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IMPACT OF PORTABLE HEPA AIR PURIFIERS ON HEALTH: A REVIEW OF CURRENT EVIDENCE AND RESEARCH LIMITATIONS

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ABSTRACT

Background: Ambient and indoor air pollution, particularly fine particulate matter (PM2.5), represents a primary risk factor for global morbidity, contributing significantly to cardiovascular and respiratory diseases. Portable high-efficiency particulate air (HEPA) purifiers are a widely available intervention, typically reducing indoor particulate matter by 50-60%.
Objective: This review aims to analyze recent evidence regarding the impact of personal air purifiers on various human health markers.
Methods: A literature search of PubMed and Google Scholar (2015–2025) identified 13 relevant studies, prioritizing randomized clinical trials and meta-analyses conducted on adult populations.
Results: Cardiovascular outcomes were the most consistent, with meta-analyses demonstrating a mean reduction in systolic blood pressure of approximately 2.35 mmHg. Significant improvements were also observed in biomarkers of systemic inflammation and coagulation, including C-reactive protein (CRP), Interleukin-8 (IL-8), and plasminogen activator inhibitor-1 (PAI-1). In contrast, respiratory findings were inconsistent; while airway inflammation (FeNO) and asthma quality of life showed improvement, most studies reported no significant changes in spirometry parameters such as FEV1 or FVC. Emerging evidence also suggests benefits for sleep duration and the regulation of stress hormones like cortisol.
Conclusion: Indoor air purifiers serve as a scientifically supported "proof of concept" for acute health protection, particularly for cardiovascular risk factors. However, the field is currently limited by small sample sizes, short intervention periods, and challenges in maintaining blinding. Future research should prioritize long-term longitudinal studies and affordable, sustainable filtration options for low-income settings.

KEYWORDS

Portable Air Cleaners, Particulate Matter, Indoor Air Quality, Environmental Health

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Introduction.

The global public health crisis precipitated by ambient and indoor air pollution remains one of the most significant environmental challenges of the twenty-first century. Fine particulate matter, PM2.5, is currently recognized as a leading risk factor for global morbidity and mortality, particularly concerning cardiovascular and respiratory diseases (Jia et al., 2023; Miller, 2023).

Among well-established cardiovascular effects, short-term exposures to particulate matter (PM2.5 and PM10) and nitrogen oxides are associated with increased risks of hypertension, myocardial infarction, heart failure and stroke, while long term exposure also increases the risk of atherosclerosis (de Bont et al., 2022). In respiratory diseases, polluted air has been shown to increase frequency and severity of symptoms such as coughing and wheezing (Mar et al., 2004), increase prevalence of asthma and allergic rhinitis (Zhang et al., 2025) and augment the risk of COPD (T. Wang et al., 2025). There is also a strong association between exposure to air pollution (mostly fine particulate matter) and all-cause dementia and poor sleep health (M. Wang et al., 2025).

In Europe, ambient air pollution is estimated to cause an annual excess mortality rate of 790,000 individuals. This pollution is also estimated to reduce the mean life expectancy in Europe by approximately 2.2 years (Lelieveld et al., 2019). Globally, in 2010, around 3.1 million out of 52.8 million all-cause and all-age deaths were attributable to ambient air pollution. Air pollution was ranked as the ninth leading modifiable disease risk factor and contributed to 3.1% of global disability-adjusted life years (Newby et al., 2015).

Air pollution is a threat to health not only outdoors, but also inside homes. One of the methods of improving indoor air quality, which is widely available for personal use, is a portable air cleaner. The most common models use high efficiency particulate air (HEPA) filters which trap particles at least 0.3 micrometers in diameter (Vijayan et al., 2015). The filtration efficiency of these air purifiers is well-documented; they are effective at reducing air levels of particulate matter by typically 50-60% (Lu et al., 2024).

However, if the air cleaners are to be recommended to the general population, the critical question remains, does the documented reduction in particulate matter exposure translate into demonstrable improvements in human health? What is the current evidence on the health benefits of using air purifiers?

