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# "You can feel the fresh air … " Rural Alaska Native household perceptions of home air purifiers and health

Madilyn Short[a,b], Jennifer Dobson[b,c], Gretchen Day[b], Brian Lefferts[c], Rosalyn Singleton[b] and James Keck [a,b]

[a]WWAMI School of Medical Education, University of Alaska Anchorage, Anchorage, AK, USA; [b]Department of Research Services, Alaska Native Tribal Health Consortium, Anchorage, AK, USA; [c]Office of Environmental Health and Engineering, Yukon-Kuskokwim Health Corporation, Bethel, AK, USA

**ABSTRACT**

Alaska Native and American Indian children experience frequent respiratory illness. Indoor air quality is associated with the severity and frequency of respiratory infections in children. High efficiency particulate air (HEPA) purifiers effectively improve indoor air quality and may protect respiratory health. In 2019, the Yukon-Kuskokwim Health Corporation implemented a pilot programme that provided education and HEPA purifiers to households of children with chronic lung conditions. The team evaluated HEPA purifier acceptability and use by interviewing representatives from 11 households that participated in the pilot programme. All interviewees reported improvement in their child's health, and some believed that the health of other household members was also improved because of the HEPA purifier. Interviewees reported that the HEPA purifiers were easy to use, quiet, and not expensive to run. Five of 11 households were still using the HEPA purifier at the time of the interview, which was about three years after receipt of the unit. The most common reasons for discontinuing use were equipment failure and lack of replacement filter, suggesting that programme support could increase sustainability. Our evaluation suggests that HEPA purifiers are acceptable and feasible for use in rural Alaska Native households.

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## Introduction

Acute respiratory infections such as bronchiolitis and pneumonia are the most common cause of hospitalisation for children less than 2 years of age in the United States [1]. Children hospitalised with respiratory infections are at high risk for recurrent respiratory symptoms. Alaska Native children in Alaska's Yukon-Kuskokwim (YK) Delta region (Figure 1) experience a high burden of acute and chronic respiratory disease. The lower respiratory tract infection (LRTI) hospitalisation rate for children in YK Delta children is 7-fold higher than that of the general U.S. child population, and the pneumonia hospitalisation rate is 10-fold higher [2–4]. Early childhood LRTIs can have significant impact on adult respiratory health and drive high rates of chronic lung disease [5].

Studies have shown that a variety of environmental exposures, such as household crowding, lack of running water, and indoor air pollution contribute to high rates of childhood bronchiolitis and pneumonia [6–9]. Indoor particulate air pollution in the region comes primarily from wood stove use and tobacco smoke, both of which are associated with increased severity and more frequent respiratory infections in children [8,10–14] Nearly 60% of rural Alaska homes lack adequate ventilation, which contributes to poor indoor air quality and moisture build-up [15–17]. Indoor air pollution increases respiratory infection duration and frequency of symptoms following respiratory tract infection [18].

Previous studies have also shown that identifying and eliminating environmental triggers and providing education on indoor air quality may reduce respiratory symptoms [19–21]. High efficiency particulate air (HEPA) purifiers effectively reduce indoor particulate matter (PM) concentrations and improve air quality [22,23], and limited studies have shown respiratory health benefits [24]. Furthermore, HEPA purifiers are cost-effective, portable, commercially available, and easy to operate.

This study was performed in Alaska's YK Delta, a region comprised primarily of Alaska Native Yup'ik people who receive health care through the Yukon-Kuskokwim Health Corporation (YKHC). In 2019, the YKHC Office of Environmental Health & Engineering

