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Audience, Content, Media: A Literature Review about Factors to Consider When Designing Technology Based Asthma Education Programs for Children

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Abstract

Childhood asthma is a growing societal problem that causes suffering for children and families. Short of finding a cure, the best way to address this problem is to give children with asthma the resources they need to control their condition. Unfortunately, research and resources for young children with asthma are lacking. The authors hypothesize that an approach using technology based delivery methods to provide age-appropriate education, which promotes self-regulation and includes psychosocial elements, could help children with asthma decrease exacerbations in the short term and establish healthy habits in the long term. To lay the groundwork for the initial investigation of this hypothesis, the authors reviewed the literature for three elements: audience (children with asthma), content (self-regulation and psychosocial elements), and media (mobile technology applications and digital story). Literature was reviewed for children's beliefs about illness and medication, self-regulation versus self-management, the psychosocial elements of parental support and peer influences, technology and education, clinical computer-based education, electronic educational games, and smartphone applications. The gaps in the literature found regarding these topics point to areas where future research would be instructive for designing effective, technology based applications for children with asthma. To produce the most effective asthma education materials for children, all three elements in this literature review—audience, content, and medium—should be investigated in future research studies.

Keywords: Childhood asthma; Pediatric asthma; Mobile apps; Computer games; Cognitive development; Self-management behavior; Teaching through story; Storytelling; Computer-assisted instruction

Introduction

The National Heart, Lung, and Blood Institute (NHLBI) defines asthma as "a common chronic disorder of the airways that is complex and characterized by variable and recurring symptoms, airflow obstruction, bronchial hyperresponsiveness, and an underlying inflammation"[1]. Childhood asthma is a growing societal problem that causes suffering for children and families. It is widespread; 6.8 million children in the United States, or one in eleven, were diagnosed in 2010 [2]. It is growing; between 2001 and 2011, the number of persons with asthma in the United States increased by 28% [3,4]. Finally, it is expensive; the average annual cost of caring for a child with asthma was $1,039 [2].

Short of finding a cure, the best way to address this problem is to give people with asthma the resources they need to control their condition, as maintaining "asthma control improves quality of life, decreases medical expenditures, and increases productivity at work and school" [5]. Providing resources for children with asthma will require a great deal of research to determine the most effective approaches. The authors hypothesize that an approach using technology based delivery methods to provide age-appropriate education, which promotes self-regulation and includes psychosocial elements, could help children with asthma decrease exacerbations in the short term and establish healthy habits in the long term. To lay the groundwork for the initial investigation of this hypothesis, the authors reviewed the literature for three elements: audience (children), content (self-regulation and psychosocial elements), and media (mobile technology applications and digital story). For this inquiry, 86 references were reviewed following a search of PubMed, CINAHL, PsychInfo, and Google Scholar using the following key words: childhood asthma, pediatric asthma, mobile apps, computer games, cognitive development, self-management behavior, teaching through story, storytelling, and computer-assisted instruction.

Audience: Children

Although the pulmonary tests used to diagnose asthma usually are ineffective for children under age five, children with the highest risk for deficits in lung function growth can display asthma symptoms before age three and as many as 50–80% of children with asthma develop symptoms before age five [1,6]. Consequently, children under age five are diagnosed using a combination of medical history, symptoms, physical examinations, perceived quality of life, and effects of therapeutic trials in managing symptoms [1,7].

While children with asthma must learn to manage their own disease, a majority of the literature examining asthma education targets families or parents [8-12]. Of the studies focused on children, most address interventions for school-aged children [13-22]. The literature is lacking in studies addressing the creation of education material for children, especially those that include information about self-regulating behaviors.

Despite research suggesting children engaged in health education have decreased morbidity and increased self-efficacy, doctors give little attention to educating young children [20,23]. Children routinely experience a "joking relationship" with doctors and usually have very little control in their conversations with them [23]. Children often have different physical, cognitive, and emotional needs than adults, but little work has been done to effectively address these needs in asthma education [23-26]. In an effort to uncover children's cognitive and emotional development surrounding illness, which can be considered in the development of asthma interventions, the author reviewed literature examining children's beliefs about illness and medication.

Illness beliefs

The majority of studies focusing on children's cognitive functioning and beliefs about illness are qualitative [25,27-30]. Two of these studies used a Piagetian framework – which describes the sensorimotor, preoperational, concrete operational, and formal operational periods of development – to determine children's beliefs about disease, including how their beliefs change over time [24,25]. Children's perception of chronic disease was investigated in Pradel et al. [24] study (n=32) of children with asthma and Koopeman et al. 2004 study (n=158) of children with diabetes [24,25].

