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## Supplemental Material

# Randomized Trial of Interventions to Improve Childhood Asthma in Homes with Wood-burning Stoves

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## Table of Contents

**Detailed description of interventions**

*Wood Stove Changeout Arm*. Older model wood stoves were changed out and replaced with EPA-certified wood stoves. The new stoves were all certified as low-emission according to EPA standards (produces < 5 grams of particulate matter per hour). EPA-certified wood stoves were purchased and installed by certified technicians within the western Montana study areas. In some cases, new hearth pads and venting packages were provided to the residences to meet code. Following installation, a contracted wood stove expert conducted specific training on best burn practices within the home, and verified the successful installation of the new stoves. The new stoves were installed during the fall (following the pre-intervention winter) prior to the start of the post-intervention winter.

*Air Filtration Unit Arm.* A Filtrete Ultra Clean Air Purifier (3M, St. Paul, MN) was placed in the same room as the wood stove (20 ft x 18 ft). In addition, a smaller Filtrete unit (17 ft × 10 ft) was placed in the child's bedroom. These units are rated by their ability to provide an equivalent amount of contaminant free air into a given room size, and have a Clean Air Delivery Rate (CADR) of 112. The filters in these units are approximately 85% efficient at removing 0.2 μm particles (cigarette smoke size particles) and over 95% efficient at removing 3 μm particles. Residents were instructed to operate the units on the “high” setting throughout the duration of the post-intervention winter period. Filters were replaced by study personnel approximately once per month to maximize collection efficiency. Kilowatt meters attached to each unit measured the amount of usage. Kilowatt hour readings were recorded up to four times during the post-intervention winter, with percent compliance for each home estimated by dividing the observed kilowatt hours used by the expected usage. The expected kilowatt hour usage for the large filtration unit (room size of 20 ft x 18 ft) was determined in the laboratory while operating on the “high” setting.

*Placebo Arm.* Similar to the Air Filtration Unit intervention, a larger Filtrete unit (for room size 20 ft x 18 ft) was placed in the same room as the wood stove, and a smaller unit (17 ft × 10 ft) was placed in the child's bedroom. Instead of a high efficiency filter, the units were fitted with placebo filters. The placebo filters used in the Filtrete devices were manufactured at the University of Montana using a porous, fiberglass filter media. Compliance was assessed with the kilowatt meters as above. Upon completion of the study, placebo-assigned homes were provided with the appropriate filters to restore the air cleaning functionality of the unit.

**Methods for determining asthma severity**

Based on the 2007 NHLBI guidelines (National Heart Lung and Blood Institute 2007) for ages greater than or equal to five years, children were classified as having intermittent or persistent asthma with further characterization of mild, moderate or severe asthma within the persistent class. Reporting of symptoms and activity limitation, frequency of rescue medication usage and peak flow monitoring data collected during multiple two-week health measure sampling visits. We used the baseline (pre-intervention) winter two-week sampling measure that indicated the most severe impairment for a given component of asthma severity classification. The 2007 NHLBI asthma severity classifications are defined by daily, weekly and monthly criteria for the different component measures. Accordingly, our two-week data on symptoms, activity limitations or medication usage were translated to these metrics where possible. For daytime symptoms we captured presence or absence of daytime symptoms rather than frequency of symptoms within day, so we were unable to distinguish between moderate and severe daytime symptoms according to the criteria. In this circumstance we recorded the subject as having moderate symptoms. The 2007 NHLBI classification uses qualitative metrics for the activity limitation component, and we interpreted these categories as follows for our two-week reporting of activity limitation due to asthma: 0 days = none; 1-2 days = minor; 3-12 day = some limitation; 13-14 days = extremely limited. Classification according to lung function measure cutpoints was based on average percent predicted $FEV_1$ and PEF for the two-week period indicating most severe impairment. As we did not collect forced vital capacity (FVC), we were unable to classify according to $FEV_1$/FVC. Per the guidelines, an overall severity classification was based on the most severe impairment in any of the component measures. For overall severity classification of subjects and severity classification according to specific components see Table S1.

**Table S1.** Characterization of asthma severity among participants according to 2007 NHLBI guidelines, based on frequency of each component.

| Components of Severity | Classification of Asthma Severity | | | |
|---|---|---|---|---|
| | Intermittent | Persistent | | |
| | | Mild | Moderate | Severe |
| Overall† | 8 | 5 | 51 | 50 |
| Daytime symptoms | 38 | 55 | 21 | ‡ |
| Nighttime awakenings | 53 | 7 | 53 | 15 |
| Short acting beta agonist use | 74 | 18 | 7 | 15 |
| Interference with normal activity | 31 | 18 | 55 | 10 |
| Forced expiratory volume in first second ($FEV_1$) | § | 42 | 39 | 33 |
| Peak expiratory flow (PEF) | § | 52 | 44 | 18 |

† Overall classification of severity is based on the most severe impairment category in which any feature occurs.

‡ Captured only presence or absence of daytime symptoms rather than frequency of symptoms within day, so unable to distinguish between moderate and severe.

§ Unable to distinguish between intermittent and mild for $FEV_1$ or PEF > 80 percent.

