Abstract:
Computer-based education in schools is not novel. However, only a few computer games have been introduced into School-based health education programs. This study describes inclusion of an asthma education space adventure game into fourth-grade classrooms. Using the gainers improved asthma knowledge in the intervention classes, children in the active participation classroom gained significantly more asthma knowledge over the observation period compared to the classroom that did not play the computer game. Knowledge gained was retained over a four-week period and the addition of physician-led talks appeared to add little to the knowledge gained. "Air Academy: The Quest for Airtopia" is an easy and successful cool for elementary-grade asthma-related health education in schools. (J Sch Health. 2000;70(4):153-159)

An In-School CD-ROM Asthma Education Program
Barbara P Yawn, Pamela J. Algatt-Bergstrom, Roy A. Yawn, Peter Wollan, Mark Greco, Marie Gleason, Leona Markson

Asthma, a common condition of childhood affecting up to 790 of children, is one of the most common reasons for school absences. Recent studies suggest that improved care, specifically use of long-term, anti-inflammatory agents, might reduce morbidity and mortality from asthma and enhance School attendance. As a chronic condition, asthma requires collaborative management by the child, family, and health care system. Such collaborative care is most likely possible with children and families that have received education regarding recognition and management of asthma and its exacerbations.

Other work suggests many children with asthma may be undiagnosed for extended periods of time. A physician diagnosis of asthma is usually based on a patient or family-initiated contact with or through health care clinicians such as a School nurse. Increasing general awareness of the symptoms of asthma and the possibility of successful treatment might increase the number of symptomatic children who seek medical care, and thereby decrease asthma sick days.

Children typically receive education in two major sites, home and School. Within the School curriculum, children receive health education. Often these programs are aimed at an organ or organ system (lung or respiratory system), but not intended to target any certain conditions or diseases and, therefore, are too general to raise awareness regarding specific health problems. Health education programs aimed at specific common conditions do exist (drug, alcohol, and tobacco abuse) and are considered valuable. While these approaches may serve as a model for other condition-specific health education programs for common problems such as asthma, few programs have been evaluated, and even fewer are offered in CD-ROM format.

This paper reports results from an asthma education program in an elementary School. Using a randomized design, the study compared improvement in asthma knowledge test scores before and after introduction of an interactive CD-ROM asthma education program titled, "Air Academy: The Quest for Airtopia." This pilot study provided information on the feasibility of using this low-cost educational package as part of a health education curriculum.

Methods
Sample
All students in three, fourth-grade classes (N=87) of Jefferson Elementary School in Rochester, Minn., participated. Two classes were randomly selected (long straws) as a group of control children. Jefferson Elementary School is the most racially and socioeconomically diverse public elementary School in Rochester, with more than 250 of children from non-White families compared to only 8% non-White residents in the city as a whole. Rochester is a metropolitan statistical area in southeastern Minnesota, surrounded by rural agricultural areas. The community is the site of the Mayo Medical Center and the Olmsted Medical Center, with more than 8,000 community residents involved directly in the health care industry.

The study was approved by the Olmsted Medical Center Institutional Review Board in February 1999. After obtaining permission from the School board, letters were sent to parents of each child in the fourth grade to explain the program, the content of the Airtopia CD-ROM, and the use of pretests and posttests (posttest 1 and 2). Parents were asked to call the School principal if they did not want their child to participate in this aspect of the School's health curriculum. No parents called to decline. The program also was explained at a Parent-Teacher Association meeting.

Intervention
"Air randomized control trial was based on a pretest and two posttest assessments of children's asthma knowledge

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of asthma management. The final mission to "Alien Mall"
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pathophysiology of asthma, environmental Triggers, symp-
variety of asthma issues including anatomy of the lung,
Missions to "Planet Poluto," "Mold West," and "King
%lien worlds" to find clues chat will lead to "Air-Topia.
fiction environment. Children complete "missions" in four
the game for "playability"
opers working in conjunction with children with asthma.
Development of the game was unique in that children with
asthma were consulted throughout the development
process. Focus groups of children aged 6-12 selected the
asthma educational tool for children aged 6-12. The CD-
ROM game presents asthma disease knowledge and
management skills, with tools for reinforcement, as it
supports motivation for children to better understand the
management of the disease. Throughout the game, simple
analogies are used to illustrate key asthma educational
messages. The important benefits of communicating about
asthma with health care clinicians, parents, teachers and
peers also are stressed throughout the game. 'Me game was
designed by a team of health care professionals, child
psychologists, educational experts, and multimedia devel-
opers working in conjunction with children with asthma.
Development of the game was unique in that children with
asthma were consulted throughout the development process. Focus groups of children aged 6-12 selected the space adventure theme, made suggestions regarding the characters and artwork, described their issues with asthma management and social situations, and continuously tested the game for "playability"

