Enhancing indoor air quality: The air filter advantage

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Air pollution has become the world's single biggest environmental health risk, linked to around 7 million deaths in 2012 according to a recent World Health Organisation (WHO) report. The new data further reveals a stronger link between, indoor and outdoor air pollution exposure and cardiovascular diseases, such as strokes and ischemic heart disease, as well as between air pollution and cancer. The role of air pollution in the development of respiratory diseases, including acute respiratory infections and chronic obstructive pulmonary diseases, is well known. While both indoor and outdoor pollution affect health, recent statistics on the impact of household indoor pollutants (HAP) is alarming. The WHO factsheet on HAP and health states that 3.8 million premature deaths annually - including stroke, ischemic heart disease, chronic obstructive pulmonary disease (COPD) and lung cancer are attributed to exposure to household air pollution. Use of air cleaners and filters are one of the suggested strategies to improve indoor air quality.

In order to extract 420 litres of oxygen that is crucial for human survival and function, a total of 10,000 litres of air enters the lungs every day. The quality of air we breathe determines the health of the lungs as well as other organs. Indeed clean air is considered to be a basic requirement of human health and well-being. However, air pollution continues to pose a significant threat to health worldwide. The World Health organization (WHO) reports that in 2012 around 7 million people died as a result of air pollution exposure confirming that air pollution is now the world's largest single environmental health risk.[1]

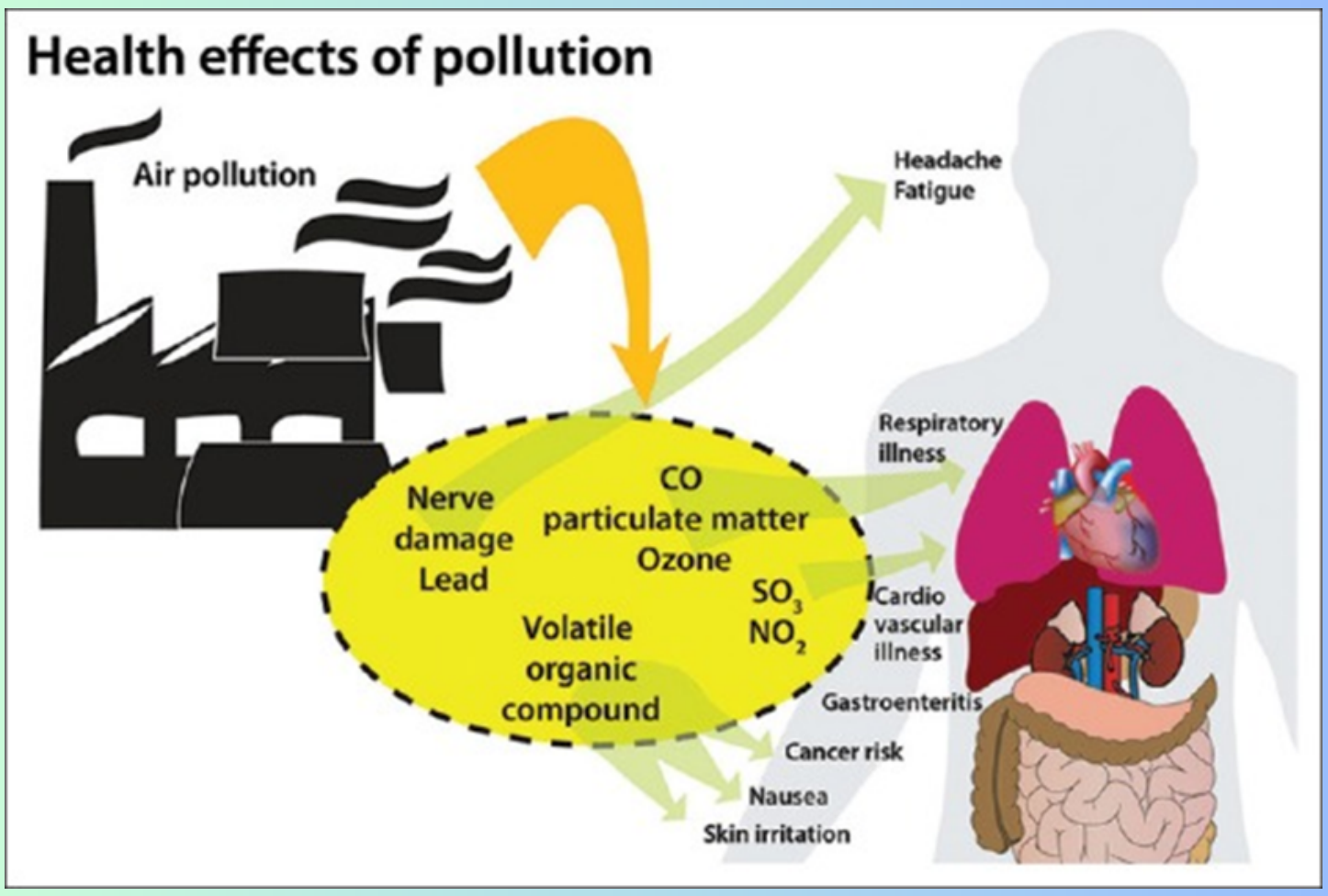
The impact of pollution on respiratory health is well known. The WHO factsheet reveal that, there exists a stronger link between air pollution exposure and cardiovascular diseases, such as strokes and ischemic heart disease, as well as between air pollution and cancer.[2] In the last decade, literature on the detrimental impacts of air pollution on brain, cognition and behavior has also exponentially increased.[3]