**CONTACT** James Keck jwkeck@anthc.org Department of Research Services, Alaska Native Tribal Health Consortium, 3900 Ambassador Dr., Anchorage, AK 99508
*Co-senior authors; contributed equally to the study.
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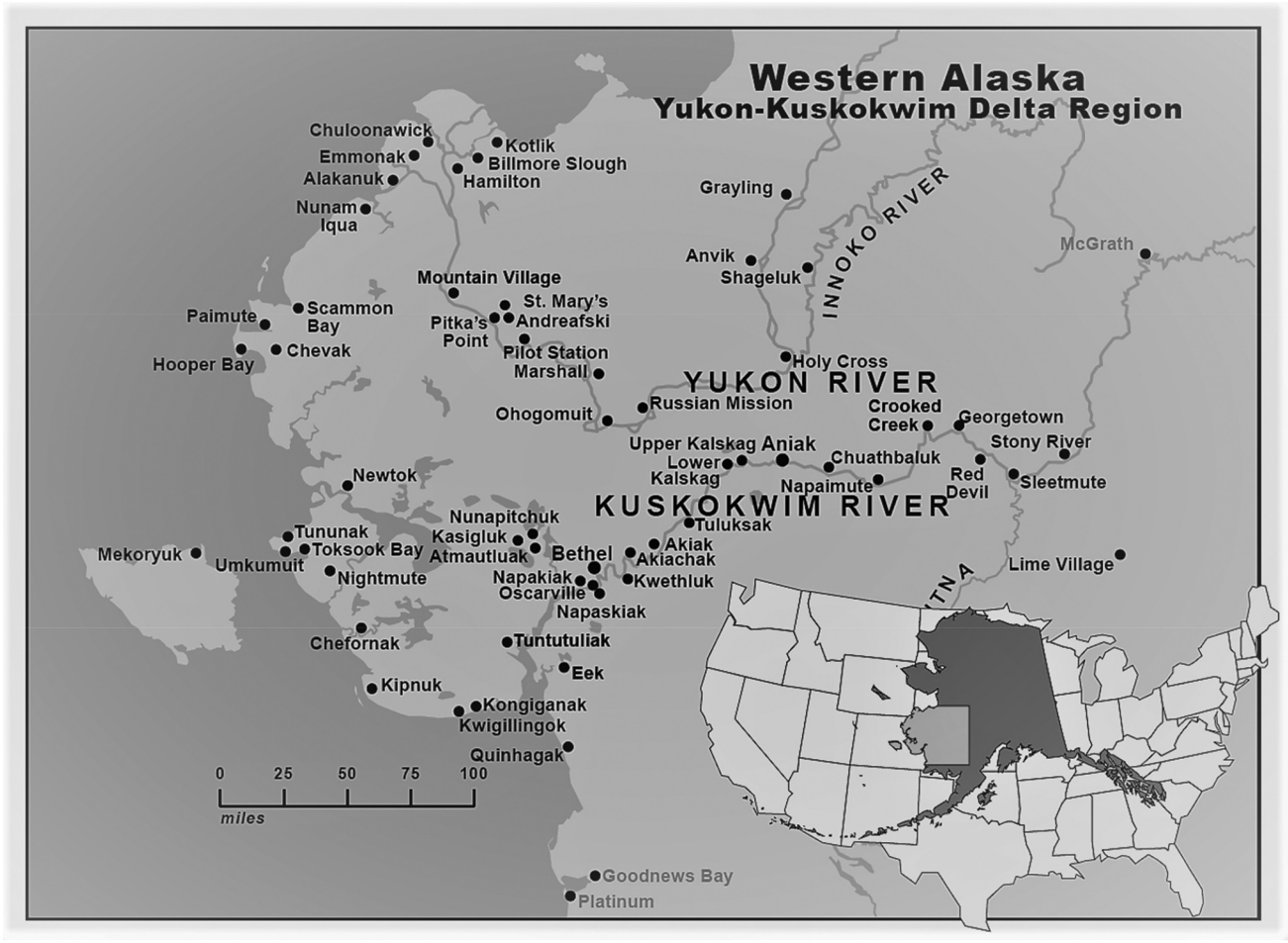


**Figure 1.** Map of the Yukon-Kuskokwim Health Corporation service area.

(OEHE) piloted a HEPA purifier project that provided education and HEPA purifier units to households of children with chronic lung conditions. The study team interviewed family members who participated in the pilot project to learn about the acceptability, feasibility, and perceptions of a home-based HEPA purifier approach to protect lung health in rural Alaska Native households.