Content of the game is set in a nonviolent, science-
fiction environment. Children complete "missions" in four
%lien worlds" to find clues chat will lead to "Air-Topia." Missions to "Planet Poluto," "Mold West," and "King Kough Island" are designed to educate children about a variety of asthma issues including anatomy of the lung, pathophysiology of asthma, environmental Triggers, symptoms, therapeutic compliance and management; and goals of asthma management. The final mission to "Alien Mall"

Table 1 Study Outline

<table>
<thead>
<tr>
<th>Week 0</th>
<th>Weeks 1-5</th>
<th>Week 6</th>
<th>Weeks 6-10</th>
<th>Week 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>Classroom</td>
<td>One</td>
<td>No CD ROM</td>
<td>Posttest</td>
</tr>
<tr>
<td></td>
<td>in Two</td>
<td></td>
<td>Activity</td>
<td>Two</td>
</tr>
<tr>
<td></td>
<td>Posttest</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Three</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>investigator</td>
<td>Three</td>
<td>investigator</td>
<td>Two</td>
</tr>
<tr>
<td></td>
<td>classrooms</td>
<td></td>
<td>classrooms</td>
<td></td>
</tr>
<tr>
<td></td>
<td>first room</td>
<td></td>
<td>second room</td>
<td></td>
</tr>
</tbody>
</table>

Two intervention and one control fourth-grade classroom participated in the study.

Table 2 Asthma Test Categories

<table>
<thead>
<tr>
<th>Category</th>
<th>Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core Asthma</td>
<td>Covered</td>
</tr>
<tr>
<td>Asthma Triggers</td>
<td>Colds worsen asthma</td>
</tr>
<tr>
<td>Asthma Medications</td>
<td>Long-term controller use</td>
</tr>
<tr>
<td>Asthma Symptoms</td>
<td>Symptoms every day</td>
</tr>
<tr>
<td>Maintenance</td>
<td>Asthma diary</td>
</tr>
<tr>
<td>General Knowledge</td>
<td>Olympic athletes have asthma</td>
</tr>
<tr>
<td>Fun Questions</td>
<td>&quot;Trigger Gang&quot; leader</td>
</tr>
</tbody>
</table>

Appropriate scenarios for dealing with peer pressure and other asthma-specific social situations are reinforced by live video clips. Mandatory "debriefing" sessions are included after each mission to illustrate straightforward links between the game analogies and important messages about asthma. Additional workshops after each mission are used to rehearse and reinforce these same messages. Té assist and enhance communication between patient and health care provider, each mission is followed by a "Log Book" that children can use to print information their symptoms. An illustrated asthma dictionary is also provided as a reference.

Children in intervention classrooms were required to participate in the 20-minute introductory session to make sure that all children knew how to start the CD-ROM game and could read the simple play instructions. According to classroom teachers and computer lab support personnel, no child had any problems in initiating the computer game. Children in intervention classrooms were allowed to play the game as desired for the last 20 minutes of computer labs held three times each week over a period of six weeks.
Children kept logs of the amount of time they spent playing the game. The physician investigator (BPY) presented a 30-minute asthma talk to one intervention classroom during week five.

Children in the control classroom continued with the usual fourth grade health and science education programs that do not include information on asthma. No other education programs dealing with asthma exist in the school health curriculum.

Following the six weeks of active use of the game in the intervention classrooms, posttests were administered to all three classrooms. Posttests included the same demographic and core asthma questions as the pretests. For the intervention classrooms, three “fun” questions that related to characters in the AIRTOPIA game were added to the posttests (Table 1). During the four weeks after the first posttest, children in the intervention groups were not in the computer lab for any classroom session. Therefore, the game was not available to them. The only school-based asthma education that occurred during the four weeks after posttest 1 was a 30-minute asthma talk presented to the second intervention classrooms by the physician investigator (BPY). Classroom teachers administered the pretests in early March 1999. Posttests were administered in May and June 1999, approximately four weeks apart. The control classroom did not receive posttest 2.