The multicenter European Study of Cohorts for Air Pollution Effects (ESCAPE) study- one of the largest ongoing studies initiated to assess the impact of air pollution on population health, involving 367,251 subjects, has generated significant data over the last 6 years. The results from the study, published in more than 25 publications, offers an insight into the correlation between air pollution and increases in cerebrovascular[4] and coronary[5] events besides an increase in respiratory illnesses.[6,7]

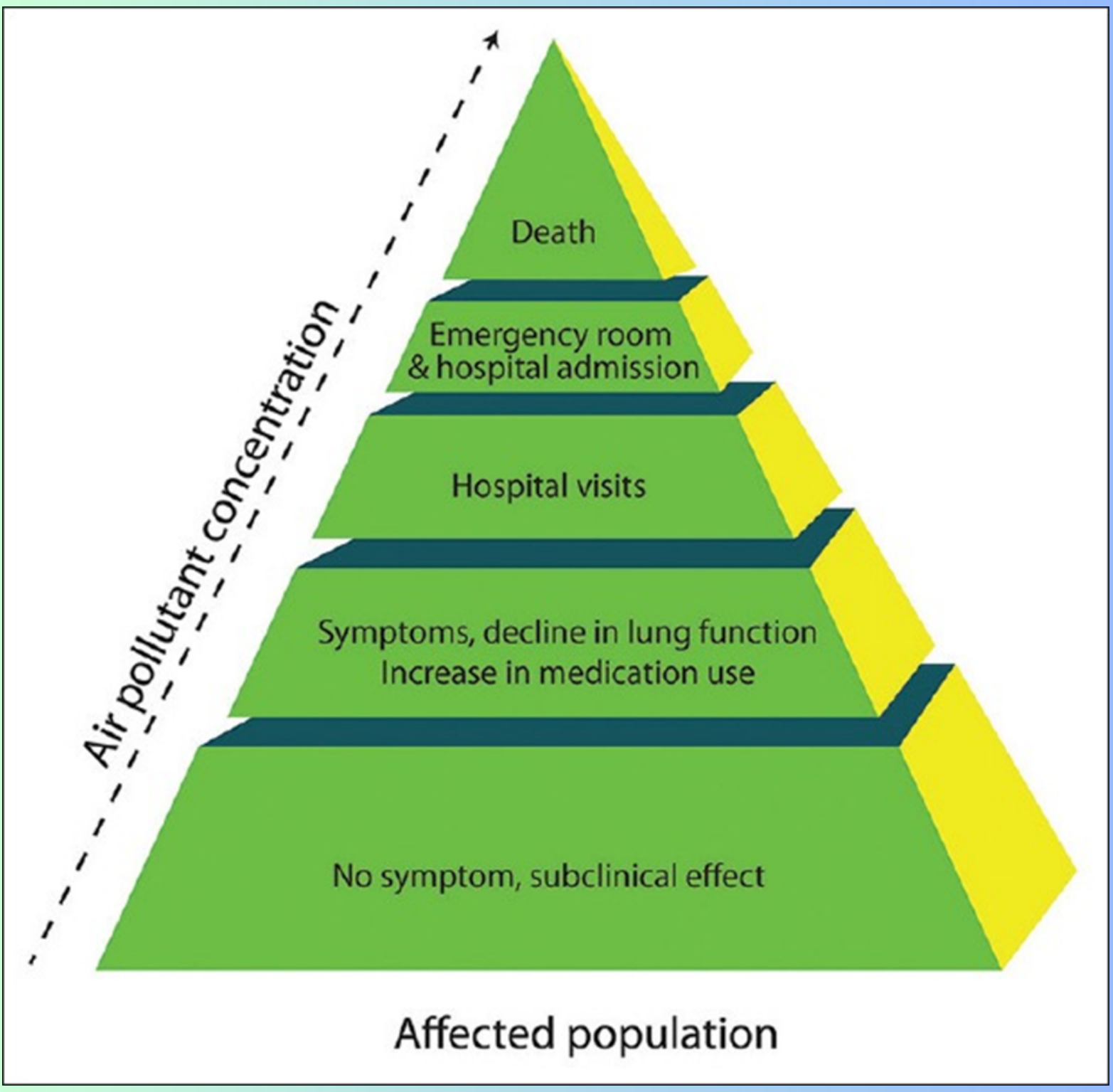
The quality of air inside homes, offices, schools, day care centers, public buildings, health care facilities or other private and public buildings where people spend a large part of their life is an essential determinant of healthy life and people's well-being, says the WHO Guidelines for Indoor Air Quality.[9] Hazardous substances emitted from buildings, construction materials and indoor equipment or due to human activities indoors, such as combustion of fuels for cooking or heating, lead to a broad range of health problems.[9]

THE SHORT- AND LONG-TERM EFFECTS OF AIR POLLUTION

Exposure to air pollution can lead to a wide range of short- and long-term effects [Figure 1]. Temporary short-term effects include discomfort such as irritation to the nose, throat, eyes, or skin or headaches, dizziness, and nausea. Air pollution can also cause respiratory conditions such as pneumonia or bronchitis.[16]



Long-term effects of air include heart disease, lung cancer, and respiratory diseases. That air pollution can cause exacerbations of pre-existing asthma is supported by accumulating evidence over several decades. Particulate matter in air pollutants cause oxidative injury to the airways, leading to inflammation, remodelling, and increased risk of sensitization. On the other hand, while several pollutants have been linked to new-onset asthma, the strength of the evidence is variable.