APPENDIX

Air Quality Index and Childhood Asthma: A pilot randomized clinical trial intervention

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Appendix Table 1: Primary outcomes displaying one-sided P value

Outcome	Had at least one during study				Within Group Change		Between Group Difference	
	At least one during study, N (%)	Risk difference (95% CI)	Risk ratio (95% CI)	P	OR[a] (95% CI)	P	ROR[b] (95% CI)	P
Severe asthma exacerbations								
Control	5 (25)	0.05	1.25	0.50	0.61 (0.23, 1.61)	0.16	0.51	0.29
Intervention	4 (20)	(-0.21, 0.31)	(0.39, 3.99)		0.31 (0.03, 2.76)	0.15	(0.05, 5.68)	
Moderate asthma exacerbations								
Control	13 (65)	0.05	1.08	0.37	0.50 (0.27, 0.91)	**0.01**	0.47	0.15
Intervention	12 (60)	(-0.25, 0.35)	(0.67, 1.75)		0.23 (0.06, 0.86)	**0.02**	(0.11, 1.95)	

Outcome	Mean (SE)					Within Group Change		Between Group Difference	
	Exit	Δ Exit-Rand	P	Unadjusted β (SE)	P	Estimate (95% CI)	P	Estimate (95% CI)	P
Asthma Control Test (ACT)									
Control (n=13)	21.1 (3.8)	0.15 (2.5)	**0.02**	1.85 (0.93)	**0.03**	0.17 (-1.17, 1.51)	0.40	1.85	**0.02**
Intervention (n=13)	23.2 (1.6)	2.00 (2.2)				2.02 (0.88, 3.15)	**0.001**	(0.09, 3.61)	
Childhood Asthma Control Test (CACT)									
Control (n=7)	22.9 (4.3)	0.29 (3.5)	0.47	1.38 (2.18)	0.27	-0.31 (-1.87, 1.25)	0.35	4.27	0.07
Intervention (n=7[c])	25.2 (1.9)	1.67 (4.4)				3.96 (-1.27, 9.20)	0.07	(-1.19, 9.73)	
Pediatric Asthma Quality of Life Questionnaire (PAQLQ)									
Control	6.20 (0.9)	0.25 (0.7)	0.24	0.18 (0.21)	0.21	0.25 (-0.06, 0.55)	0.06	0.30	0.10
Intervention	6.65 (0.4)	0.42 (0.6)				0.54 (0.20, 0.88)	**0.001**	(-0.16, 0.75)	

Notes: For exit and Δ Exit-Rand analyses for asthma exacerbations and asthma control outcomes n=39, and n=40 for analyses within and between groups. For PAQLQ which was obtained at 2 visits, all analyses n=39. Models were not adjusted for other variables. P value of risk difference and risk ratio obtained from Fisher Exact Test or X^2, where appropriate. P value for Δ Exit-Rand obtained from Wilcoxon rank sum. Within group change obtained from generalized linear models adjusting for correlation between values including interaction term (between group difference). For asthma exacerbations (both severe and moderate), estimates obtained are from visit 2 -7 (no randomization values) and are adjusted for visit 2 values. Boldface indicates statistical significance (P<0.05) [a]Within-group changes for binary outcomes are quantified by odds ratios (OR); within a given group, OR=λ indicates that the odds of outcome at study exit are λ times the odds of outcome at baseline. [b]Between-group differences are quantified by ratios of odds ratios (ROR); a ROR=γ indicates that the OR for intervention participants is γ times the OR for controls.[c]N=6 for exit and Δ Exit-Rand, n=7 for analyses within and between groups.

Appendix Table 2: Secondary outcomes

Outcome	At Exit		At least once during the study			Within Group Change		Between Group Difference	
	Exit N (%)	P	Risk difference (95% CI)	Risk ratio (95% CI)	P	OR[a] (95% CI)	P	ROR[b] (95% CI)	P
Checked AQI prior to outdoor activity, yes[c]									
Control	3 (15)	**0.003**	-0.50	0.47	**0.001**	0.94 (0.45, 1.96)	0.87	7.31	**0.01**
Intervention	12 (63)		(-0.74, -0.26)	(0.29, 0.78)		6.89 (1.85, 25.6)	**0.004**	(1.62, 32.9)	
Reported any change in outdoor activity in response to AQI, yes[d]									
Control	2 (10)	0.06	-0.40	0.56	**0.01**	0.34 (0.08, 1.47)	0.15	2.79	0.26
Intervention	7 (37)		(-0.66, -0.14)	(0.35, 0.88)		0.96 (0.35, 2.68)	0.94	(0.47, 16.5)	
Outdoor moderate or vigorous physical activity for 10 minutes at least once/week[e]									
Control	9 (45)	0.52	--[f]	--[f]	--[f]	0.42 (0.24, 0.76)	**0.004**	0.29	**0.03**
Intervention	7 (35)					0.13 (0.05, 0.31)	**<0.0001**	(0.10, 0.87)	