At the end of the school year (June) each child in the intervention group was given their CD-ROMs to take home. Each child in the control classroom also was given the CD-ROM game and participated in a special computer lab session to learn to use the game. No child declined the game. Each classroom teacher completed a postprogram questionnaire dealing with ease of use, and their impression of the CD program regarding graphics and appropriateness for grade level.

**Data Analysis**

Demographic data of the control and intervention groups presented as proportions and potential differences were assessed using chi-squared tests. The percentage of children with correct answers were compared across control and intervention groups in the pretest, and between the pretest and posttests within groups using chi-square tests. Wilcoxon rank sum tests were used to compare the between-group number of correct answers to the 17 asthma knowledge questions. Children were also stratified into those with high pretest scores (> 65% correct, 11/17) and

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**Table 3**

Questions About Asthma

<table>
<thead>
<tr>
<th>Question (Answer)</th>
<th>control</th>
<th>Intervention A</th>
<th>Intervention B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colds can make asthma worse. (true)</td>
<td>82</td>
<td>89</td>
<td>93</td>
</tr>
<tr>
<td>Some Olympic athletes have asthma. (True)</td>
<td>82</td>
<td>82</td>
<td>93</td>
</tr>
<tr>
<td>Long-term controller medicines are only taken during an asthma attack. (False)</td>
<td>59</td>
<td>67</td>
<td>74</td>
</tr>
<tr>
<td>It is important for children with asthma to keep quick-relief medicine with them all the time. (True)</td>
<td>85</td>
<td>93</td>
<td>85</td>
</tr>
<tr>
<td>Smoke, pets, and paint fumes can make asthma symptoms worse. (True)</td>
<td>82</td>
<td>100</td>
<td>96</td>
</tr>
<tr>
<td>It is important for children with asthma to keep an asthma diary to record asthma triggers and symptoms. (True)</td>
<td>52</td>
<td>89</td>
<td>93</td>
</tr>
<tr>
<td>Having asthma symptoms every day (Is not normal, and should be reported to the doctor.)</td>
<td>83</td>
<td>97</td>
<td>93</td>
</tr>
<tr>
<td>When the airways become smaller (Less air gets in and out of the lungs.)</td>
<td>79</td>
<td>93</td>
<td>93</td>
</tr>
<tr>
<td>When should a child with asthma take a long-term controller medicine? (Every day, just like brushing teeth)</td>
<td>35</td>
<td>43</td>
<td>57</td>
</tr>
<tr>
<td>How can a child with asthma keep from losing the quick-relief medicine? (Always keep it in the same place.)</td>
<td>93</td>
<td>100</td>
<td>78</td>
</tr>
<tr>
<td>Asthma symptoms can happen. (At any time)</td>
<td>96</td>
<td>96</td>
<td>97</td>
</tr>
<tr>
<td>If a child thinks they are having an asthma attack, they should... (Follow the action plan from their doctor or nurse.)</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>If a child with asthma is taking medicines correctly and still having asthma symptoms... (They should talk to the doctor about changing the action plan.)</td>
<td>79</td>
<td>93</td>
<td>89</td>
</tr>
<tr>
<td>A peak flow meter... (Measures air flow when you blow into it.)</td>
<td>36</td>
<td>63</td>
<td>48</td>
</tr>
<tr>
<td>An asthma exacerbation is... (An asthma attack.)</td>
<td>55</td>
<td>85</td>
<td>63</td>
</tr>
<tr>
<td>If an asthma trigger is making asthma worse the child with asthma should... (Leave the place and follow the action plan.)</td>
<td>48</td>
<td>85</td>
<td>82</td>
</tr>
<tr>
<td>Spacers are... (Devices that you can attach to the mouthpiece of your inhaler.)</td>
<td>71</td>
<td>82</td>
<td>74</td>
</tr>
<tr>
<td>If the medicine a child with asthma is taking makes them feel funny, they should... (talk to the doctor or nurse right away.)</td>
<td>66</td>
<td>92</td>
<td>86</td>
</tr>
</tbody>
</table>
those with lower pretest scores (< 65% correct). Improvement in scores (posttest 1 score - pretest score) were calculated as absolute and relative improvement stratified by high and low score groups on the pretest. After stratification, comparisons were made among the three classrooms and between control and intervention groups using chi-square and Wilcoxon rank sum tests. Retention of knowledge was assessed comparing scores from both the core asthma and "fun" questions on posttests 1 and 2 in the intervention classrooms using the rank sum test.

The CD-ROMs were presented to the school at no cost. The gains are available from the sponsoring company. The only expense for the school was teacher preparation time.

