ORIGINAL RESEARCH

Impact of digital parental education tools versus traditional methods in enhancing asthma management among parents of asthmatic children of age 5-14 years: A randomized controlled trial

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ABSTACT

Background: Asthma is one of the most prevalent chronic conditions among children, on quality of life and the burden on healthcare. Effective management of pediatric asthma depends greatly on parents understanding and adhering to the care plan. Unfortunately, traditional educational measures, i.e., handouts and verbal guidance, seldom engage parents adequately. Digital educational tools prove to be interactive and flexible to some extent, yet their effectiveness in improved pediatric asthma care has yet to be evaluated wholly. **Objectives:** To assess the role of a digital parent education tool on parental knowledge, confidence, and engagement in managing pediatric asthma as compared to traditional handouts. **Methods:** Randomized controlled trials were conducted in a pediatric asthma clinic associated with a tertiary medical college involving approximately 160 parents of children aged 5-14 years with physician-diagnosed asthma. Upon randomization, two groups were created: The control group received printed educational materials, while the intervention group received access to the digital education tools. Outcomes were measured over six months, including parental knowledge (20-item questionnaire), confidence in asthma management (Likert scale), frequency of clinic visits for asthma exacerbations, and medication compliance (captured via parent-reported logs). **Results:** The mean increase in scores on asthma knowledge was found to be statistically significant in the intervention group (22%) as compared with the control group (8%), with a p value of less than 0.001. A significant increase in confidence in asthma management was also noted in the intervention group (mean Likert scale score: 1.5; 0.6; $p < 0.01$). Secondary outcomes showed a 31.25% decrease in the number of clinic visits for asthma exacerbations (1.1 vs. 1.6; $p < 0.05$) and an 85% adherence to prescribed medication in the intervention group compared with 68% in the control group ($p < 0.05$). **Conclusion:** The digital parental education tool significantly improved parental knowledge, engagement, and adherence to the management of pediatric asthma. The findings emphasize the potential of digital interventions as efficient and scalable alternatives to conventional educational methods in pediatric chronic illness management. Further studies are warranted to explore their long-term impact and broader applicability.

INTRODUCTION

Asthma remains one of the most common chronic conditions affecting children and is quite burdensome from both the perspective of its health and economic impact. Worldwide, approximately 14% of children are affected with pediatric asthma, and in low- and middle-income countries, it is estimated to be even more so due to underdiagnosis and minimal access to treatment (1). Among the 18-year-old and younger set, the prevalence of asthma within the United States is estimated at 9.3%. This translates into about 14 million lost school days and inordinately burdensome for caregivers(2).While many effective management strategies exist, their success decisively hinges on the active engagement of children and caregivers alike. Hence, parental education and empowerment assume an essential role in the improvement of asthma control and outcomes(3).

Educational interventions geared toward asthma management have been shown to potentially improve knowledge of the disease, adherence to treatment plans, and overall health outcomes. Printed materials and verbal instructions have been commonplace for many years. The limitations of these strategies become apparent, especially among populations with limited health literacy, who often find that the reading level of educational materials exceeds the fifth grade (4). Studies have shown that poor parental health literacy is associated with uncontrolled asthma, greater rates of visits to the emergency room, and higher hospitalization rates among children who have asthma(1, 5). A myriad of opportunities that digital health technologies offer will help improve upon these shortcomings. These interactive digital solutions enable personalized, enjoyable, and convenient education targeted to patients that might improve engagement and retention. An investigation into web-based programs such as “My Child’s Asthma” offers great potentials to encourage better asthma management behaviors. Meischke et al. (2012) observed greater compliance to controller medications and self-efficacy in managing their child’s asthma among parents participating in a structured digital program compared to those receiving standard education(6).

Parental involvement is important in securing success for these interventions. Research has shown that health motivation, technology comfort, and perceived usefulness of digital tools notably contribute to engagement levels(7). In addition, user experience and outcomes may be augmented through interactive features such as customized reminders, multimedia, and progress tracking (8). Butz et al. (2008) provided value to structured education in engaging both children and caregivers, emphasizing how interactive means enhanced knowledge, self-efficacy, and symptom control(5).

Despite the broad promises these technologies may hold, barriers such as inequitable technology access, disparities in digital literacy levels, and concerns of data privacy will have to be dismantled to support a fair implementation. Families of lesser socio-economic conditions often experience a heavier toll of asthma morbidity, wherein access to and effective use of such tools may be an impediment (9). Bridging the gap requires a concerted effort to fashion culturally sensitive and accessible interventions alongside policies toward a state of equitable access to digital resources.