Notes: N=39 for exit analyses, and n=40 for analyses within and between groups. Within group change obtained from generalized linear models adjusting for correlation between values including interaction term (between group difference). P value of risk difference and risk ratio obtained from Fisher Exact Test or X^2, where appropriate. Boldface indicates statistical significance (P<0.05)

[a]Within-group changes for binary outcomes are quantified by odds ratios (OR); within a given group, OR=λ indicates that the odds of outcome at study exit are λ times the odds of outcome at study start.

[b]Between-group differences are quantified by ratios of odds ratios (ROR); a ROR=γ indicates that the OR for intervention participants is γ times the OR for controls.

[c]Question read to participant: "In the past 4 weeks, did you check the air quality index before going outside to be active?" Choices: yes, no

[d]Question read to participant: "In the past 4 weeks, how many times did you change your outdoor activity because of the air quality index?" Choices: All of the time, most of the time, some of the time, a little of the time, none of the time. Responses were coded yes if the answer was not "none of the time".

[e]Questions read to participant: Section heading- "For the following questions please think about the activities you do outside only. Do not count any activity that you do indoors. Think about the activities you've done in the last month." (1) "In a typical week do you do any vigorous-intensity sports, fitness, or recreational activities that cause large increases in breathing or heart rate like running or basketball for at least 10 minutes continuously outside?" Choices: yes, no, refused, don't know. (2) "In a typical week do you do any moderate-intensity sports, fitness, or recreational activities that cause small increases in breathing or heart rate such as brisk walking, bicycling, swimming, or volleyball for at least 10 minutes continuously outside?" Choices: yes, no, refused, don't know. Answers of no, refused, don't know were coded as negative.

[f]all participants reported moderate or vigorous activity for at least 10 minutes once a week at least once during the study, thus unable to calculate risk difference and ratio.

Appendix Table 3: Daily Air Quality Index during the study period and corresponding recommendations

AQI Category	Color Category	Number of days (%)	Description of Air Quality[a]	Behavioral Recommendations[b]
Good	Green	131 (52%)	Air quality is satisfactory, and air pollution poses little or no risk.	Great day to be active outside!
Moderate	Yellow	113 (45%)	Air quality is acceptable. However, there may be a risk for some people, particularly those who are unusually sensitive to air pollution.	Good day to be active outside! Students who are usually sensitive to air pollution could have symptoms.
Unhealthy for sensitive groups	Orange	8 (3%)	Members of sensitive groups may experience health effects. The general public is less likely to be affected.	It's OK to be active outside, especially for short activities such as recess and physical education (PE). For longer activities such as athletic practice, take more breaks and do less intense activities. Watch for symptoms and take action as needed. Students with asthma should follow their asthma action plans and keep their-quick relief medicine handy.
Unhealthy	Red	0 (0%)	Some members of the general public may experience health effects; members of sensitive groups may experience more serious health effects.	For all outdoor activities, take more breaks and do less intense activities. Consider moving longer or more intense activities indoors or rescheduling them to another day or time. Watch for symptoms and take action as needed. Students with asthma should follow their asthma action plans and keep their-quick relief medicine handy.
Very Unhealthy	Purple	0 (0%)	Health alert: The risk of health effects is increased for everyone.	Move all activities indoors or reschedule them to another day
Hazardous	Maroon	0 (0%)	Health warning of emergency conditions: everyone is more likely to be affected.	

Notes: Daily AQI represents AQI for ozone and particulate matter <2.5μm during the study period, July 14th 2020 thru March 22nd, 2021, for Pittsburgh, PA Core Based Statistical Area. Total days= 252, median AQI (Interquartile range)= 50 (40, 61). Data obtained from https://www.epa.gov/outdoor-air-quality-data/air-data-daily-air-quality-tracker, accessed 10/11/2022. [a]Description of air quality obtained from https://www.airnow.gov/aqi/aqi-basics/, accessed on 10/11/2022. [b]Behavioral recommendations are from Air Quality and Outdoor Activity Guidance for Schools, available https://www.airnow.gov/sites/default/files/2021-03/school-outdoor%20activity%20guidance.pdf, accessed on 10/11/2022. The School guide recommends to watch for symptoms includes coughing, wheezing, difficulty breathing, and chest tightness. If symptoms are noticed, it is recommended the student might need a break, do a less intense activity, stop all activity, go indoors, or use quick-relief medicine.