The aim of this review is to analyze the results of recent studies on personal air purifiers and their impact on various health markers.

Methods.

To conduct this review, Pubmed and Google Scholar were searched independently for relevant articles on air purifiers using a simplified systematic approach. The broad search strategy employed the use of key terms “air purifier”, "air purification", "air filters", “air filtration” with Boolean operator ‘OR’. The search criteria included the publication year between 2015-2025, up to December 13th 2025. Only studies in English or Polish, conducted on human subjects, measuring any health-related markers were included. Preference was given to randomized clinical trials and meta-analyses. Letters to the editor and repeat publications were excluded. All abstracts resulting from the search were screened for relevance. Studies were excluded if the examined population included children (to reduce variability related to developing respiratory systems) or if there was no control group. Data extraction was performed to retrieve study design, population characteristics, intervention details, and specific health outcomes.

Results.

The search yielded 97 articles, out of which 13 were included in the review. Studies were excluded mainly on the grounds of no measurement of health markers. The selected literature was analyzed to establish the effects of air purification on health, compare results from replicated studies, discuss the common methodology issues and define the needs for future research directions. The characteristics of the included studies are summarized in Table 1.

Table 1. Characteristics of included studies

Author	Year	Population	Methodology	Intervention Duration	Comparison	Main Outcomes
Li et al.	2017	55 healthy college students in Shanghai, China	randomized, double-blind crossover trial	9 days with a 12-day washout period	HEPA vs. sham filtration	Short-term reductions in cortisol, cortisone, epinephrine, and norepinephrine following indoor air purification (Li et al., 2017)
Shao et al.	2017	35 non-smoking seniors, with and without COPD, Beijing, China	randomized crossover trial	2 weeks, no washout period	HEPA vs. sham filtration	Indoor air filtration reduced IL-8, but did not improve spirometry results (Shao et al., 2017)
Morishita et al.	2018	40 non-smoking senior adults in a low-income building in Detroit, Michigan, USA	a randomized, double-blind, 3-way crossover intervention study	3 days (Three 3-day scenarios separated by 1-week washout periods)	Sham filtration, low-efficiency (LE) HEPA-type air filtration, and true HEPA filtration	A decrease in systolic and diastolic blood pressure and pulse pressure with any air filtration, no significant change in HRV or aortic hemodynamics metrics (Morishita et al., 2018)
Zhao et al.	2020	29 healthy young adults in Beijing, China	randomized crossover trial (single-blind)	Dependent on the pollution wave duration (a rise in PM2.5 levels for at least 2 consecutive days); washout period of at least 2 weeks	HEPA vs. sham purification before, during, and after a pollution wave	Air filtration prevented a rise in FeNO levels and alleviated the change in spirometry and platelet activation markers during pollution waves (Zhao et al., 2020)