[17] Several large studies suggest that pollutants exert significant effects on the cardiovascular system. It has been shown that for any increase in mortality caused by pollutants, two-thirds of the effect was accounted for by cardiovascular diseases.[18] Chronic exposure to pollutants results in vascular inflammation leading to atherosclerosis. Acute exposure causes changes in coagulation and platelet activation. Increase in pollution has been linked to increased hospital admissions for congestive heart failure and ischemic heart disease [Figure 2].[18]



Air pollution can also cause long-term damage to nerves, brain, kidneys, liver, and other organs. It is also believed that air pollutants cause birth defects.[16]

WAYS TO IMPROVE HEALTH – FILTRATION OF INDOOR AIR

Several measures are recommended to reduce exposure to contaminants of biological origin (e.g., dust mites, household pets, cockroaches, mould, and mice) and non-biological origin (e.g., environmental tobacco smoke, wood smoke, volatile organic compounds). With a better understanding of indoor pollutants, new and effective measures have evolved, including the development of indoor air filters.[34]

Air filtration is frequently recommended as a component of environmental control measures. Indoor air filtration can be provided by whole house filtration via the home's heating, ventilation, or air conditioning system, by portable room air cleaners, or a combination of the two.[3,34]

The key attribute of any air filter, is a balance of the following:

- Air flow to assure adequate ventilation
- Efficiency to filter out a range of small particle sizes, and
- Capacity to allow for reasonable cost-effective maintenance schedules without adversely affecting airflow and efficiency.