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Appendix Figure 1: Asthma action plan received by all participants

Asthma Action Plan

Name: _____ **Birthdate:**_____ **Date:** _____

Goals for asthma care:

- Full participation in all desired activities (okay to need albuterol before activity)
- Albuterol use two times or less a week (not counting use with exercise)
- Cough interfering with sleep no more than 2 nights a month
- Oral steroids (usually pill or liquid) no more than once a year
- No hospitalizations for asthma

GREEN ZONE: No asthma symptoms. You are able to do usual activities and sleep without difficulty.

1.Take controller medicines every day

Medicine	Amount	How often

Remember (1) to rinse your mouth or brush your teeth after taking your inhaled controller medicine to reduce the risk of thrush, (2) to get a new inhaler each month and (3) the inhaler doesn't work well if you miss doses.

YELLOW ZONE: YOU have asthma symptoms! Asthma symptoms can include:

•Cough •Wheeze •Shortness of breath •Chest tightness

1. Start rescue medicine Medicine (prime it first, if needed)	Amount	How often
Albuterol	2-4 puffs with spacer	Every 4 hours as needed

2. If your symptoms are not improving or worsening, call your doctor or nurse.

3. Remember to continue to take your green zone medicine

It is not uncommon to need albuterol during a cold, continue albuterol every 4-6 hours as needed for up to 5 days. Remember to keep taking your green zone medicines

RED ZONE: Asthma symptoms may be severe or not responding to yellow zone treatments.

Symptoms may include:

•very short of breath • fast breathing • non-stop coughing • the skin may be pulling between the ribs or around the neck.

1. Increase rescue medicine Medicine (prime it first, if needed)	Amount	How often
Albuterol	4 puffs with spacer	Every 4 hours

2. If you've given albuterol 4 puffs and it didn't help → give another albuterol 4 puffs in 20 minutes.

- **If symptoms don't improve, call 911 OR go to nearest emergency room.**
- **If your symptoms improve, continue to take albuterol every 4 hours.**
- **If your symptoms improve but you need albuterol more frequently, for example every 2 hours, call your doctor or nurse immediately. If you can't talk to your doctor or nurse immediately, call 911 OR go to the nearest emergency department.**

Footnote: All participants received an asthma action plan completed by the principal investigator based upon medications reported by the participant's parent/legal guardian and confirmed either by chart review or by the participant's asthma care provider.

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Appendix Figure 2: Air Quality Index (AQI) script research coordinators used to provide AQI education to all participants.

AQI EDUCATION:

[Note to RC: do not provide AQI education/intervention until after participants (parent & child) have completed the AQI intake questionnaire].

1. FOR ALL PARTICIPANTS- Research Coordinator will read:

"The Air Quality Index, called the AQI, is an index that tells you how clean or polluted the air is. Its purpose is to help you understand what the air quality means for your health.

Ground-level ozone and particle pollution are threats to health. Some cities, like Pittsburgh, report the AQI for ozone and particles. When checking the AQI, use the highest category to determine your health risk.

The AQI is reported hourly, as the AQI can change during the day.

To learn more, visit the EPA website airnow.gov."

2. FOR ALL PARTICIPANTS- Research coordinator will read AQI page as on back of AAP+AQI:

Research coordinator will say: "Let's think about outdoor activity in children with asthma" as a transition.

RC to read asthma checklist

Research Coordinator to review AQI table but does not need to read in entirety. Provide general overview such as the AQI is a range from 0 to 500, with 0 being cleanest and 500 being most polluted. Note that categories are color coded and have corresponding recommended behavioral change. RC to tell family these are also available online.

RC to review each information point (information below AQI table) with participants. Key points to ensure participants understand is that it is good to be active outdoors and that asthma symptoms can happen even on days when the air quality is good.

3. FOR INTERVENTION GROUP ONLY:

RC will assist family with locating airnow app for smartphone. Parent/participant will download onto smart phone. If the parent/participant does not have a smart phone or does not wish to download app, parent or participant will be asked to navigate to airnow.gov on computer. RC will ask parent/participant to pull up current AQI either on app or internet. RC will provide feedback based on AQI category—for example, if AQI is green RC will point to AQI chart on AAP to identify green category and recommended behavioral intervention.

Adapted from https://airnow.gov/index.cfm?action=aqibasics.aqi, accessed 01_29_2020.

Footnote: RC=research coordinator, AQI= Air Quality Index, AAP=asthma action plan, "back of AAP+AQI" refers to Appendix Figure 3.

Appendix Figure 3: Air Quality Index (AQI) information used for education and provided in physical form to the intervention group.

Asthma checklist before going outside:

☑ ALWAYS keep your rescue inhaler (& spacer) handy

☑ Check the air quality index (AQI):
airnow.gov **OR** Airnow smartphone app

☑ Watch for symptoms: cough, wheezing, difficulty breathing, chest tightness.