**Table S2.** Pre- to post-intervention mean changes (95% CI) for treatments relative to placebo, adjusted for age, gender, baseline measures and amient temperature (n = 114 subjects)[a]

| | Adjusted for baseline measure | | Adjusted for ambient temperature | | Adjusted for baseline measures and ambient temperature | |
|---|---|---|---|---|---|---|
| Outcome | Wood Stove Changeout | Air Filter | Wood Stove Changeout | Air Filter | Wood Stove Changeout | Air Filter |
| PAQLQ | | | | | | |
| Overall | 0.18 (-0.27, 0.64) | -0.06 (-0.42, 0.30) | 0.15 (-0.35, 0.65) | -0.10 (-0.49, 0.30) | 0.17 (-0.29, 0.62) | -0.08 (-0.44, 0.28) |
| Symptoms | 0.39 (-0.11, 0.89) | -0.04 (-0.44, 0.36) | 0.37 (-0.18, 0.92) | -0.06 (-0.50, 0.37) | 0.39 (-0.11, 0.89) | -0.05 (-0.45, 0.35) |
| Limitation of Activity | 0.13 (-0.42, 0.68) | -0.23 (-0.67, 0.21) | 0.07 (-0.55, 0.69) | -0.29 (-0.78, 0.19) | 0.09 (-0.47, 0.66) | -0.26 (-0.71, 0.20) |
| Emotion | -0.09 (-0.54, 0.35) | -0.02 (-0.37, 0.33) | -0.13 (-0.63, 0.37) | -0.07 (-0.47, 0.33) | -0.12 (-0.56, 0.33) | -0.04 (-0.40, 0.31) |
| Two-week spirometry monitoring | | | | | | |
| Evening $FEV_1$ % predicted | 2.9 (-5.8, 12) | 0.16 (-6.8, 7.1) | 2.8 (-7.4, 13) | 0.32 (-7.8, 8.4) | 2.7 (-6.1, 12) | 0.02 (-7.0, 7.1) |
| Morning $FEV_1$ % predicted | 3.5 (-5.3, 12) | -0.53 (-7.6, 6.5) | 3.6 (-6.8, 14) | -0.63 (-8.9, 7.6) | 3.5 (-5.4, 12) | -0.67 (-7.8, 6.5) |
| Evening PEF % predicted | 6.7 (-1.6, 15) | 2.2 (-4.5, 8.9) | 6.6 (-2.7, 16) | 2.0 (-5.5, 9.5) | 6.1 (-2.3, 14) | 1.6 (-5.2, 8.4) |

| | | | | | | |
|---|---|---|---|---|---|---|
| Morning PEF % | 7.4 | 3.3 | 7.5 | 3.0 | 7.0 | 2.6 |
| predicted | (-0.84, 16) | (-3.3, 9.9) | (-1.9, 17) | (-4.6, 11) | (-1.2, 15) | (-4.0, 9.3) |
| Diurnal PEF | -2.7 | -4.4 | -2.9 | -3.8 | -2.6 | -4.4 |
| variability, % | (-6.8, 1.5) | (-7.8, -1.1) | (-7.7, 1.9) | (-7.7, 0.12) | (-6.8, 1.6) | (-7.8, -1.0) |

PAQLQ = Pediatric Asthma Quality of Life; $FEV_1$ = forced expiratory volume in first second; PEF = peak expiratory flow.

[a] Missing observations for models with ambient temperature: n = 10 for PAQLO measures; n = 9 for peak flow measures.

**Table S3.** Pre- to post-intervention changes for treatments relative to placebo, adjusted for age and gender, for primary subjects only (n = 97 subjects).

| Outcome | Observations | Wood Stove Changeout Mean Change (95% CI) | Air Filter Mean Change (95% CI) |
|---|---|---|---|
| PAQLQ | | | |
| Overall | 359 | 0.37 (-0.18, 0.93) | -0.13 (-0.56, 0.29) |
| Symptoms | 359 | 0.56 (-0.07, 1.2) | -0.14 (-0.62, 0.34) |
| Limitation of Activity | 359 | 0.47 (-0.18, 1.1) | -0.23 (-0.73, 0.27) |
| Emotion | 359 | 0.07 (-0.48, 0.63) | -0.08 (-0.50, 0.35) |
| Two-week spirometry monitoring | | | |
| Evening $FEV_1$ % predicted | 349 | -1.2 (-12, 9.9) | 0.74 (-7.7, 9.2) |
| Morning $FEV_1$ % predicted | 351 | -1.7 (-13, 9.8) | -0.88 (-9.6, 7.8) |
| Evening PEF % predicted | 350 | 3.1 (-6.2, 12) | 3.3 (-3.9, 10) |
| Morning PEF % predicted | 352 | 2.6 (-7.6, 13) | 2.9 (-4.9, 11) |
| Diurnal PEF variability, % | 347 | -0.52 (-5.7, 4.6) | -3.2 (-7.2, 0.80) |

PAQLQ = Pediatric Asthma Quality of Life; $FEV_1$ = forced expiratory volume in first second; PEF = peak expiratory flow.

**References**

National Heart Lung and Blood Institute. 2007. Expert Panel Report 3: Guidelines for the diagnosis and management of asthma. NIH publication 07-4051. Bethesda, MD:National Heart, Lung, and Blood Institute.