The study will evaluate a digital health intervention aimed at boosting parents' knowledge, confidence, and engagement in pediatric asthma management. The research will identify innovative interactive and accessible digital methods aimed at improving asthma outcomes in diverse populations. The findings will further add to the body of evidence in favor of digital health interventions as a vital component of chronic disease management.

METHODOLOGY

What was already known?

Asthma, which is one of the world's most common chronic ailments in children, causes millions of deaths around the world. It requires a permanent self-management plan to control symptoms, keep the attacks at bay, and improve the quality of life. Educational interventions in children and parents have improved asthma knowledge and management behaviors. However, traditional formats like brochures and verbal education have limitations in engagement and retention especially in pediatric patients (10). Digital tools are increasingly explored as alternatives and found to be helpful in pediatric patients especially in the parents who continuously keep in touch with web-based learning (6) .

Gap Analysis

Table 1: Gap Analysis

Type of Gap	Description	References
Evidence Gap	Lack of data validating digital interventions in tertiary care settings.	Garbutt et al., 2012(11)
Knowledge Gap	Limited awareness of interactive education’s impact on self-management amongcaregivers.	Meischke et al., 2011(6)
Practical Knowledge	Implementation of digital tools in resource-constrained pediatric clinics	Shegog et al., 2001(8)
Conflict Gap	Conflicting evidence on the efficacy of traditional vs. digital education in asthma management	Macy et al., 2011(4)
Empirical Gap	Insufficient studies with longitudinal follow-up in digital interventions for asthma management	Butz et al., 2008(5)
Theoretical	Lack of integration of behavior change theories in intervention design	Joseph et al., 2003(7)
Methodological	Need for RCTs with rigorous randomization and blinding specific to Indian pediatric populations	Wildfire et al., 2012(12)
Population	Studies predominantly involve Western populations; limited focus on socio-cultural contexts of India	Krieger et al., 2009(9)

Why This Topic Was Chosen

This study addressed critical gaps in asthma management in pediatric populations in India. With the rising incidences of asthma and the inequities in health literacy already in place, there is a more urgent need than ever to explore culturally tailored digital solutions that could be scaled. The site of this study-a tertiary care center in Ghaziabad-facilitated rigorous evaluations of digital interventions in a real-life clinical setting, catering directly to the local pediatric population.

Research Question

PICO Analysis

Table 2: PICO Analysis

Parameter	Description
Population (P):	Parents of children aged 5-14years with diagnosed asthma attending a pediatric asthma clinic.
Intervention (I):	Digital parent education tools.
Comparison (C):	Traditional printed asthma education materials.
Outcome (O):	Improved parental knowledge, confidence, and engagement in asthma management.

FINER Analysis

Table 3: FINER Analysis

Feasibility	Availability of a digital tools and clinic infrastructure made implementation realistic.
Interest	Provided insights into technology's role in chronic disease management.
Novel	Few of the studies in India to compare digital and traditional methods in asthma education for pediatric patients.
Ethical	Non-invasive intervention with potential benefits for caregivers and children.
Relevant	Addressed a pressing public health issue in India.

AIMS AND OBJECTIVES

Primary Objective

To compare the effectiveness of a digital parent education tool with normal printed materials in given parental knowledge and confidence in treating asthma.

Secondary Objectives

To evaluate the effect of digital education on asthma clinic visits and medication adherence.
To assess parent's satisfaction with this mode of education.

Sample Size Calculation

This power calculation, based on previous studies, estimated 80 participants per group would have sufficient power (80%) to detect a 20% difference in knowledge improvement (with a significance level of 0.05)(11).

Study Design

Prospective, randomized controlled trial at a tertiary care pediatric asthma clinic in Ghaziabad.

Population and Setting

The study population includes parents of children aged 5-14 years with a physician diagnosis of asthma visiting the pediatric asthma clinic.

Inclusion Criteria

- Parents of children using controller medications.
- Parental ability to read and understand Hindi or English.

Exclusion Criteria

- Parents having prior experience with digital asthma education programs.
- Presence of other severe comorbid conditions in children.

Randomization and Blinding

- **Randomization:** Computer-generated randomization allocated participants randomly into two groups.
- **Blinding:** The information assessors stayed blinded to the group to which the participants were assigned. Participants were aware of their assigned group but not of the alternative intervention.

Intervention vs. Control Group

- **Intervention group:** Digital education for parents with interactive modules, videos, and reminders.
- **Control:** Traditional printed forms of education materials.

Outcome Measures

1. **Primary Outcomes**:
- Change in parental asthma knowledge scores (questionnaire).
- Confidence in managing asthma (Likert scale).
2. **Secondary Outcomes**:
- Frequency of clinic visits for asthma exacerbations.
- Adherence to prescribed medications (parent-reported and pharmacy refill data).

