Review

Breathing with an enemy in the kitchen: a narrative review of the concepts on cleaner energy, respiratory effects of indoor air pollution due to cooking and the potential way forward

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Abstract

Indoor air pollution due to household cooking is a hidden public health problem especially in developing countries. This review article discusses global literature on the concepts on cleaner energy, effects of indoor air pollution due to cooking on the different aspects of the respiratory system and the potential way forward in dealing with them. We searched relevant articles published from year 2000 onwards in three electronic databases and in other publications using keywords. Two authors independently assessed the relevance of the articles based on the scope of review. Altogether, 56 articles and four webpages were cited. A narrative review was done.

Primitive fuels mentioned in the energy ladder are still commonly used for cooking, especially in the developing world. Around 40% of people worldwide suffer from energy poverty. The choice of fuel energy is decided by multi-faceted influences. Primitive fuels including bio-mass fuels yield more pollutants than cleaner fuels. Cooking practices have an influence on the amount of pollution. Higher prevalence of respiratory infections is associated with cooking smoke especially among children. Most documented literature points toward a higher prevalence of respiratory symptoms, lung cancer and impaired lung functions with cooking smoke. Cleaner fuels seemingly cause less pollution though the literature is rare on kerosene. In conclusion, energy poverty is expected to worsen in future. The associations between cooking smoke and negative respiratory consequences have been well-established in most research studies. Strategies of reducing household smoke due to cooking must be promoted.

Introduction

Indoor air pollution within households is one of the main contributors of mortality and disability globally (1). Emission due to household cooking fuels is found to be one of the main factors affecting indoor air pollution (2). Its adverse events may include communicable diseases, non-communicable diseases, growth retardation of children as well as negative effects on the foetus (1, 3-4). Around 3.8 million premature deaths that happen annually from non-communicable diseases are attributed to exposure to household air pollution from cooking with solid fuels (3).

Respiratory system is the main system that is adversely affected by air pollution (5). Though much literature is available, many articles have been composed on fragmented areas in relation to the respiratory effects. This review article discusses documented global literature on the concepts on cleaner energy, effects of indoor cooking on the different aspects of the respiratory system and the potential way forward of dealing with them with special emphasis on the developing world.

Methods

Our literature search was done through PUBMED, GOOGLE SCHOLAR and MENDELEY databases. We explored the original research articles and reviews from year 2000 up to April 2017. The search terms included were: "biomass fuel AND indoor air pollution", "indoor air pollution AND respiratory symptoms", "air pollution AND cooking", "developing countries AND indoor air pollution" and "energy ladder". Furthermore, publications of the World Health Organization and United Nations, and other related webpages were searched. Academic colleagues were consulted in tracing unpublished articles. Cross-referencing was done through references of the original articles.

The selection of publications was done in three rounds. In the first round, based on the abstracts or summaries, publications that were relevant to the scope of the present review were selected. By going through the selected publications, sub-titles for further review were determined. The second round of the selection process was done considering these sub-titles. In the third round, clarity of the conclusions was considered. Two authors independently assessed the relevance of the publications. When both agreed, the articles were selected; otherwise, the decision of another author was sought. Altogether 56 articles were selected and additionally four webpages were cited (Figure 1). A narrative review was done without pooled analysis.

