalence of treatments. First, using parametric and nonparametric tests, we determined whether the differences in control and telemedicine patients' ages, AASs, and changes over time were statistically significantly different. Second, we determined whether the changes in AASs of the telemedicine treatment were statistically noninferior or equivalent to the office visits scores. Third, we reported results of multivariate analysis of asthma scores as a function of treatment, age, sex, and visit number. This analysis used 2-way analysis of variance with repeated measures to explore the potential influences of covariates and factors and the noninferiority and equivalence of the treatments.

Noninferiority Analysis

The goal of our study is to find evidence that the new treatment (telemedicine delivery) is equivalent or at least noninferior to that of the well-established treatment (ie, office visits).[5,6] Although demonstrating statistically that 2 treatments are equal in terms of their outcomes is impossible, this helps to determine equivalence between the 2 treatments with a specific degree of certainty.

The determination of equivalence margins is a critical step in noninferiority and equivalence testing. An inappropriately low absolute value makes it inappropriately more difficult to confirm noninferiority and equivalence. To determine whether there is equivalence, a validated, clinically relevant measure for the minimally important difference (MID) was needed. For this study, we used the ACT, C-ACT, and TRACK, respectively, for children at different ages. In this case, we used an MID of 3, which is slightly higher than the MID for the rescaled TRACK (MID, $11/4 = 2.75$)[7] and the C-ACT (MID, 2.0)[8] but equal to the ACT (MID, 3).[9] We inferred equivalence of the telemedicine treatment if the 95% confidence interval (CI) was within the bounds of −3 to 3.

For the current study, the mean adjusted scores for the initial visit were compared for the 2 treatment groups (Table 1). Next, the differences between the initial visit and 30 days or 6 months were determined for each group. The difference between those 2 scores (telemedicine minus in-person) was next determined along with a 95% CI for that difference. The question we explored was whether there was a difference between the 2 values. If the 95% CI did not include the MID, then the probability that the 2 outcomes were nonequivalent was less than 5%; therefore, we concluded that the 2 are equivalent.

Results

A total of 194 patients were approached for participation in the study (Table 2). Of these, 25 declined to participate. There was a tendency for patients from St Joseph, which is 70 miles away, to decline more often than patients from Wichita, which is 180 miles away, although this finding was not statistically significant (19.6% vs 10.1%, $\chi^2 = 33.2$, $P = .07$). A total of 100 patients who agreed to participate decided to keep their in-person visit, whereas 69 decided to be seen by telemedicine.

Table 3 gives the characteristics of patients in each group. The largest group consisted of children 4 to 11 years old. Surprisingly, there was no tendency for patients who lived in Wichita (180 miles) to prefer telemedicine over those from St. Joseph (70 miles). There were twice as many boys as girls in the study, which is similar to the overall prevalence of asthma by sex in this age group. Although there were 100 control and 69 telemedicine patients enrolled in the study, only 44 controls (44%) and 62 telemedicine patients (90%) made it to the first visit, completed an ACT, and filled out a satisfaction survey. Some patients did show up to the first visit but decided to not complete the surveys after they were seen. There were more dropouts in the control group, which was the group that had to travel to get to their appointment. Of the patients who did show up for an initial visit, most made it to the second and third visits. A total of 35 control and 40 telemedicine patients completed all 3 visits.

Asthma control as measured by the ACT, C-ACT or TRACK is given in Table 1. As shown, there were significant differences between the 6-month and first-visit AASs for all the control and 1 of telemedicine age groups. However, despite nonsignificance of differences, patients in all 3 age groups had improvements in their scores over time. However, when all patients are combined into single age groups (Table 4), these improvements were statistically significant

Table 1
Asthma Control for Control and Telemedicine Groups by Age Group at 3 Different Visits[a]

Visit	Treatment group		*P* value
	Control group	Telemedicine group	
TRACK (<4 years) (n = 14 and 19 in control and telemedicine groups, respectively)			
First visit	52.5 (23.4)	52.3 (26.5)	.90
30-Day visit	65.6 (19.9)	60.3 (22.4)	
6-Month visit	73.2 (17.9)[b]	66.6 (26.8)[b]	
C-ACT (4–11 years) (n = 16 and 15 in the control and telemedicine groups, respectively)			
First visit	17.4 (3.9)	16.7 (7.1)	.98
30-Day visit	20.1 (4.0)	20.6 (2.8)	
6-Month visit	20.1 (4.2)[b]	19.0 (4.7)[c]	
ACT (≥12 years) (n = 4 and 6 in the control and telemedicine groups, respectively)			
First visit	17.5 (7.7)	18.9 (4.7)	.98
30-Day visit	18.3 (5.0)	19.5 (4.1)	
6-Month visit	21.5 (5.7)[b]	19.7 (5.0)[c]	

Abbreviations: ACT, Asthma Control Test; C-ACT, Childhood Asthma Control Test; TRACK, Test for Respiratory and Asthma Control in Kids.
[a]Data are expressed as mean (SD) of the measurement. Only patients who completed all 3 visits are included.
[b]Differences between 6-month visit and first visit are statistically significant ($P < .05$).
[c]Differences between 6-month visit and first visit are not statistically significant ($P > .05$).