RESULTS

Of the 87 children, 46 (53%) were boys and 41 (47%) were girls. The gender distribution was the same in the control and intervention groups (p=0.80). All children were either 9 or 10 years old, with no difference in the average ages of the intervention and the control groups (9.9 years vs. 9.8 years, p=0.5). Most children in all three classrooms reported having a computer at home (71% to 85%) with a slightly higher percentage in the intervention groups (71% vs. 82%). More than 90% reported playing computer games at some time, varying from 85% in the control classroom to 95% in the intervention classrooms.

Thirteen percent (n=3) of children in the control classroom and 11% (n=2) and 20% (n=5) of children in the intervention classrooms reported they had been told they had asthma. All the children who reported they had asthma also reported taking asthma medications. An additional two children who stated they had not been told they had asthma also reporting using asthma medications.

Children played an average of 9.7 hours (median 6 hours) with a maximum of 21 hours and a minimum of 2 hours. Scores on individual pretest items were quite high, with more than 75% (n=65) of children accurately answering 5 of the 17 asthma knowledge questions on the pretest. Only questions regarding long-term controller medication and peak flow meter use were answered inaccurately by more than 50% of the children on the pretest.

Pretest scores were similar in the two intervention classes (median scores of 11 and 12 out of 17, Wilcoxon rank-sum p-value 0.61). Pretest scores in the control class were slightly higher (median score was 13 out of 17, with rank-sum p-values of 0.08 and 0.10 compared to the intervention classes).

The intervention had a clear impact on the test scores of the asthma-related questions. Within each intervention class, an increase in scores occurred between pretest and posttest 1 with a median increase of 2 in each (Wilcoxon signed-rank p-value = 0.001 and 0.002, respectively) (Figure 1). In the control class, no evidence suggested any change in the scores between pretest and posttest (rank-sum p-value = 0.53) (Figure 2).

After the intervention, both intervention classes had median scores higher than the median scores in the control classroom, with one class being more clearly different than the other (rank-sum p = 0.20 and 0.0009, respectively). Neither the inclusion of a 30-minute physician asthma talk nor longer playing times (mean of 6 hours vs. mean of 12 hours) had a significant impact on the pretest-posttest scores in the two intervention classrooms. Combining the two intervention classes, posttest 1 scores in the intervention classes were significantly higher than the score in the control classroom (rank-sum p = 0.008). Figure 3 displays the pretest and posttest 1 scores of the control and intervention classes, and Table 3 compares posttest questions and answers for the control and intervention classrooms.

Improvement from pretest to posttest 1 was 13% for the intervention group and 4% for the control group. When students in the intervention groups were stratified on the basis of their pretest scores, those with scores less than 65% correct on the pretest had a 19% absolute improve-
ment in test scores and a 35% relative improvement. Three children had lower scores on posttest 1 than the pretest.

For the group with higher pretest scores (> 65% correct), the absolute improvement was only 8% with a relative improvement of 10%. This group included five children whose posttest 1 scores were lower than their pretest scores.

The second posttest (completed only in intervention classrooms) showed that students had retained the improved scores in the asthma core questions with a median change in the number of correct answers of -0.4 (12.6 out of 17 on posttest 1 to 12.2 out of 17 on posttest 2, p = 0.7). Average scores on the "fun" questions did not change between posttests 1 and 2 (median change = 0.2 from 2.9 out of 3 to 2.7 out of 3, p = 0.8).

On the post-program questionnaire teachers reported no problems in using the program with the exception of some older computers that did not allow the children to save their "quit" positions on the hard drive, requiring them to manually advance through the program when beginning the next session. Teachers stated that the children enjoyed the game and appeared to choose it over the other educational offerings available during computer lab sessions. Other offerings included keyboarding games, math games, and two encyclopedia programs.

DISCUSSION

Children in this school intervention program gained asthma-related knowledge and retained it over a four-week period of time as evidenced by posttest 2 scores. The CD-ROM program was well received by the children and teachers. Children with lower initial scores demonstrated greater improvement on the posttest, and retained this knowledge as evidenced by scores of the second posttest, including responses to "fun" questions.