Data Collection

Baseline and follow-up data were collected at 6 months using structured interviews questionnaires (Given in appendix)

Statistical Analysis

We analyzed the data using SPSS. Paired t-tests compared pre- and post-intervention changes within groups, while ANOVA assessed between-group differences (Detailed statistical analysis, in appendix)

Ethical Considerations

The study was approved by the institutional ethics committee. Written informed consent was obtained from all participants.Declaration of Helsinki (2013) principals were followed (13).

Limitations

- Limited generalizability due to single-center design.
- Potential biases in self-reported outcomes.

RESULTS

Baseline Characteristics

A total of 160 participants were enrolled and equally randomized into the intervention group (a digital education tool) and the control group (traditional printed materials).

Appendix Table 4 summarizes baseline characteristics of all recruited participants, including the mean postnatal age of the children, levels of parental education, and prior experience of asthma management practices. There was no statistically significant difference between the two groups ($p > 0.05$), indicating that randomization had been successful.

Primary Outcomes

Parental Knowledge Improvement (Table 6 in appendices)

Parents' knowledge scores were obtained using a 20-item validated questionnaire both at the start of the trial and 6 months into follow-up. Parents in the intervention group exhibited much greater improvements in knowledge scores compared with parents in the control group (mean total increase of 22% versus 8%; $p < 0.001$). These improvements held true for each knowledge domain assessed, including knowledge of asthma triggers, ability to recognize symptoms, and proper inhaler technique.

For example, after the intervention, 89% of parents in the intervention group were able to identify common asthma triggers correctly compared to 67% in the control group; 84% of parents in the intervention group were shown to have correct inhaler techniques, compared with 58% of parents in the control group ($p < 0.01$).

Parental Confidence in Asthma Management (Table 5 in appendices)

The 5-point Likert scale measuring confidence about asthma management showed significant differences favoring the treatment group. The intervention group exhibited an increase of 1.5 points in confidence scores compared to control parents, who had a mean increase of 0.6 points ($p < 0.01$). Parents in the intervention group felt much more empowered in managing acute exacerbations and adherence to therapy.

Secondary Outcomes

Reduction in Asthma-Related Clinic Visits (Table 6 in appendices)

That is, a reduction in asthma-related clinic visits (Appendices Table 6)

With respect to frequency, the number of visits by the intervention group for asthma-related symptoms was considerably lower than for the control group. The average number of visits per participant over six months was 1.1 in the intervention group compared with 1.6 in the control group ($p < 0.05$). This points to showing the efficacy of the digitally based parental education tool to empower rural parents to manage milder cases of asthma with less need for medical care to moderate asthma symptoms at home.

Improvement in Medication Adherence (Table 6 in appendices)

Medication adherence was evaluated through parent-reported logs and pharmacy refill data and was higher in the intervention group than in the control group (85% versus 68% adherence; $p < 0.01$). This improvement was presumably due to reminders and interactive modules included in the digital tool.

Parental Satisfaction with Education Modality (table 7 in appendices)

The intervention group reported significantly higher parental satisfaction, with 94% rating the digital tool as "helpful" or "very helpful" compared with 62% for printed materials ($p < 0.01$). The interactive features of the tool, such as animated tutorials and customized alerts, were noted as highly beneficial in qualitative feedback.

Additional Findings

Subgroup Analysis (Table 8 in appendices)

Subgroup analysis described that the digital tool proved especially effective among parents with minimal prior knowledge on asthma management. In this subgroup, knowledge scores increased by 32%, in comparison to 13% in the control group ($p < 0.001$). Also, parents of lower education levels were more engaged with the digital tool, providing evidence that it could help yield mitigated disparities in health literacy.

Impact on Quality of Life (table 6 in appendices)

Although not a primary outcome, improvement in asthma-related quality of life for children was evident too. The intervention group reported significantly fewer missed school days (mean: 2.8 days) compared with the control (mean: 4.6 days; $p < 0.05$). There were also fewer disruptions of daily routines reported by parents.

DISCUSSION

Contextualizing Findings: The study could successfully demonstrate that the use of digital education tools can be more effective in improving parental knowledge and management of asthma. Compared to their printed counterparts, the digital intervention offered an attractive and suitably multimedia platform that appealed to the way parents prefer to learn. This result confirms past studies (e.g., Tieffenberg et al. 2000) that underscored the importance of interactive and autonomous learning tools in chronic disease management(14).

Knowledge and Confidence Gains: The gains in knowledge scores were remarkable: 70 against 50. This signifies that digital education is rather good at delivering information. The digital tool does provide the parents some chance to return to the difficult subject, which increases their retention. The level of confidence improved markedly more in the digital group, indicating a higher perceived self-efficacy in managing asthma. The interactive format of the digital tool probably assisted in gaining knowledge better than with static printed materials.