## Methods

### *Study population*

This study was conducted in the YK Delta region, which encompasses 195,000 square kilometres of southwestern Alaska. The region's population of approximately 28,000 people is comprised primarily of Yup'ik Alaska Native people who live in about 6,500 households across 50 remote villages and the regional hub town of Bethel [25]. Pre-paid healthcare implemented under the federal Indian Health Service is provided to all Alaska Native people through YKHC at the YK Delta Regional Hospital and at primary care clinics in YK Delta village communities. Patients requiring tertiary care are transported to the Alaska Native Medical Center in Anchorage. The YK Delta communities are connected by air, water, and snowmobile, with no road access to the remainder of Alaska.

### *HEPA purifier pilot project*

During paediatric pulmonary field clinics at YKHC during spring 2019 – spring 2020, high-risk paediatric patients (with bronchiectasis and other chronic lung conditions) were invited to join a pilot programme involving a HEPA purifying unit and targeted education. After each pulmonology appointment, the nurse case manager provided a programme flyer and delivered a script to patients/families, inviting them to meet with OEHE staff. OEHE staff met with interested families with children aged 1–12 years during the pulmonary field clinic visit. For families that chose to enrol in the pilot programme, OEHE staff collected baseline household characteristics and risk factors for respiratory

illness, such as tobacco use, house ventilation, heating and cooking fuel types, household occupancy, and piped water. Staff provided educational cue cards (adapted from the AIR MATTERS Toolkit developed by the Tribal Healthy Homes Network) and information on HEPA purifier use [26]. HEPA purifying units and toolkits were mailed to participating homes. The HEPA purifier unit distributed was a Winix model 5500–2, a medium-sized purifier (38 × 21 × 60 cm) with multiple stages of filtration including a pre-filter, washable carbon filter, and HEPA filter. The unit filters out mould spores, allergens, and dust from the air. It was widely available for purchase for $160–190 and two replacement HEPA filters cost $37. The manufacturer recommends replacing the HEPA filter every 12 months under normal use. The Healthy Homes Toolkit included a collection of items customised for each home, such as a carbon monoxide detector, allergen impermeable pillows and mattress covers, stove thermometer, firewood moisture metre, bed bug interceptors, and lead test kits. The OEHE staff included environmental health professionals with Registered Environmental Health Specialist credentials [27] that had completed additional training on indoor air quality and healthy homes. Oversight was provided by a registered Healthy Homes Specialist and a multidisciplinary team with environmental health, applied research, and clinical expertise.

A total of 19 patients and their families enrolled in the pilot project between 2019 and the spring of 2020 in coordination with three paediatric pulmonology field clinics at the YK Delta Regional Hospital. Baseline questionnaires were conducted in person during pulmonary clinic visits by OEHE staff who recorded responses on a paper form. Enrolled households agreed to be contacted for a follow-up evaluation. The follow-up evaluation was delayed two years because of the COVID-19 pandemic.

### *Evaluation design and data collection*

Team members conducted semi-structured interviews over the telephone with families who participated in the YKHC HEPA Purifier Pilot Project to identify factors that were associated with increased or decreased compliance and duration of HEPA filtration use. The interview guide was developed by the YKHC OEHE team during project conception in 2019 and included questions about HEPA purifier usage, barriers to use, noise and cost concerns, purifier maintenance, and perceptions of HEPA purifier-related health benefits. HEPA purifier pilot programme participants were contacted using telephone numbers they provided at programme enrolment. Contact was attempted with each household by phone up to three times. Participants provided verbal informed consent prior to the interview. Two study team members were present for each phone interview, and one of the team members took detailed notes, transcribing quotes verbatim. Phone interviews lasted approximately 15 to 25 minutes.