Author	Year	Population	Methodology	Intervention Duration	Comparison	Main Outcomes
Park et al.	2020	44 adult patients with house dust mite (HDM)-induced allergic rhinitis, Seoul and Gwangju, South Korea	randomized, double-blind placebo-controlled study	6 weeks	HEPA vs. sham filtration	A decrease in allergy medication use with air filtration, no difference in symptoms and quality of life scores (Park et al., 2020)
Yoda et al.	2020	32 healthy adults, Hanshin, Japan	randomized crossover intervention study (single-blind)	4 weeks, with a 4-week washout period	HEPA vs. sham filtration	No significant difference in spirometry results following the intervention (Yoda et al., 2020)
van Boven et al.	2020	482 patients with allergic asthma (meta-analysis of 10 trials)	meta-analysis, which included randomized clinical trials with blinding and a control group	Not applicable	Included studies compared active HEPA filtration with placebo or no filtration	Statistically significant mean differences in AQLQ (Asthma Quality of Life Questionnaire) scores and FeNO levels (van Boven et al., 2020)
Wang et al.	2021	54 healthy students in Beijing, China	randomized crossover trial (single-blind)	One week with a washout period of more than 2 weeks	HEPA vs. sham filtration	Decreased DBP, FeNO, and 8-isoPGF2α levels, and improved lung function indicators (FEV1, PEF, FEF25%-75%) with air purification (Y. Wang et al., 2021)
Guo et al.	2021	24 healthy residents of an aged-care center in Chongqing, China	a randomized, double-blind crossover trial	48 hours with a washout period of 12 days	HEPA vs. sham filtration	A reduction in average heart rate and several biomarkers of inflammation and blood coagulation with active air filtration. No difference in FEV1, FVC, PEF or FeNO (Guo et al., 2021)
Lamport et al.	2023	30 healthy adults, Reading, UK	randomised, double-blind, controlled crossover study	2 weeks with a 2-week washout	HEPA vs. sham filtration	Increased total sleep time and total time in bed with air filtration; no difference in other sleep and mood outcomes (Lamport et al., 2023)
Faridi et al.	2023	880 participants from 17 included trials (meta-analysis and systematic review)	meta-analysis and systematic review of randomized crossover/controlled trials and one panel study	Not applicable	Active vs. sham filtration (14 studies evaluated HEPA filters, one study - electrostatic filter, 2 studies - ionization filters)	Air filtration led to a significant decrease in systolic blood pressure (Faridi et al., 2023)
Liu et al.	2023	24 patients with stable coronary artery disease (SCAD), Beijing, China	randomized single-blind crossover study	3 days with a washout period of >14 days	HEPA vs. sham filtration	Significant decrease in C-reactive protein and an increase in high-density lipoprotein (HDL) cholesterol (Liu et al., 2023)

Author	Year	Population	Methodology	Intervention Duration	Comparison	Main Outcomes
Brugge et al.	2025	156 non-smoking adults living near a high-traffic highway, Massachusetts, USA	pragmatic randomized crossover trial	1 month with a 1-month washout period	HEPA vs. sham filtration	A significant decrease in systolic blood pressure (SBP) in participants with elevated SBP (>120mmHg) (Brugge et al., 2025)

Respiratory health.

The impact of air purifiers on respiratory health is usually assessed through spirometry and markers of airway inflammation such as fractional exhaled nitric oxide (FeNO). The outcomes in spirometry in the analysed studies are mostly inconsistent. A 2021 trial by Y. Wang et al. reported a significantly higher FVC, FEV1, and FEF25%–75% after an intervention with an air purifier for a week. For example, FEV1 increased from 3.57 L in the non-intervention period to 3.60 L in the intervention period ($p < 0.05$), on average by around 300ml. Also, as indicated by a statistically relevant decrease in FeNO levels, there could be an alleviating effect on respiratory inflammation (Y. Wang et al., 2021). On the other hand, in a 2020 study by Yoda et al., pulmonary function didn't improve with a 4-week use of air purifiers. There was again a small decline in FeNO, but it didn't reach statistical significance. However, in this study the overall pollution level was low, and the measured particulate matter difference between the two groups was not statistically significant, which explains the lack of effect (Yoda et al., 2020). Another study by Zhao et al. in 2020 measured the lung function in healthy adults before, during and after a PM2.5 pollution wave. They found that air filtration managed to prevent a rise in FeNO during the pollution wave, which did occur in participants receiving sham purification (in this group, the FeNO rose by 17.6%). Lung function also changed under filtered conditions, however insignificantly, while in the control group with sham purifiers, there was a 1.4% rise in FVC and 1.3% rise in FEV1. This was also a short-term exposure, with the pollution waves lasting up to 7 days (Zhao et al., 2020).

Again, when measured by Guo et al. in 2021, air purification in a 48-hour intervention in seniors didn't affect FEV1, FVC, PEF or FeNO, despite significant improvement in levels of PM2.5 (Guo et al., 2021).

Considering the included studies, the evidence regarding lung function in healthy adults is conflicting**.** While (Y. Wang et al., 2021) reported significant improvements in FEV1, and Zhao (2020) showed a protective effect under conditions of a pollution wave, other studies (Guo et al., 2021; Yoda et al., 2020) found no statistically significant changes in spirometry parameters after intervention. However, markers of airway inflammation like FeNO show more consistent sensitivity, also in asthma patients.