Presenting health-related information to children can be difficult. In this school setting the children were enthusiastic about the opportunity to play the game. The study investigator who visited each of the intervention classrooms was met with cheers when introduced as the person responsible for them receiving the games to play. During the classroom talks regarding asthma, it was clear that the children had considerable knowledge regarding asthma but were eager to learn more. Children with asthma volunteered information about their asthma, and many other children discussed their belief that they could help a classmate having an asthma attack by better recognizing signs of distress and when to ask an adult for help. Of even greater importance in demonstrating the impact of this program may be four children (two children in each intervention classroom) who reported they asked their parents about symptoms they thought might be asthma. Three of the four children were taken to a physician and received diagnoses of asthma or exercise-induced bronchospasm.

The classroom talk by one of the investigators during the intervention period did not appear to improve the test scores of children in that classroom. This lack of improvement might be due to the small sample size or the ceiling effect of high scores on the first posttest. Alternatively, it could suggest that this program does not require additional intervention beyond the CD-ROM game to achieve its affect. Mis finding would be helpful since locating a physician or nurse to speak each time this program is used is unlikely to be feasible in many school settings.

All three teachers were enthusiastic about the CD-ROM game and wanted to include it in future years as a portion of their health education curriculum. None of the three had any concerns regarding negative impact of the game on any child. Each believed that it could be used with children one or two years younger if so desired. The lack of statistically significant improved scores in the classroom that played twice as long as the other intervention group appears to indicate that the educational messages are easily assimilated with only modest play time. This finding suggests that
The game could be used even in classrooms where computer time for health-related education is limited. Of additional interest is chat children also retained knowledge on the four “four” questions, possibly confirming that knowledge learned about asthma was learned through the CD-ROM and rot external influences.

Questions that appeared most difficult for children on both the pretest and posttests were two questions regarding long-term medications, and a question asking what a peak flow meter does. These questions correspond to the same areas of monitoring and treatment of asthma that have the lowest physician compliance with current treatment recommendations. Both questions relate to the nature of asthma as a chronic disease requiring chronic therapy. Due to the low number of children who have other chronic medical conditions and the episodic nature of many children’s asthma attacks, it may be chat the concept of “chronic” is difficult for both child (patient) and physician to relate to asthma.

At least one other study attempted to include specific asthma education in the general school curriculum. This program used peak flow meters to introduce the idea of breathing capacity but was included primarily as a tool to collect data to be used in mathematical calculations. Researchers reported the program was well received by the teacher, but the children with low peak flow values (most likely to be children with asthma) were upset with their low values and did not want to participate. In this program, the children with asthma were excited to share information with other children. These unanticipated effects of a general educational program must be included in the decision to consider use of a general program vs. one aimed only at children with known asthma.

Educational programs aimed only at children with known asthma have been assessed and reported previously. These programs are presented to a limited group of children as pull-out programs. They often deal with both general asthma knowledge and asthma self-management skills, and they have demonstrated an improvement in children’s self-efficacy and asthma self-management index. Goals for these programs are much different than the use of this asthma education program as an enhancement to the school’s general health education curriculum. Few comparisons can be made in results or purpose across the studies. This pilot study has its limitations. The sample size was small and limited to one school. Though this population of students represented the most racially diverse school within Olmsted County, it still was more than 70% White and middle class. Most children had home computers and experience with other computer games that may have increased their ability to learn from the CD-ROM game. The high level of asthma knowledge prior to the intervention also may be unusual but would lessen the measured impact of the intervention.

CONCLUSION

CD-ROM or computer-based education is not a new concept. Other computer-based asthma education programs have been tested, primarily in the ambulatory care setting. CD-ROM educational programs in other areas of science such as math have been evaluated and integrated into the school curriculum. However, this pilot study represents one of the first to assess educational impact and acceptability of an asthma-related CD-ROM education program presented as part of the general health education curriculum.

It would be useful to compare outcomes of this general asthma educational program and special pull-out programs aimed only at children with asthma. Outcomes of interest would include self-efficacy of children with asthma, comfort of children with asthma in providing self-care during school, acceptance of asthma-related temporary disability by children without asthma, and enhanced understanding by all children regarding the triggers of asthma.

![Figure 3](image-url)
Table 1: Symptoms of Asthma

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Percentage of Children Experiencing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shortness of breath</td>
<td>45%</td>
</tr>
<tr>
<td>Wheezing</td>
<td>32%</td>
</tr>
<tr>
<td>Chest tightness</td>
<td>28%</td>
</tr>
<tr>
<td>Nocturnal symptoms</td>
<td>24%</td>
</tr>
<tr>
<td>Fatigue</td>
<td>20%</td>
</tr>
<tr>
<td>School absenteeism</td>
<td>16%</td>
</tr>
</tbody>
</table>

References