☑ If you have symptoms, this is a sign to take it easy. Follow your yellow zone & consider: limiting time outside, increasing the number of breaks, do less intense activities, stop activity, or go indoors.

AQI	AQI #	What to do:
Good	0-50	No action required. A good day to be active outside!
Moderate	51-100	Children who are unusually sensitive to air pollution could have symptoms. If so, take steps to reduce prolonged or heavy exertion.
Unhealthy for sensitive groups	101-150	Ok to be active outside for short activities. For longer activities take more breaks & do less intense activities. Reduce prolonged or heavy outdoor exertion.
Unhealthy	151-200	Move longer or more intense activities indoors. Avoid prolonged or heavy exertion outdoors- a good day to work out in the gym.
Very Unhealthy	201-300	Move activities indoors. Avoid all physical activity outdoors.
Hazardous	301-500	Stay indoors and keep activity levels low. Keep windows closed and avoid frying/broiling on these days.

- Air pollution can make asthma symptoms worse and trigger attacks. Asthma symptoms can happen even on days when the air quality is good. Always keep your rescue inhaler handy.
- Exercising on days when air pollution is bad can mean more air pollution in your lungs. Changing your activity level can help. For example, take a walk instead of a run. Changing how long you spend outside exercising can also help. For example, don't stay outside as long.

Plan activities when and where pollution is lower:

- Ozone is usually higher on hot summer days in the afternoon & early evening. On days ozone is high, plan your outdoor activities in the morning.
- Particulate pollution can be higher in certain places. Try to avoid exercising where particles are higher. Examples: near busy roadways, during rush-hour traffic, near industrial areas, and when there is smoke in the air.

Don't let asthma keep you from being active. The CDC recommends 60 minutes of physical activity a day. If asthma is limiting your activity, talk to your doctor!

Footnote: All participants were provided with a physical (paper) copy of their asthma action plan (Appendix Figure 1). The intervention group received Appendix Figure 3 in print on the back of their asthma action plan.

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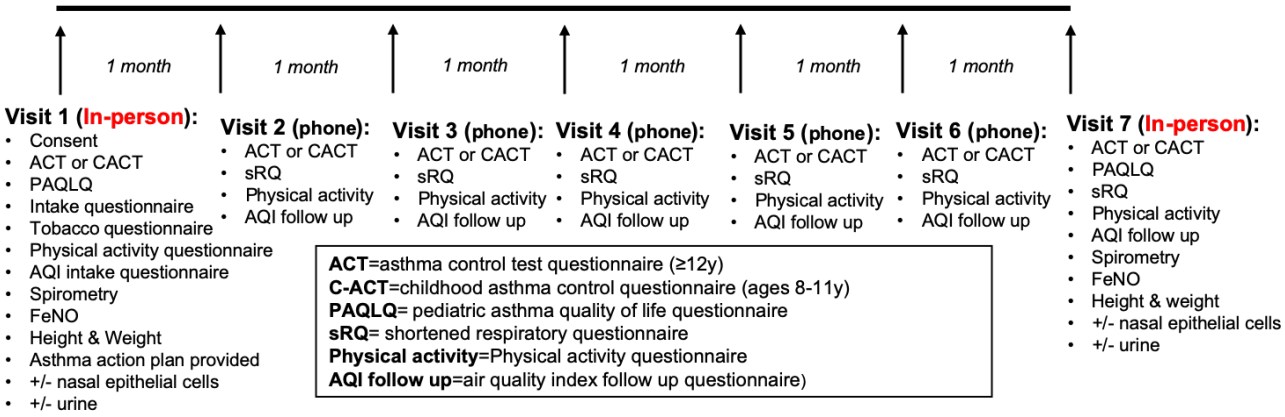
Appendix Figure 4: Description of study procedures by visit



Footnote: ACT and C-ACT are validated asthma control questionnaires. ACT was completed by the participant, C-ACT was completed by both the caregiver and participant. The range of scores is 5-25 for ACT and 0-27 for C-ACT. For both, scores 19 or less indicate poor asthma control and in general, higher scores indicate better asthma control. PAQLQ(S) is a validated pediatric asthma quality of life questionnaire. It was administered verbally by the research coordinators to the participants. The range of PAQLQ scores is from 1-7, with 7 representing no impairment and 1 indicating severe asthma impairment. sRQ is a questionnaire developed to capture the presence and number of severe asthma exacerbations in the prior 4 weeks and the presence of any moderate exacerbation. It was completed by either the caregiver or participant. The physical activity questionnaire was completed by either the caregiver or participant. Research coordinators were instructed to have same person complete the form for all visits with preference for participant completion. The AQI follow up was a questionnaire developed to capture usage of the AQI and was administered to participants.