Asthma.

A meta-analysis (van Boven et al., 2020) selected ten trials including a total of 482 patients. The analysis showed an improvement in Asthma Quality of Life Questionnaire (AQLQ) by +0.36 ($p=0.01$) and a decrease in FeNO levels by 6.67 ppb ($p = 0.0008$) following the intervention with purifiers. However, again, lung function on spirometry, medication use and symptom severity score was not significantly changed.

Allergic rhinitis.

In allergic rhinitis on the other hand, the benefits from air purification may manifest as a decreased need to use medication. In a 2020 trial by Park et al., patients with house dust mite-induced allergic rhinitis received a 6-week intervention of HEPA air purification. Compared to the placebo group, the active purification group had a 26.3% reduction in use of medication. What is worth noting, the effect appeared only after 3 weeks of air filtration. When it comes to symptoms, quality of life, or visual analog scale scores, there was a reduction, but it was similar in both groups, which could indicate a presence of placebo effect (Park et al., 2020).

Chronic Obstructive Pulmonary Disease (COPD).

Another respiratory condition commonly associated with air pollution, is Chronic Obstructive Pulmonary Disease (COPD). A study by Shao et al. (2017) followed 35 non-smoking seniors, 20 of whom had COPD. The key respiratory findings indicated that despite significant reductions in indoor air pollution, the two-week air filtration intervention did not lead to demonstrable improvements in the participants' lung function (FEV1, FVC, MMEF). In the active group researchers observed a 58.59% reduction of IL-8 levels, an inflammatory biomarker, and for the subgroup of patients with COPD the effect was even more pronounced with a 70.04% reduction. However, no difference with spirometry or other markers of inflammation (CRP, IL-6 and fibrinogen) was found. Overall, the study concluded that short-term air filtration did not produce clear changes in the respiratory outcomes that were measured (Shao et al., 2017).

Cardiovascular health.

Blood pressure.

Compared to the respiratory effects, the cardiovascular results are more consistent. Among them, blood pressure is perhaps the most frequently measured clinical endpoint in air purification research, as it serves as a sensitive proxy for cardiovascular risk. In 2023, a meta-analysis by Faridi et al. was published, which pooled the results of 17 studies of air cleaners impact' on blood pressure. The calculated effect was a mean 2.35 mmHg decrease of systolic blood pressure (95% CI: -4.5 to -0.2). Interestingly, the impact on diastolic blood pressure is consistently less pronounced, showing a non-significant reduction of roughly 0.81 mmHg in pooled analyses (Faridi et al., 2023).

In a newer, 2025 study, lowering of systolic blood pressure (SBP) following air filtration was replicated by Brugge, however the result is more nuanced. In this randomized crossover trial, only participants with elevated SBP of >120mmHg had a significant 2.8-mm Hg mean reduction in SBP after air filtration. Conversely, with sham purification, there was a 0.2 mmHg increase of SBP, however it was non-significant. This net difference of 3.0 mmHg could be important clinically; epidemiological evidence suggests that even a 2-mmHg reduction in SBP can translate into a 7% lower risk of death from ischemic heart disease and a 10% lower risk of death from stroke (Brugge et al., 2025).

Blood coagulation, cardiovascular inflammation and other markers.

Beyond blood pressure, air purification appears to influence systemic inflammation and lipid profiles. Liu et al. (2023) investigated air filtration's effect on multiple biological markers in patients with stable coronary artery disease. Reducing indoor PM2.5 levels with an air purifier led to several cardiovascular effects even after controlling for used medication, which was a marked strength of this study. Notably, levels of C-reactive protein (CRP) decreased by up to 24.11%. Additionally high density lipoprotein (HDL) cholesterol increased by up to 6.48%, and endothelin-1 (ET-1), a vasoconstrictor, was reduced by 5.64%. No significant effect on other indicators of inflammation, coagulation, plaque stability, or blood lipids was registered (Liu et al., 2023). The aforementioned study by Guo et al. (2021) registered reductions in: fibrinogen (by 15.1%), monocyte chemoattractant protein (MCP-1) (by 17.7%), and myeloperoxidase (MPO) by 17.2%, following a HEPA intervention.