Koopeman et al. [25] found that children in the preoperational stage are unable to identify the reasons for their illness, how the illness occurs, and how it affects their bodies [25]. Another study showed that, until about age seven, children do not understand what causes asthma or what triggers an attack and therefore describe the illness and its health interventions in "magical" terms [27]. While young children demonstrate a better understanding of illness when they see its physical manifestations, they are unable to describe behavioral strategies to assist in the self-management of asthma symptoms [24,25,28]. A study of children ages four to 12 that examined their beliefs about contagious illnesses, non-contagious illnesses, and injuries supported this claim by showing that children answered questions about injuries like broken bones or bruises far more accurately than those about internal diseases [27]. A study of children's perceptions of hypothetical peers with diabetes, asthma, AIDS, or cystic fibrosis found that even children in grades four through six (n=179) lacked knowledge about disease transmission [31]. Specifically, many of the students believed that genetic diseases were transmittable and were more likely to blame affected children for their illnesses and limit social acceptance of these children [31]. In this study, the younger children showed higher levels of distrust and blame towards ill children than did older children [31].

As children progress into Piaget's concrete and formal operational levels, they begin to identify bad behavior, unhealthy bodily conditions, physiological properties, and psychological influences as potential causes for disease [25,28]. However, children of all ages still rely heavily on personal experience and parental explanations of illnesses in forming their cognitive frameworks [24,27]. Overall, young children have difficulty understanding internal body processes and detailed physiological disease explanations, and are not effective in adopting self-managing behavior [24-26,28].

Medication beliefs

Young children show a significant lack of knowledge about the importance of medication, recognizing the warning signs of illness, and what to do when illness occurs [24,28]. In a study using the Children's Health Belief Model to examine children's motivation for illness management, children revealed that the unpleasant taste and inconvenience of taking asthma medications caused them to ignore their asthma symptoms. Many of these children ignored their symptoms primarily because they did not recognize them, understand why they occurred, or appreciate the significance of taking medication [24].

Additionally, misperception of medication use and appropriate self-management behavior is common among children throughout cognitive developmental stages. An influential older study focusing on children in grades K–8 (n=85) in Baltimore MD, New York, NY, and Worcester, MA revealed that negative perceptions of and fears about taking medications often are prevalent among schoolchildren [28]. Specifically, kindergarten-aged children knew medications by color and appearance more than name brand or therapeutic purpose. These children also demonstrated their misunderstandings about medications by reporting they could develop another child's illness by taking the wrong medication, and voicing fears that some medicines contain poison [28]. These results were corroborated by a discussion group study by Hameen-Anttila et al. [30] that reported most children do not think to use medications preemptively and are unable to describe how a medication works [30]. Similar findings on children's negative attitudes towards medicine and their misunderstandings regarding medication were shown in a study conducted in Finland [29]. These literature findings highlight the need for individuals designing asthma education to understand where children are in their cognitive development and give them information that is customized to their level of understanding.

Content: Self-regulation

Self-management can be defined as an individual's ability to manage the symptoms, treatment, physical and psychosocial consequences, and lifestyle changes inherent in living with a long-term health condition [32]. Following diagnosis, children with asthma must learn effective medical self-management [13]. Since studies have suggested that self-management of asthma is essential to minimizing asthma exacerbations, teaching behavioral elements (avoiding triggers) and the proper use of tools (inhalers and peak flow meters) could have a substantial effect on children's asthma morbidity [1,33,34].

Unfortunately, self-management often requires higher levels of development than those present in very young children [35]. For this reason, young children with asthma need to be taught self-regulation, which refers to how an individual systematically manages feelings, thoughts, and behaviors, [36] adjusting them to meet a situation's demands [37]. Self-regulation also includes the abilities to inhibit first responses, resist interference from irrelevant stimulation, and persist in relevant but unenjoyable tasks [37]. As with many chronic diseases, self-regulation behavior is crucial for reducing asthma morbidity. Depending on the developmental level of the child, encouraging self-regulation in learning, specifically regarding proper behavior and attainment of an appropriate level of medical knowledge, is imperative until the child can effectively begin to medically self-manage their own behaviors [38,39]. Young children should be able to begin attaining self-regulation skills in the first few years of life [35].