Table 2
Age Groups and Location of Patients Who Were Invited to Participate in the Study

Age group, y	Control group	Telemedicine group	Declined	Total
0–3				
St Joseph	6	2	2	10
Wichita	21	21	2	44
4–11				
St Joseph	16	13	4	33
Wichita	43	21	11	75
>12				
St Joseph	3	5	5	13
Wichita	11	7	1	19
Total	100	69	25	194

Table 3
Age Groups, Location, and Sex of Patients Who Participated in the Study

Characteristic	Control (n = 100)	Telemedicine (n = 69)	*P* value
Age group			
0–3	27	23	.46
4–11	59	34	
>12	14	12	
Location			
St Joseph	25	20	.56
Wichita	75	49	
Sex			
Male	71	38	.03
Female	29	31	

Table 4
Mean (95% CI) AASs for the Control and Telemedicine Patients

Time	Control group	Telemedicine group	Difference (telemedicine − control)	*P* value
Initial	15.9 (14.3–17.5)	16.1 (14.6–18.8)	0.2	.35
30 Days	18.1 (16.2–20.0)	17.4 (15.8–19.0)	0.7	.60
6 Months	19.6[a] (18.2–21.0)	18.5[a] (16.9–20.2)	1.1	.33

Abbreviations: AAS, adjusted asthma score; CI, confidence interval.
[a]Compared with the initial AAS, the 6-month AAS is statistically significantly higher ($P < .006$) for both groups.

($P < .006$) for the control and telemedicine groups from the first visit to the 6-month visit.

Adjusted Asthma Scores

Table 4 gives the mean adjusted ACT scores and 95% CIs for the controls and telemedicine patients. The *P* values used independent-samples *t* tests on the differences between the controls and telemedicine patients across all 3 visits. Because our hypothesis is that there would be no difference between the 2 groups at each of these visits, the nonsignificant *P* values were consistent with that hypothesis.

Table 5 gives the noninferiority and equivalence analysis for differences in patient AASs. Patients were included in this analysis only if they completed 2 or more visits. We were looking at the mean of the differences between the first and 30-day or 6-month visit. Equivalence was inferred if the 95% CIs were within the equivalence margin range of −3 to 3, which was our a priori MID. Noninferiority was inferred if the lower limit was within but the upper limit was outside the equivalence range because that could still indicate superiority.

The difference between the telemedicine and control groups after 30 days was −0.20. Because the CI was within the −3 to 3 range, we can conclude that the difference was less than the MID with 95% confidence and therefore that the 3 groups had equivalent AASs. Similarly, for 6 months, the difference of −0.78 CI fell within the target range; therefore, we conclude that the 3 groups resulted in equivalent AASs.

Satisfaction

Patients who were seen by telemedicine professionals were asked to fill out a satisfaction survey that asked questions about their experience (Table 6). Most patients strongly agreed that it was easy to see and hear the health care professional and that they could understand the instructions. They also had a sense that the health care professional cared and that they could ask questions. For the most part, the distance traveled by the telemedicine patients was short; however, several patients still had to travel a longer distance to get to the telemedicine clinic even though it was less than it would have been had they gone to Kansas City. Finally, most agreed that they would recommend telemedicine, although there were a few who were uncertain of this.

Discussion

Telemedicine has been used to provide health care professionals to treat a variety of conditions for almost a decade now.[10] In a randomized clinical trial, an automated interactive voice response system with specialist nurse support reduced health care utilization, improved quality of life, and reduced costs per patient in 121 children with asthma.[11] Another randomized clinical trial estimated the effectiveness of an Internet-based system to monitor peak flows and symptoms in 164 children with persistent asthma. The intervention group experienced a variety of improvements, including decreased nighttime and daytime symptoms, improved morning and night peak flows, increased adherence rates, improved knowledge regarding self-management, and improved quality of life when compared with a control group.[12]

Bergman et al[13] described the use of real-time video and audio conferencing between 83 students with an on-site nurse at a school and an asthma specialist who was at San Francisco General Hospital. The investigators demonstrated improved student and parent asthma knowledge and a trend toward reduced asthma episodes, although other parameters did not change. In this study, health care professionals were able to see 3.5 children per hour by telemedicine vs 2 per hour in their clinic.