There was also a significant reduction in biomarkers related to blood coagulation: plasminogen activator inhibitor-1 (PAI-1) was reduced by 14.9%, and tissue-type plasminogen activator (t-PA) decreased by 13.5%. Despite the lack of respiratory effects in this study, a 5.8% reduction in average heart rate was found in the active group (Guo et al., 2021). Previously mentioned RCT data from Zhao et al. (2020) also show an influence of air filtration on blood coagulation. During a pollution wave, there was a 12% increase in sP-selectin levels, which is a biomarker for platelet activation, when there was only a sham purifier. With air filtration, the effect was attenuated, and the increase was 7.6% ($p <0.01$) (Zhao et al., 2020).

These findings suggest that the cardiovascular benefits of air purifiers extend to the stabilization of atherosclerotic risk factors, even over very short intervention periods of three days.

Heart rate variability (HRV).

Two of the included studies measured HRV parameters under active and sham purification. There were no significant differences found in either of the studies (Morishita et al., 2018; Shao et al., 2017).

In contrast to the mixed respiratory results, the impact of air purification on cardiovascular markers appears more consistent, particularly regarding inflammation, coagulation, and blood pressure. Reductions in CRP, IL-8, and coagulation markers (Fibrinogen, PAI-1) were observed across multiple studies (Guo et al., 2021; Liu et al., 2023; Shao et al., 2017).

Other health effects.

Sleep quality and mental health.

The effect of air purification on sleep quality was studied by Lamport in 2023. In a crossover study with a 2-week intervention with a HEPA filter during sleep, and 2 weeks of sham purification, participants had their sleep monitored by means of actigraphy watches and using sleep diaries. Researchers noted an average increase of 12 minutes per night of longer sleep in the active filter group, as well as a 19-minute longer total time in bed. Other outcomes such as mood, depression, anxiety and subjective sleep quality questionnaires showed no significant results. However, what is worth noting, there was a greater improvement in total sleep time in participants who had the placebo purifier first, then the HEPA filter. As mentioned by the authors, it could mean that the noise of flowing air is something that could possibly disturb sleep at first, and needs getting used to (Lamport et al., 2023).

Stress hormone levels.

In a metabolomics-oriented 2017 study, Li et al. studied the effect of air pollution on stress hormone levels, as well as a possible counteraction of this effect with use of air filtration. In a randomized, double-blind crossover trial, during the period of real air purification and therefore lower PM2.5 exposure, participants had significantly lower serum levels of glucocorticoids (cortisol and cortisone), catecholamines (epinephrine and norepinephrine), CRH (corticotropin-releasing hormone) and ACTH (adrenocorticotropic hormone).

These findings suggest that reducing PM exposure by means of air filtration can dampen the activation of the body's primary stress response systems: the hypothalamus-pituitary-adrenal (HPA) and sympathetic-adrenal-medullary axes. In addition, in this study also the systolic blood pressure was higher in participants receiving sham purification. Perhaps the mechanism behind the elevation of SBP due to air pollution is in part the rise in stress hormone levels (Li et al., 2017).

Discussion.

Despite some promising findings detailed above, especially the cardiovascular effects, the validity and generalizability of indoor air purification research are constrained by several factors.

Small sample sizes. A significant portion of the evidence base is derived from studies with sample sizes that are insufficient to achieve statistical power. For example, several crossover trials rely on cohorts of only 24 to 35 participants. Small samples are particularly vulnerable to the influence of outliers and are often unable to control for the many confounding variables present in real-world residential environments, such as variation in dietary habits, physical activity levels, or housing characteristics. The 2021 study by Guo et al. on aged-care residents exemplifies this issue; while it found significant changes in coagulation markers, the authors conceded that the sample size of 24 might have missed modest but potentially important differences in oxidative stress biomarkers. Furthermore, small cohorts limit the ability to conduct subgroup analyses. As demonstrated by Brugge et al. (2025), the benefits of air purification are often concentrated in specific high-risk populations, such as those with pre-existing hypertension or severe asthma. Studies with limited enrollment are likely to overlook these effects, reporting no significant results for the total population while obscuring significant benefits for vulnerable subgroups.