Although children under five cannot self-manage their behavior, Ladebauche's study reports that even toddlers begin seeking levels of personal autonomy in behavior and are, therefore, considered an optimal age for teaching cooperative, medical self-regulating behaviors [35,40]. This assertion has been further supported by studies and

reviews from the late 1980s to the present that have examined toddlers' interactions and behavior [41,42]. The desire for increased autonomy and skill acquirement continues into preschool and early grade school and provides continued opportunity for health education [40]. Early experiences are reported as having lasting impacts on behavioral choices and situational perceptions, so teaching positive, effective attitudes and behaviors in young children could have implications for long-term lifestyles [43]. A landmark study by Ouellette and Wood suggested that past behavior is likely to influence future behavior when those behaviors are repetitive, stable, and societally supported [44]. Therefore, establishing a routine of asthma self-regulation for children, with the support of family and peers, could improve patient outcomes later in life.

Content: Psychosocial elements

Along with behavioral regulation, psychosocial development also must be strengthened to support children with asthma [44]. Chronic diseases often leave children feeling alienated and excluded, but providing psychosocial management elements within asthma educational materials could help improve children's social interactions [45]. Although this discussion of children's development and learning is generalized, specific examples of research related to childhood asthma also are given.

Parental support

Since children's initial behavioral, emotional, and cognitive learning occurs at home, the home provides an optimal environment for fostering beneficial learned attitudes and behaviors [46]. Even in infancy, research suggests that secure attachment to caregivers results in numerous positive social outcomes in later life [47]. Additionally, research suggests that parental care of infants and toddlers results in higher levels of socio-emotional and cognitive development than that of children in institutionalized care [48]. The primary position of parents as teachers and supporters is evidenced in a qualitative study of children ages six through 12 (n=20), where children with asthma reported that their mothers were their primary source of support [45]. Even in adolescence, high parental support and low levels of negative parental controls are indicators of higher levels of social acceptance and in-group status when compared to low parental support or presence [49]. Since peer acceptance is essential to children's social relationships, parental support is indicative of social inclusion even beyond home life.

Peer influence

Although peer influence is most notable in adolescence, even infants as young as six months begin to show greater attention to infants close to their age as compared to other companions, indicating a preference for physical similarity and familiarity [50]. Similarly, in another study toddlers showed marked gravitation towards like-groups and increased preference for behavior models who are similar to themselves [51]. Despite some studies suggesting that toddlers already evaluate in-group status as a prerequisite for social inclusion, a 2015 study revealed that social adherence to groups is not as powerful in toddlers as it becomes in later years [52]. This study worked with children, ages three and five years (n=144), and tested their collaboration and in-group preferences using puppets as collaborative partners in tasks [52]. The researchers also assigned puppets to the same team or group as the child as determined by arbitrary clothing color and then tested the children's helping behavior towards in-group and out-group puppets [52]. The researchers found that, when asked, both the three- and five-year-old children preferred the puppets they collaborated with during a task, while only the five-year-old children showed a preference for in-group members [52]. These researchers suggested the five-year-old children value in-group membership and social group status more highly than do younger children [52]. This finding reveals that early collaboration between children with illness and children without may provide opportunities for increased social inclusion before children establish their own exclusionary group criteria.

As children spend more time away from home, peer relationships become increasingly crucial to emotional stability and development [47]. This peer influence has been defined as the perceived influence of peers on an individual's thoughts or actions [53]. By the time children enter preschool, in-group status becomes crucial for peer inclusiveness and lays the groundwork for future emotional stability as well as social acceptance and support [43,54-58]. These desires for peer acceptance and inclusion grow stronger throughout grade school and reach their peak in adolescence [40]. Research suggests that the desire for peer acceptance along with added developmental stressors unique to adolescence can result in decreased levels of self-management of chronic diseases [34,59]. In fact, by the time children reach older adolescence, researchers found that despite parental support to increase self-management behaviors, peers were more influential and often discouraged self-management behavior [34]. This desire for peer acceptance can lead to social anxiety in children with chronic diseases. Due to the unique limitations of these children, in-group status can be threatened and social relationships strained. According to several researchers, children with a chronic disease report challenges creating and maintaining relationships as well as fear of social isolation, being different, being bullied, being harassed, and social incompetence while participating in group activities [40,45,59-62]. Children with chronic illnesses often fear peer rejection and report added pressure to decrease illness manifestations in an attempt to adhere to social norms [40,45]. In a qualitative study by Callery, the importance of social conformity was emphasized as one child reported, "I try not to cough in assemblies because then I get embarrassed." Researchers found that children evaluated their asthma experience as either a "good day" or "bad day" depending on whether their disease made them feel different than their peers [60]. Children's fears regarding social isolation are not unfounded. In a survey of sixth-grade students (n=248), researchers found that even active pro-social behavior displayed by a child with a chronic illness was not enough to completely mediate the stigma assigned to the child because of their disease [63]. Other research suggests that the inability to participate in various social interactions due to a chronic disease could lead to higher levels of social rejection [64].