In a meta-analysis of telemedicine for treatment of asthma,[14] telemedicine was found to result in better outcomes than conventional in 8 controlled and 3 uncontrolled trials. The problem with these studies is that they did not involve use of telemedicine as a vehicle for delivering patient care by facilitating real-time interaction among patients and health care professionals. The 4 Internet studies compared remote monitoring and interactive surveys with conventional visits, 3 used text messaging with short message service, and 5 used telephone counseling. This leaves open the question of whether encounters between patients and health care professionals, when done by video conferencing, provide outcomes that are as good as conventional in-person visits with a health care professional.

In the current study, telemedicine was used to facilitate care as a replacement for in-person visits to see new patients with asthma. This is very different than the studies described above. Although

Table 5
Noninferiority and Nonequivalence Analysis for Differences in Patient AASs[a]

Treatment	No. in the control group	No. in the telemedicine group	Difference (telemedicine − control) (95% CI)	Noninferior	Equivalence
AAS difference (30 day − initial)	71	84	−0.20 (−1.98 to 0.90)	Yes	Yes
AAS difference (6 month − initial)	34	38	−0.78 (−2.94 to 1.08)	Yes	Yes

Abbreviations: AAS, adjusted asthma score; CI, confidence intervals.
[a]Patients were included in this analysis only if they completed both or all 3 visits. Equivalence is inferred if the 95% CIs are within the equivalence margin range of 3. Noninferiority is inferred if the lower limit of the 95% CI is within that equivalence range.

Table 6
Satisfaction Survey of Patients Who Were Seen by Telemedicine Specialists

Variable	Strongly agree	Mostly agree	Neutral or no opinion	Mostly disagree	Strongly disagree	Total
The room was comfortable for my visit with the health care professional.	50	7	2			59
It was easy to see the health care professional throughout our conversation.	55	3				58
It was easy to hear the health care professional throughout our conversation.	52	7				59
The health care professional was looking directly at me when it was appropriate.	56	2				58
It was easy to understand the health care professional's instructions.	55	3	1			59
I had all the materials needed to manage my child's health care.	54	4				58
I understand the health care professional's recommendations I received today.	55	3	1			59
My health care professional really seemed to care about my child and me.	53	5	1			59
I was provided an opportunity to ask questions.	56	3				59
It was important that my child have today's evaluation.	50	4	1			55
The distance I had to travel to see the health care professional was acceptable.	53	4		1		58
The appointment using telemedicine was as good as an appointment in person.	47	7	4			58
Not having to travel to Kansas City for this appointment is important to me.	46	8	3		1	58
After my experience today, I would recommend health care appointments by telemedicine.	51	4	3			58
Mean count	52.4	4.6	2.0	1.0	1.0	

admittedly there are deficiencies in the current study design (small numbers of patients, large number of dropouts, and open allocation to treatment groups), it demonstrates that telemedicine can be used to deliver care to children with asthma that is as effective as in-person visits (at least based on measurements of ACT) while maintaining high levels of satisfaction in the patients who participated.

It is interesting that adherence with the study was greater in the telemedicine group than in the in-person group, although the reason for this, including the increased convenience of not having to travel, is not clear. Because we are trying to show that telemedicine is as good as or at least not inferior to in-person visits, improved adherence seems to further that aim.

There are many factors that could potentially affect the ACT, such as the comorbidities of variations in pollen count and seasonality of viral respiratory infections. The fact that both groups behaved similarly suggests that similar factors were acting on them and affecting their asthma control status. That is why we used MID as a more pertinent and accurate measure of the effect of the intervention rather than the absolute ACT score itself. The fact that the AASs did not differ by more than the MID leads us to conclude that patients are not sacrificing asthma control by participating in telemedicine. The advantages of telemedicine therefore are obtained without a compromise in asthma outcomes.

According to the Centers for Disease Control and Prevention's most recent report in May 2011, 1 in 12 people has a diagnosis of asthma and that ratio is the result of several decades of increasing asthma and allergy rates, with the most significant being a 28% increase between 2001 and 2011.[15] Compounding the effects of the increase in patients with asthma is the decrease in the number of practicing allergists/immunologists. The American College of Asthma, Allergy, and Immunology estimates a 7% decrease in the number of these specialists from 2006 to 2020.[16] Knowing that effective management of asthma requires ongoing monitoring by patients and health care professionals and that outcomes are improved if specialists are involved, the aforementioned statistics make a formidable situation desperate.[1] Alternative health care delivery methods and models that foster these relationships while increasing efficiency are overdue.

Telemedicine, with its ability to completely remove distance and travel as barriers for both patients and health care professionals is one option. The industry argues that telemedicine greatly increases the coverage that specialists can provide. As noted, however, the research on quality and clinical outcomes using remote presence to treat patients with asthma is lacking. This study is one of the first of its kind to use *synchronous telemedicine* as a viable alternative to traditional in-person health care professional–based care for the treatment and management of one of the most prevalent chronic health care conditions.

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