Currently available air purifiers usually use a multilayer filter system composed, often of a prefilter, a carbon filter, an antibacterial filter, and a HEPA filter.

The use of HEPA filters traditionally used in hospitals, has indeed been a significant inclusion to home air purifiers. A HEPA filter uses mechanical filtration to remove airborne particles. A HEPA filter is standardized at a minimum 99.97% efficiency rating for removing particles greater than or equal to 0.3μm (1/83,000 of an inch) in diameter. This means that for every 10,000 particles that are 0.3μm in diameter, 3 will pass through the filter, and the rest will be trapped by the filter.[33]

Research Studies!
Efficacy of indoor air filters

A study by van der Heide et al.,[35] assessed the efficacy of air-cleaners with respect to their capacity to capture airborne allergen particles. Over a 6-month period, the efficacy of air filters to capture particulate matter and allergens was measured. The study included three interventions - application of active air-cleaners in living-rooms and bedrooms, placebo air-cleaners used in combination with allergen-impermeable mattress covers or active air-cleaners used in combination with allergen-impermeable mattress covers.

Allergen levels in mattress and floor dust were measured before, and 3 and 6 months after the interventions. After 6 months, the air-cleaners were dismantled and the filters were analysed for the amount of dust collected and allergen content.

In the air-cleaners, the air was filtered first by a coarse pre-filter, followed by a Rota-filter, in which small dust particles were captured by rotation at high speed. The last filter consisted of a high efficiency particulate air (HEPA)-type filter, filtering 70% of 0.3-μm particles and 95% of 1.0-μm particles. The air cleaners in this study clearly showed the capacity to capture substantial amounts of airborne dust particles and airborne allergens.

Another study, a randomized controlled trial, evaluated the effectiveness of free-standing air filters and window air conditioners (ACs) in 126 low-income households of children with asthma. Indoor air quality (IAQ) was monitored for week-long periods over three to four seasons. High concentrations of particulate matter (PM) and carbon dioxide were frequently seen.[36] When IAQ was monitored, filters reduced PM levels in the child's bedroom by an average of 50%. A similar study by Du et al. [37] found reduction in PM, by an average of 69 to 80% suggesting that while PM levels in homes with asthmatic children can be high, levels can be dramatically reduced using filters.

The benefits of capturing large amount of allergens and dust particles by the air cleaners reflect in improved respiratory function.

Research Studies!
Air filters improve respiratory health

In a year-long, randomized, parallel-group study, Francis et al., measured the clinical outcomes for the use of indoor HEPA air cleaners of 30 adult asthmatics who were sensitized to, yet lived with an indoor cat or dog.[38] Primary end points in combined asthma outcomes (bronchial reactivity and treatment requirements) were statistically improved in the treatment group over the controls.

Another study by Sulser et al., compared sham versus HEPA portable room air cleaners (PRACs) in 36 asthmatic children sensitized to cat or dog.[39] A significant reduction in nocturnal symptoms including stuffy nose was observed in the HEPA filter group. There was also a trend toward an improvement in bronchial hyper-responsiveness- seen as a decrease in delta FEV1 (comparing FEV1 before and after cold air challenge) as opposed to an increase in the sham group.

Another double blind, placebo-controlled, cross-over study by Van der Heide et al.[40] compared the effects of air cleaners for 3 months with that of sham air cleaners. Within a short period of intervention of 3 months with active air cleaners, airway hyper-responsiveness, expressed by PC20 adenosine, was significantly diminished compared with baseline values. Peak flow amplitude also decreased (P =0.045).