Clinical Impact: Less frequent visits to clinica and improved compliance to medicine were noted in the digital group. Similar findings were noted in other studies, such as Garbutt et al. (2012) that education reduced reliance on clinical services.(11).

Limitations and Challenges: Aside from the effectiveness of the digital intervention, limitations such as technology access and lack of digital literacy would be barriers to its general applicability elsewhere. Further, this study was based on a certain demographic, which will inhibit generalizability. Future studies should aim at socioeconomically and culturally diverse settings.

CONCLUSION

This RCT seeks to spell an imminent triumph in the management of asthma in children through digital educational tools. The demonstrated betterment in knowledge, confidence, and clinical outcomes gives strong backing to the technology-driven changes in caregiver education. While traditional methods still remain as valid, the digital platform brings forth a new dimension of scalability and adaptability, thus rightfully occupying the center stage in modern-day healthcare. Further studies should also seek to explore long-term impacts and how to make sure that inclusion in implementation addresses the digital access gap.

APPENDICES

APPENDIX 1: RESULT FINDING TABLES

Table 4: Baseline characteristics

Variable	Intervention Gp (n = 80)	Control Gp (n = 80)	p
Mean Child's Age (Years)	8.6 ± 2.3	8.4 ± 2.5	0.34
Gender (Male) (%)	56%	58%	0.78
Parent's Education (%)			
- High School	48%	46%	0.81
- Bachelor's Degree	35%	37%	0.89
Prior Asthma Management (%)	28%	30%	0.67

Table 5: Changes in Primary Outcomes

Outcome	Intervention Gp	Control Gp	Between-Group Difference	p
Knowledge Score Improvement (%	+22%	+8%	+14%	< 0.001
Correct Identification of Triggers (%)	89%	67%	+22%	< 0.01
Correct Inhaler Usage (%)	84%	58%	+26%	< 0.01
Confidence Improvement (Likert Scale)	+1.5	+0.6	+0.9	

Table 6: Secondary Outcomes

Outcome	Intervention Gp	Control Gp	p-value
Clinic Visits (Mean)	1.1	1.6	< 0.05

Medication Adherence (%)	85%	68%	< 0.01
Missed School Days (Mean)	2.8	4.6	< 0.05

Table 7: Parental Satisfaction with Education Modality

Satisfaction Level	Intervention Gp (%)	Control Gp (%)	p-value
Very Helpful	58%	24%	< 0.01
Helpful	36%	38%	0.74
Neutral	6%	28%	< 0.01
Not Helpful	0%	10%	< 0.01

Table 8: Subgroup Analysis of Knowledge Scores

Subgroup	Intervention Gp (%)	Control Gp (%)	p-value
Parents with Low Education	+32	+13	< 0.001
Parents with High Education	+18	+6	< 0.05
Prior Asthma Knowledge	+20	+7	< 0.01

APPENDIX 2:

- **Detailed Intervention Protocols**

Digital Parental Education Tool (Intervention Group)

- **Overview**: The parents received a mobile-based educational tool meant for this project; "Asthma Parent Educator."
- **Content Delivery**:
- Interactive modules on the basics of asthma, medications, and emergency management. Videos about correct inhaler techniques demonstration and identification of triggers. Quizzes about asthma education .

Follow-Up:

- Weekly reminders for parents to complete modules.
- Notifications about high pollen levels or other triggers.

Printed Materials (Control Group)

Overview: Parents received printed booklets with similar educational content.

Content:

Booklets explain asthma symptoms, triggers, and medications.

Preparation of an asthma action plan.

Distribution:

Booklets were distributed to the parents during the first session.

2. Questionnaires

Baseline and Follow-Up Questionnaire

1. **Knowledge Assessment** (Scored out of 100):
- "Name early warning signs of an attack of asthma."
- "Name the medications which are used to control asthma."
2. **Confidence in Management** (Likert Scale 1-5):
- "I feel I can recognize asthma triggers."
- "I can give my child his/her medications correctly."
3. **Parental Engagement** (Multiple Choice):
- "How frequently do you check your child for symptoms?"
- "Do you regularly check if your child is adhering to the prescribed medication plan?"
4. **Satisfaction Survey** (Follow-Up Only):
- "How helpful did you think the educational materials were from 1-10?"
- "Would you recommend this program to others?"

3. Data Collection Tools and Validation

Knowledge and Confidence Assessment

- This consists of a validated questionnaire adapted from Garbutt et al., 2012(11)."
- Pilot tested on 10 parents for cultural relevance and readability.**Cl**

Cinical Data

- Collected from medical records:
- Frequency of attending clinic visits,
- Medication adherence (self-reported and pharmacy refill data).

Parental Feedback

- Obtained by conducting a focus group at the end of the study.

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