Strong family and peer support can mediate the social anxieties of children with chronic diseases. In one study of social support for adolescents with asthma, researchers defined social support as positivity towards asthma management by family and peers [34]. Such support has been the focus of multiple studies regarding children's self-management of asthma symptoms. For example, Yang, Sylva, and Lunt's study of children ages 9–14 (n=96) suggested strong parent and peer support in acute asthma exacerbations, trigger avoidance, and physical activity directly correlated with successful asthma-related behavioral management [34]. Similarly, Stewart's 2011 study revealed that 19 out of 20 children expressed a desire for peer support when dealing with asthma or severe allergies [60]. A second study by Stewart that same year revealed that 73.7% of children 11 to 16 years (n=28)

participating in an online chat group designed to bolster peer support of children suffering with asthma felt that the open and supportive atmosphere was beneficial to their feelings of emotional well-being and social inclusion [45]. Adolescents in this study reported benefiting from communication and mutual affirmation with similar individuals [45]. Casier reported that previous studies involving children with chronic pain, arthritis, and cystic fibrosis have shown "higher acceptance of chronic illness is related to positive outcomes such as less anxiety, less depression, less disability, and better emotional, social, and physical functioning"[65]. Casier observed similar findings in an adolescent population (n=62) in the Netherlands [65]. These literature findings underscore the need for individuals designing asthma education to understand the importance of children's psycho-social development to their asthma management and find ways to incorporate these elements into asthma education programs.

Media: Technology based delivery methods

Technology is an ever-present, ever-growing element of the modern world. Technology based programs have proven effective methods for educating young children and technology is being used as an educational resource in the healthcare field [66]. In fact, a 2012 report stated that, "half of smartphone owners use their devices to get health information and one-fifth of smartphone owners have health apps" [67]. For example, there are approximately 147 asthma applications (apps) available [68]. Of these, seven are designed for children [68]. These asthma apps are one way that researchers can begin educating children about their chronic illness and the behavioral and social management skills necessary to living with asthma. Due to children's proclivity for electronic media, many studies focus on children's asthma management through computer-based educational methods [13-15,19-22,25,27]. However, relatively few researchers incorporate asthma education into mobile forms and no apps focus on preliterate children [68].

Technology and education

As technology became more prevalent in homes and schools, researchers began focusing on the possibilities of technically driven education methods. Since combining traditional and new technological methods has been shown to produce the best information retention, developing new educational methods has become an emerging area of study. [69,70]. Specifically, the use of story to enhance communication and boost education methods is supported in the literature [67,70-73].

Holzheimer, Mohay, and Masters' study comparing the effectiveness of books versus videotaped materials found that videos were not as useful as books that allow children to self-pace and better understand the material [70]. Still, the idea of using electronic media for education fueled further research regarding electronic books, also called CD-ROM storybooks, talking books, interactive books, or computer books [74]. One 2002 study conducted in the Netherlands surveyed kindergarten children (n=48) to determine how much of a book they would read if the books provided varying levels of interactive material [74]. A similar study was later done with American children [75]. First, children were presented with one plain-text, online storybook and then another with added multimedia enhancement [75]. The children were then tested regarding story content [75]. Both studies found that children with access to added multimedia elements scored lower on the follow-up tests and revealed levels of distraction not observed in children reviewing stories with no multimedia enhancements [74,75]. In learning story material, children are likely to skip over narratives to progress to interactive features, thus missing a large portion of the information presented [74,75].