### *Data analysis*

Thematic analysis of interviews explored parents' experiences, perceptions, and priorities associated with HEPA purifier use. Interview notes were independently analysed by two study team members who manually coded the transcripts in Microsoft Excel 2016 (Redmond, WA). The team used a deductive approach to developing the codebook, i.e. codes, code definitions, and coding rules. The transcripts were then analysed using the established codebook by other team members. Coding was compared and discrepancies were discussed and reconciled. Transcripts were then summarised and discussed by team members to identify themes associated with HEPA purifier use and acceptability. Participant baseline demographic data and data from the household follow-up interviews were described using counts and percentages for categorical variables and medians and ranges for quantitative variables.

### *Ethics*

This study was approved by the Alaska Area IRB (#2021-08-039), the YKHC Human Studies Committee (#22.01.02), and the Alaska Native Tribal Health Consortium Human Research Review Committee.

## Results

### *Interviews*

The study team called all 19 households that enrolled in the HEPA purifier pilot programme and interviewed representatives from 11 of the 19 households. Of the 8 households that were not interviewed, 2 households were unable to schedule interviews, 1 household declined to participate, and 5 households were excluded from the evaluation because they never received a HEPA purifier ($n = 3$) or child or parent was deceased ($n = 2$). Reasons for not receiving HEPA purifiers were household move and purifier shipping issues.

### Demographics

The baseline demographics of the 11 interviewed households were similar to the 19 households that participated in the HEPA purifier pilot project (Table 1). All interview participants were parents or guardians of children residing in the YK Delta. Most interviewed households had a child aged 5–12 years (45%, $n = 5$) and more than half of the children were male (55%, $n = 6$). Wood stoves were used as a primary heat source for 18% ($n = 2$) of interviewed households, and as a secondary heating source for 45% ($n = 5$) of interviewed households. Almost three-quarters of interviewed households ($n = 8$) included a smoker; however, only 2 of these households reported that someone smoked inside the house. About half of interviewed households (55%, $n = 6$) reported ventilating their home daily, mostly using a Fresh 80 Passive Air inlet. Only one of the interviewed households was using an air purifier at baseline. The majority of interviewed households had piped water (73%, $n = 8$), and few homes had furry pets (27%, $n = 3$).

### HEPA purifier usage

All 11 interviewed households reported using the HEPA purifier and all respondents believed that the HEPA purifier improved their child's health. Most households (82%, $n = 9$) used the HEPA purifier daily, with median usage of 10 hours per day. Almost half of the households (45%, $n = 5$) were still using the HEPA purifier at the time of the interview, approximately three years after receiving it. When asked when the HEPA filter was last changed, responses included greater than or equal to six months ago (55%, $n = 6$) or unknown (45%, $n = 5$). The HEPA purifiers were located in the child's sleeping area (55%, $n = 6$) or a living room (45%, $n = 5$). HEPA purifier use by the 11 interviewed families is further described in Table 2.

### HEPA purifier perceptions

Interviewed households reported that the HEPA purifier was easy to use, quiet, cost-efficient, and beneficial to the health of their child and other family members.

### Air quality

Several respondents (45%, $n = 11$) reported generally "cleaner" air in their homes. "Air quality is different… more fresher. It's a really good filter". Some believed that the HEPA purifier increased ventilation in their home. One interviewee stated "We all notice a difference in the air quality, sometimes we put it upstairs and it feels stuffy downstairs, you can feel the fresh air when you go up". Interviewees also reported that the HEPA units improved humidity control and provided "nice" cool air in the home.