Pedroletti et al.[41] studied 22 patients (12 to 33 years) with mild to moderate asthma, sensitized to cat or dog, dust mite, birch tree pollen, or a combination of these allergens. The device tested, provided laminar airflow of cooled, HEPA-filtered air directed to the sleep breathing zone (SBZ). At the end of 10 weeks, the treatment group showed improvement in the mini-Asthma Quality of Life Questionnaire ($P < 0.05$) –with benefits seen within the first 2 weeks of treatment.

Air filters have a positive impact on vascular health
Exposure to particulate matter is associated with risk of cardiovascular events, as a consequence of oxidative stress and systemic inflammation leading to endothelial dysfunction.[42,43]

The effects of controlled exposure to indoor air particles on micro vascular function (MVF) were studied in a healthy elderly population, of 21 non-smoking couples.[42] In this study the participants were subjected to two consecutive 48-hour exposures to either particle-filtered or non-filtered air (2,533-4,058 and 7,718-12,988 particles/cm3, respectively) in their homes. MVF was assessed non-invasively by measuring digital peripheral artery tone after arm ischemia. Indoor air filtration significantly improved MVF by 8.1% (95% confidence interval, 0.4-16.3%). The study suggested that MVF was significantly associated with personal exposure to iron, potassium, copper, zinc, arsenic, and lead in the fine fraction. Reduction of particle exposure by filtration of recirculated indoor air for only 48 hours improved MVF in healthy elderly citizens, suggesting that this may be a feasible way of reducing the risk of cardiovascular disease.

To assess the impact of portable air filters on particle exposures and endothelial function among healthy adults in a woodsmoke-impacted community, 45 healthy adults were exposed to consecutive 7-day periods of filtered and non-filtered air, in a randomized cross-over intervention study.

Air filters reduced indoor fine particle concentrations by 60%. Filtration was associated with a 9.4% (95% confidence interval, 0.9-18%) increase in reactive hyperemia index and a 32.6% (4.4-60.9%) decrease in C-reactive protein. These two studies by Brauner et al. and Allen et al., support the hypothesis that systemic inflammation and impaired endothelial function, both predictors of cardiovascular morbidity, can be favorably influenced by reducing indoor particle concentrations.

In one of the recent studies by Weichenthal et al.[44] the benefits of an electrostatic air filter was assessed in 37 residents from 20 homes. The indoor PM2.5 decreased substantially during the period when air filter was used relative to placebo (mean difference: 37 µg/m3, 95% CI: 10, 64). On average, air filter use was associated with a 7.9 mmHg (95% CI: -17, 0.82) decrease in systolic blood pressure, and a 4.5-mm Hg (95% CI: -11, 2.4) decrease in diastolic blood pressure.

SUMMARY AND CONCLUSIONS

Despite the rapid rise in environmental pollutants, the causal pathways leading to adverse health effects is often complex and poorly understood.

Children, the elderly, and women are most vulnerable to potential indoor air pollution health effects because they spend more time in the home environment.

There are many sources of indoor air pollution. Air pollution inside homes consists of a complex mixture of agents penetrating from ambient (outdoor) air and agents generated by indoor sources. Indoor pollutants can vary in their potential health effects and intensity, as well as in their distribution across geographic areas, cultural backgrounds, and socioeconomic status. Exposure to indoor air pollutants can cause health effects ranging from sneezing and coughing to exacerbation of chronic respiratory disorders such as asthma and outcomes such as cardiovascular disease and even cancer.

Studies appear to suggest, that reduction in particulate matter and allergens results in reducing symptoms and in certain cases, preventing disease progression across all age groups, including the elderly and children. The evidence is apparent, in chronic respiratory diseases, such as asthma and in cardiovascular health.
Reduction in particulate matter and allergens is achieved successfully through efficient air filters. The British Guideline on Asthma Management from the British Thoracic Society recommends use of air filters for removal of pet and other allergens.[45]
Technologically advanced air filter systems are now available which efficiently remove particulate matter, resulting in significant health benefits to patients of asthma and cardiovascular disease. Cost-benefit studies are currently not available; however, such studies are required in countries like India for assessing the utility of universal application of these devices.