These results were remarkably different from Takacs, Swart, and Bus' who reported that multimedia components promoted children's story learning [76]. Like previous studies, this meta-analysis noted that games distracted from children's learning, but also found that, in the absence of an adult, interactive storybooks were more useful than children reading on their own [76]. Takacs et al. concluded that the scaffolding provided by multimedia storybooks was similar to that provided by adults reading a narrative [76]. Some researchers have gone so far as to suggest that technology is superior to human-to-human interaction in promoting self-regulation and enhancing learning autonomy [77]. These researchers also suggested that the ability to learn without social pressure and the constant demands of perfect compliance to a regimented schedule might promote children's self-motivated learning [77].

Clinical computer-based education

Doctors' offices and hospitals have taken an interest in supplementing asthma education given in a professional setting with technology based education methods [78,79]. Using a program based on the National Asthma Education and Prevention Program, one randomized control study consisting of children under age 18 years (n=246) tested the value of a new electronic educational tool called an "Interactive Multimedia Program for Asthma Control and Tracking" or IMPACT [79]. The IMPACT program focused on asthma pathophysiology, triggers, medication, and self-management strategies and was met with notable success [79]. The intervention group showed an increase in asthma knowledge, reduced asthma morbidity, and reduced emergency room costs following program completion [79]. A follow-up study of the IMPACT program evaluated lung function, children's and parents' perception of the program, as well as the elements evaluated in the initial study [80]. The follow-up study reported results similar to the 2003 study, although it was found that children's lung function did not statistically increase [80]. Children who use electronic education programs showed increased behavioral asthma self-management and needed less inhaled corticosteroids while maintaining the same levels of lung functioning after completing the electronic program [80].

In another study of children between the ages of 3 and 18 (n=69), 81% (n=56) of children felt an electronic educational program was easy to use, 65% (n=45) found it interesting, 64% (n=44) enjoyed it, 80% (n=55) liked receiving asthma education via computers, and 75% (n=52) would be willing to use the same program again in the near future [78]. However, children younger than age six were unable to use this program alone and required their parents' assistance in completing the program and corresponding surveys [78]. Furthermore, all children under age 11 were placed into one group and the cognitive differences between the three-year-old children and the 11-year-old children were not considered [78].

Electronic educational games

Another growing source of educational material is electronic asthma games. Computer-assisted instruction (CAI) has been supported in the literature as an effective medium for child education [81]. Children learn more quickly when they are directly involved in their education through interaction and CAIs are increasingly being

noticed for their value in an educational setting [81]. A landmark study by Rubin et al. evaluated children who used a program entitled Asthma Command and reported asthma knowledge and medical self-management behaviors increased in children enrolled in the program [82]. Following the success of Asthma Command, several other programs—including Watch, Discover, Think, Act; Wee Willie Wheezie; Bronkie the Bronchiasauras; The Asthma Files; Okay With Asthma; and Okay With Asthma 2.0—were developed and tested [14,15,17,19,20,22]. Children age seven to 18 years were tested on their asthma knowledge, symptom management, behavioral responses, and overall feelings towards their chronic disease and they improved in all of these areas after using electronic education games [14,19,20,82]. Multiple evaluation tools including the Asthma Knowledge and Appraisal Questionnaire, Asthma Information Quiz, and the Child Attitude toward Illness Scale have been used to evaluate children's changing levels of knowledge and attitudes following the use of the programs and all have shown increases in children's asthma knowledge in pre and posttest trials [14,20]. Notably, children using CAIs designed for minority populations showed increased feelings of autonomy, more extensive behavioral strategies for asthma management, high motivation for continuing their education in the gaming format, higher overall asthma knowledge, and increased self-efficacy compared to control groups [13,15,17]. Ninety-seven percent of children in one study reported electronic asthma games were both fun and educational [15]. A second study on the same program showed children aged 8 to 13 years (n=76) increased their self-management, self-efficacy, and intrinsic motivation for asthma education following the programs implementation [13].

Finally, combining gaming and storytelling features, online interactive stories were used for asthma education [14,22]. Wyatt and Hauenstein's 2008 pilot study of the online program, Okay With Asthma, showed encouraging results for young children [14]. This study also found statistically significant improvements in health-related knowledge and attitudes following use of the program [14]. These results were used to assist in the creation of Okay With Asthma 2.0, a refinement of Wyatt et al.'s original program [22]. Children have shown interest in mobile forms of the interactive stories and at least one app is being developed to help increase the accessibility of these asthma tools [22].