### HEPA unit operation

Interviewees mentioned a variety of characteristics of the HEPA purifying units related to their acceptability. These characteristics included electricity costs, noise, HEPA purifier unit maintenance, space considerations, and ease of use. These topics came up organically aside

**Table 1.** Characteristics of individuals and households in the HEPA purifier pilot programme, Yukon-Kuskokwim Delta.

| | Interviewed ($n = 11$) | Enrolled ($N = 19$) |
|---|---|---|
| | n (%) | n (%) |
| **Male** | 6 (55) | 12 (63) |
| **Age of child** | | |
| <5 | 3 (27) | 8 (42) |
| 5 to 12 | 5 (45) | 7 (37) |
| >12 | 3 (27) | 4 (21) |
| **Ventilation used** | 10 (91) | 17 (89) |
| **Daily ventilation** | 6 (55) | 9 (47) |
| **Primary heating system** | | |
| Woodstove | 2 (18) | 3 (16) |
| Other | 9 (82) | 16 (84) |
| **Secondary heating system** | | |
| Woodstove | 5 (45) | 8 (42) |
| Other, including none | 6 (55) | 11 (58) |
| **Household member who smokes lives in the home** | 8 (73) | 15 (79) |
| Household member smokes inside the house | 2 (18) | 2 (10) |
| Used an air purifier prior to pilot project | 1 (9) | 3 (16) |
| Furry pets in the home | 3 (27) | 5 (26) |
| Home has piped water from a community distribution system | 8 (73) | 15 (79) |

**Table 2.** HEPA purifier use by interviewed households in the HEPA purifier pilot programme, Yukon-Kuskokwim Delta, 2019–2022.

| | Households ($n = 11$ unless otherwise noted) |
|---|---|
| | n (%) |
| **Daily use of HEPA purifier** | 9 (82) |
| **HEPA filter last changed** | |
| <6 months ago | 0 |
| ≥6 months ago | 6 (55) |
| Unknown | 5 (45) |
| **Location of HEPA purifier** | |
| Child's sleeping area | 6 (55) |
| Living room | 5 (45) |
| **Using HEPA purifier at time of interview** | 5 (45) |
| **HEPA purifier setting usually used** | |
| Low | 2 (29) |
| Medium | 5 (71) |
| High | 0 |
| Unknown | 4 (36) |
| | Median (range) |
| Distance of the HEPA unit from child's sleeping area, feet ($n = 10$)* | 4 (2–10) |
| Hours the HEPA unit used each day ($n = 10$)* | 10 (0.33–24) |

*One response of unknown, ten numerical responses received.

from cost and noise, which were explicitly inquired about during the interview.

Two households (18%) reported that the HEPA unit took up too much space in their home. One family had moved, brought their HEPA purifier with them, but were unable to use it because it did not fit in their new home. This household stated, "When my son has his own room, I will let him use it again. It really helped!"

When asked what households did not like about the HEPA purifier, about half of the households (45%, $n = 5$) shared no concerns. A few households (27%, $n = 3$) raised concerns about the filtering capacity of the HEPA purifier and the need for replacement filters. An interviewee stated "It would get dirty. I would check the filter every month and it looked dirty after two months and we were only given two replacement filters". Two households (18%) shared that the HEPA purifier was easy to use, and one interviewee stated "It's easy to change [the filter]".

Interviewees were prompted specifically about cost and noise, and most households (82%, $n = 9$) did not report any cost or noise concerns during their interview. When specifically asked about the cost to run the HEPA purifier during the interviews, one household was concerned about the cost of electricity and another household was concerned about the cost of replacement filters. When asked about the noise associated with running the HEPA purifier during the interview, one household stated, "sometimes it seems like it gets pretty loud, but it's better than the ones we got before". Another household said they appreciated that the HEPA purifying unit was quiet when running.

### *Health*

All interviewed households reported health benefits with use of the HEPA purifier in their home. Interviewees described that the HEPA purifier helped to improve their children's breathing by reducing congestion, coughing, and shortness of breath.

Several households (45%, $n = 5$) reported less coughing with use of the HEPA purifier. "It helped him. It improved his health. During the night, he doesn't cough as much". More than one interviewee reported improvement in their child's sleep quality due to less coughing at night. Some households (18%, $n = 2$) reported less congestion with use of the HEPA purifier. "Really helped with son's gunk, was much better. Less congestion".