Length of intervention period. The intervention and follow up period can also prove problematic. Most randomized crossover trials use intervention periods lasting only 48 hours to 2 weeks. While this duration is sufficient to observe transient changes in heart rate or inflammatory cytokines, it is inadequate for evaluating the prevention of chronic disease progression or long-term clinical events like myocardial infarction. The 1-month trial by Brugge et al. (2025) is considered "long-term" in this context, yet even one month is insufficient to assess whether air purifiers can permanently lower the risk of atherosclerosis, which develops over decades of exposure.

Blinding. Another issue in air filtration research is the blinding. All the included studies have a placebo group, using a sham purifier, usually by removing the HEPA filter. Although many claim that there’s little difference, the filters change the airflow and noise characteristics of the device. While Brugge et al. (2025) reported success using James' Blinding Index (achieving scores of 0.83 to 0.87, where 1.0 is perfect blinding), many other studies do not report blinding success at all. If participants can "guess" their intervention status based on a quieter fan or different air drafts, their subjective reports of symptom improvement (such as reduced wheezing) are highly susceptible to bias.

Exposure standardization. Furthermore, standardizing exposure in indoor air studies is uniquely challenging because, unlike in a controlled laboratory, the home is a dynamic environment where human behavior significantly alters pollutant concentrations. Domestic activities such as cooking on gas stoves, burning incense or candles, and using aerosolized cleaning products can create sharp, high-intensity "peaks" in concentration. These peaks often exceed outdoor levels, as demonstrated by Park et al. (2020), where bedroom concentrations were 1.8 times higher than outdoor averages before purification began. Standardizing exposure requires participants to stay indoors and keep windows and doors closed, which is difficult to obtain, and therefore frequently violated in pragmatic studies. Yoda et al. (2020) highlighted that windows are frequently opened for ventilation, which can immediately negate the work of an air purifier by introducing high volumes of unfiltered ambient air. Moreover, most studies do not strictly track how much time participants spend in the specific room where the purifier is located. If a participant spends the majority of their day in an unpurified living room but sleeps in a purified bedroom, their personal exposure reduction will be significantly less than the indoor concentration reduction measured by a stationary monitor.

On the other hand, such a design that doesn't restrict the participants' activities, is more reflective of real-life usage of the air purifier. For the purpose of the trials that try to elucidate an effect that's potentially not very strong, however, it would be perhaps more beneficial to study a better controlled environment.

Directions for future research. Future research should focus on long-term longitudinal studies, with a follow-up period of several years, and include more data from low- and middle-income countries. In those areas, household air pollution is substantial because of solid fuel cooking (Chowdhury et al., 2024). In these settings, high purchase costs, filter replacement expenses, and unreliable electricity are significant barriers. Research is needed to evaluate more sustainable and affordable options, such as the DIY Corsi-Rosenthal boxes, which utilize filters and box fans to achieve high clean air delivery rates at a fraction of the cost of commercial units (Holder et al., 2022).

Conclusions.

The synthesis of existing research on indoor air purifiers confirms their status as a scientifically proven intervention for the acute reduction of exposure to air pollution, and the improvement of sub-clinical cardiovascular and respiratory markers. The reduction of systolic blood pressure, the attenuation of airway inflammation (FeNO), and the decrease in systemic pro-inflammatory cytokines provide a strong "proof of concept" for the health-protective role of HEPA filters. However, future research should focus on long-term longitudinal studies, examining lower-income populations and investigating affordable alternatives to commercially available purifiers.

Conflicts of interest: No conflicts of interest to declare.

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