Smartphone applications

Smartphone applications are a relatively new and largely untapped medium for asthma education. While Boulous, Brewer, Karimkhani, Buller, and Dellavalle reported that a staggering 40,000 healthcare apps were in use, a surprisingly low number of asthma apps are available [83]. Of all the available apps on the market found during a systematic assessment of Android, Apple, Blackberry, and Windows Phone's app stores by Huckvale, Car, Morrison, and Car, 103 asthma-related apps were identified [84]. These apps focus on either education or behavioral management tools, none have found that included both of these elements [84]. Only 13 of the available apps included multimedia information and only seven targeted children [84]. Regardless of the targeted age group, very few of the apps were working tools or based on accurate asthma information [84]. Huckvale et al.'s 2015 reevaluation of the Apple iOS and Android app stores revealed similar results [68].

Despite an increase in available asthma apps (n=147), there was not a significant increase in apps for children [68]. Of the few newly released children's apps, most targeted caregivers [68]. A significant number of newly released apps used multimedia methods of education, but only three include some form of interaction or gameplay for children and teenagers [68]. A Cochran review of tablet apps and related clinical trials yielded similar results [85]. Overall, no conclusive evidence supports the use of clinical apps as an asthma management tool [85,86].

Literature gaps: Recommendations future research

The gaps in the literature found in this review point to topics where future research would be instructive for designing technology based applications for children with asthma that include self-regulation and psychosocial elements. A reoccurring limitation of the reviewed literature was the fact that cognitive levels of younger children had not been fully considered during the creation of the educational tools, which prevented some children from using them [13,15,78,79]. Even when researchers attempted to include young children in their studies, the children's parents were primarily responsible for completing the program and reporting results [78].

Despite research showing social relationships affect children's asthma self-management, only four programs studied in the literature included social elements and none targeted children younger than school age [13,14,19,22,40,45,62]. Additionally, no resources were found that focused on establishing healthy behavioral habits in the home while the children are solely under their parents' influence [52].

Although young children need self-regulation tools, current electronic media are not accessible to children under age six [44]. Most programs target children's self-management, which is not an appropriate intervention for preliterate children [13-15,19,22,24,33,35,68,85]. None of the programs focused on young children's self-regulation of thoughts, feelings, and behaviors. Since young children do not understand internal physiological functioning, stories teaching self-regulating behaviors instead of illness facts may prove to be more effective in decreasing morbidity.

Additionally, while some investigators found multimedia elements distracting, no researchers have investigated whether stories that specifically teach behaviors can be enhanced by including demonstrations within the story [75]. Finally, because none of the studies was longitudinal, children's understanding and retention of materials presented in electronic form cannot be evaluated beyond the short-term scope of the studies [24].

Conclusion

Increasing behavioral, emotional, and social resources for young asthma sufferers could help increase the children's self-regulation and future self-management behaviors, while reducing hospitalizations and financial burdens on families. Such education also could promote beneficial health habits that could extend into later life and improve health outcomes.

Resources targeted for children with asthma are lacking. Because many children acquire asthma before they reach school age, it is unfortunate that most studies involving children focused on literate children within school system. Since research suggests that behavioral management is crucial to decreasing children's asthma exacerbations, educational media should present these behaviors in a way young children can understand.

The content of asthma education programs for children should include information about self-regulation and psychosocial concerns.

Most educational resources studied in the literature primarily focus on the physiological causes of disease and exclude behaviors necessary to decrease morbidity. Educational materials should be tailored to cognitive and behavioral development levels. Children's behavioral development is a crucial consideration when creating educational tools, but there is currently an absence of age-appropriate learning tools for very young children. There also is a gap in the research about preliterate children's educational needs and methods for teaching appropriate self-regulation strategies. Despite the strong influence peer acceptance has on social behavior, this psychosocial element is absent from asthma education resources targeting very young children. Providing young children with age-appropriate asthma education that includes psychosocial content could help give them the social support they need to establish healthy behaviors before they face peer pressure at school.

The role innovative technology based media could play in asthma education for children is relatively unknown. Multimedia stories on a technological medium appear to be useful for teaching children about asthma. However, despite increases in the number and variety of computerized stories and games, few educational mobile apps are available to children and only one was found during the review that included interactive stories. Despite research suggesting that children need information presented in novel ways due to differences in their cognitive functioning, very few technological sources are tailored to young children's educational needs. Further, although computer-assisted instruction has been explored, very little interactive educational materials are available in a mobile form. There also are discrepancies in the effectiveness of various interactive features that requires further exploration. To produce the most effective asthma education materials for children, all three elements explored in this literature review—audience, content, and medium—should be investigated in future research studies.

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