Many households (55%, $n = 5$) reported less illness of their child with use of the HEPA purifier. "Doesn't get sick as much anymore – fewer hospital visits". Additionally, several households (36%, $n = 4$) reported decreased need for breathing treatments, such as nebulisers, nasal sprays, or inhalers, after using the HEPA purifier in their home. "He's improving. He's not using his inhalers, like albuterol, as much". Some households (36%, $n = 4$) reported improvements with their child's asthma following use of the HEPA purifier.

Two households (18%) also reported that use of the HEPA purifier also improved the health of other family members in the household. "After filter was used, my mom's 'forever cough' didn't happen as much. She would still catch a cold here and there, but it wasn't as bad or as long as it used to be". "When one child gets sick, we run filter on high…then the other kids don't get as sick". "It not only benefits the child, it helps all of us with allergies".

### *Reasons for no longer using the unit*

Several households (45%, $n = 5$) were still using the HEPA purifiers at the time of the interview, approximately three years after receiving it. Reasons for no longer using the HEPA purifier were equipment failure and lack of replacement parts. Some households were no longer using the HEPA purifier because the unit was not functioning, and some households were no longer using the HEPA purifier because of a lack of replacement parts. These households indicated that they would use the HEPA purifier again if new HEPA purifiers and/or replacement filters were provided. Several replacement filters were mailed to families upon completion of the interviews.

One household was no longer using the HEPA purifier because their child's health got better and they stated "when [child] starts coughing again, I'll use it". One additional household also reported use of the HEPA purifier as needed, for example when their child is ill. Two households were no longer using the HEPA purifier because they moved houses; one household left their HEPA purifier behind with family and the other does not have enough space for the purifier in their new house.

## Discussion

In interviews with households that were part of the YKHC HEPA purifier pilot programme, we found that the units were acceptable and household representatives universally believed the purifiers had positively impacted their child's health. Interviewees reported less coughing and/or congestion, decreased treatment, and improvements in asthma in their child with chronic lung disease. Households not only reported improvements in their child's health but also the health of other

family members in their house. There were few concerns identified, although equipment issues such as lack of replacement filters did limit use for some respondents.

In this rural setting, HEPA purifiers were a low cost, acceptable, and feasible intervention for addressing indoor air quality. Households did not have electricity cost concerns associated with running the purifier, and noise levels were acceptable to families. All households used the purifiers, and some families were still using the original HEPA purifiers three years after receiving the pilot project initiation, demonstrating the feasibility and potential sustainability of this intervention. The most common reasons for discontinuing use were equipment failure and lack of replacement filter, suggesting that programme support for equipment could further increase sustainability.

The American Academy of Pediatrics 2021 policy statement, "Ambient air pollution: health hazards to child" highlights the role of air pollution in respiratory diseases and recommends identifying and mitigating environmental triggers that affect indoor air quality to improve respiratory symptoms in children with asthma and LRTIs [28]. Portable HEPA purifiers and educational materials such as the Healthy Homes kit are inexpensive, easily implemented strategies to improve indoor air quality, but these strategies will not be effective without understanding the household and other factors that affect their uptake and use. This study provides critical information for understanding these factors in a rural population with historically high indoor particulate matter levels.

Numerous studies have demonstrated that HEPA purifiers effectively reduce $PM_{2.5}$ concentrations in indoor air, with most studies indicating reductions of at least 50% [29]. HEPA purifiers are appealing as interventions because they are relatively low cost and commercially available. In interventional trials, use of HEPA purifiers has been associated with improvement in respiratory outcomes and reduction of exacerbations for asthma in children and chronic obstructive pulmonary disease (COPD) in adults [30,31].

The ARTIS study (Ward et al., 2015) demonstrated a 69% reduction in $PM_{2.5}$ in wood stove homes using one large and one small Filtrete Ultra Clean Air Purifier (3 M, St. Paul, MN) [22]. However, poor compliance occurred due to concerns about the noise of the filtration units and electrical costs for running the units during the winter. In our evaluation, households reported high compliance and little concern about noise or electrical cost with the Winix Model 5500–2. Investigators from University of Montana successfully implemented and completed the KidsAIR study evaluating the impact of household education or HEPA purifiers in homes using wood stoves on LRTI incidence [32]. Participant retention was high. Although the study did not demonstrate a meaningful difference in LRTI in the air filtration or education arms compared with the control arm, in the exposure-response analysis, odds of LRTI were increased with higher indoor $PM_{2.5}$, providing further evidence that indoor air pollution adversely impacts childhood LRTI [33].

This HEPA Purifier Pilot study builds on prior research on indoor air quality with YKHC and other Alaska Native Tribal Health Organizations. From 2011–2016, a Healthy Homes cohort study enrolled 63 homes in rural YK Delta and Bristol Bay regions of Alaska to evaluate the association of indoor air pollutants on respiratory symptoms and the impact of home interventions on respiratory outcomes [2,3,14]. Investigators demonstrated an association between indoor air quality and respiratory symptoms in children. After home remediation and education, parents reported decreases in runny nose, cough between colds, wet cough, wheezing with colds, wheezing between colds, and school absences. Children had an age-adjusted decrease in LRTI visits [21]. During 2016–2018, researchers with Alaska Native Tribal Health Organizations evaluated the feasibility of providing in-hospital environmental health consults for caregivers of children <5 years old hospitalised at the Alaska Native Medical Center with respiratory infections or asthma [34]. Caregivers reported changes in household behaviours that were specifically addressed in the consult or Healthy Homes Toolkit. The investigators demonstrated that it was feasible to provide environmental consults, mail toolkits, and arrange home modifications to the homes of children hospitalised with respiratory illness.

Findings from this study are informing strategies to increase HEPA purifier use in programmatic interventions and a clinical trial. YKHC has expanded programme services to provide follow-up support via check in phone calls and replacement filters regularly to participants. The programme has provided HEPA purifiers and toolkits to 46 additional families of high-risk patients following the initial success of the pilot programme. In 2022 the National Institutes of Health Environmental Childhood Health Outcome (ECHO) paediatric clinical trials network initiated a multisite clinical trial (the BREATHE study – Bronchiolitis recovery and the use of HEPA filters) to determine whether use of HEPA purifiers units reduces the respiratory symptom burden for 24 weeks after hospitalisation compared to the use of a control unit [35]. Information from this

evaluation provided critical information to the BREATHE investigators on the acceptability, feasibility, and cost of introducing HEPA purifying units to households in rural settings.

This evaluation had several limitations. There was a delay in the planned evaluation due to the COVID-19 pandemic which may have introduced interviewee recall bias. The evaluation was limited to interviews with of a subset of households that were part of the YKHC HEPA purifier pilot programme. However, interviewed households had similar baseline characteristics to those that were not interviewed, which suggests that their experiences and perceptions of HEPA purifiers may be similar to those from non-interviewed households. Although the sample size was small, the interviewed households provided useful information about the acceptability and perceived benefits of home HEPA purifier use in remote Tribal communities. These findings likely generalise to other Tribal communities and rural households that experience indoor air quality challenges and respiratory health disparities.

## Conclusions

Our evaluation found that HEPA purifiers were acceptable and feasible for use in rural Alaska Native households. Households reported that the HEPA purifiers were easy to use, quiet, and had low electricity costs; households believed that use of HEPA purifiers improved their child's health. Based on this positive evaluation, we recommend that health organisations implement home HEPA purifier programmes with households at increased risk for poor respiratory health, such as those with individuals living with chronic lung disease or with reduced indoor air quality. Furthermore, programmes should provide replacement HEPA filters to sustain HEPA purifier interventions in low resource communities.

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## Data availability statement

The data that support the findings of this study are available on request from the corresponding author, JWK, contingent upon Alaska Area IRB and YKHC Tribal approvals. These data are not publicly available due to Tribal sovereignty.

## Disclosure statement

No potential conflict of interest was reported by the author(s).

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## ORCID

James Keck http://orcid.org/0000-0001-7193-065X

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