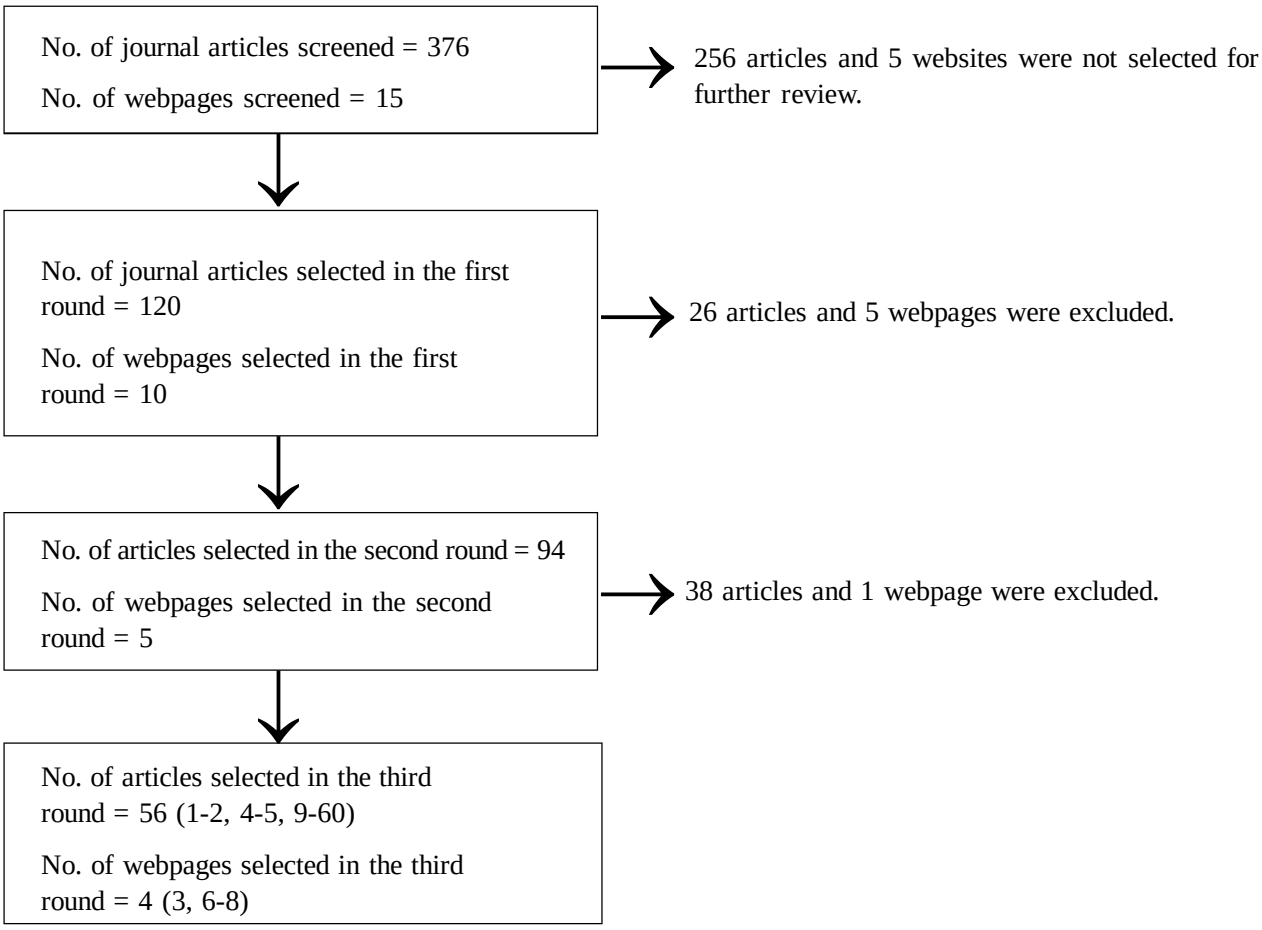

Figure 1. Flow diagram on the selection of publications

Results and Discussion

Cooking fuels and the energy ladder

Cooking food is assumed to be of evolutionary significance to the human beings (9). It is believed that cooking would have increased the net energy intake from eating food (10). Even though literature is occasionally found on the disadvantages of cooking, more literature is in favour of the advantages of eating cooked food (10-12). In addition, home-based cooking has been found to be with many benefits compared to the consumption of eating out (13-15).

Many fuels have been used for indoor cooking in households. The traditional fuels include products of plants and animals, which include wood, animal dung, crop waste and coal. Out of these, the organic material which are derived from living organisms are termed as biomass fuel (16). The modern fuel methods include liquefied petroleum gas (LPG), kerosene, biogas, ethanol, gel-fuels, biodiesel and electricity (17).

The energy ladder model shows that household fuels can be grouped into three categories: primitive fuels, transition fuels and advanced fuels (18). The bio-mass fuels belong to the primitive fuel category, whereas kerosene, charcoal and coal belong to the transition fuel category. LPG, electricity and biogas are found in the advanced fuel category. It is assumed that with the improvement of the socio-economic status, households would shift upwards in the ladder (19). The fuels found higher up in the ladder produce less pollution per unit of fuel (20).

Energy poverty is defined as "the absence of sufficient choice in accessing adequate, affordable, reliable, high-quality, safe and environmentally benign energy services to support economic and human development" (21). Since the bio-mass fuels are assumed to be producing more pollutants, households using them as prime domestic fuel are suffering from energy poverty. The energy poverty is worse in developing countries and expected to be worse in the coming years (17, 22). It has been estimated that two out of five people in developing countries suffer from energy poverty (23). The statistics of World Health Organization (WHO) summarizes that around the world, about three billion people cook using burning bio-mass (wood, animal dung and crop waste) and coal (3).

Factors affecting the choice of energy

In a research done in Sri Lanka, factors impeding the transition to cleaner fuels were explored. It concluded that not having enough motivation for switching over, lack of better technology options, financial risks and financing related reasons as the impeding factors (24). The way people make choices on fuel is not simple to explain. Many households use multiple fuel sources (25-26). Furthermore, they may revert back to a previous method (24). Many positive and negative factors have been identified to influence the decision of energy source for cooking. Those include characteristics of householders, income level, food preferences, access to fuel, fuel prices and cultural aspects (27-31). The direction of factors mentioned in the literature varies according to the context. However, income related factors are given priority in the analysis of many of the studies. Furthermore, the associated factors have different impacts on the choice process at different settings (19).

Air pollutants through cooking

In most parts of the developing world, traditional devices are used for cooking. The incomplete combustion of these give rise to many pollutants including carbon monoxide, aldehydes, nitrogen oxides, polycyclic aromatic hydrocarbons, etc. (32-33). Indoor cooking is also a primary source of particle pollution, which is also called 'particulate matter' (PM). This consists of solid and liquid particles in the air (7). In a study on PM, it was found that 29-48% of source-wise attribution was from solid fuels (2). An Indian study revealed that 50-80% of the total suspended particulate emissions of cooking stoves using biomass and coal, were respirable being less than 2 μm in size (34). According to a Chinese study, PM levels during winter were significantly correlated with the usage of solid fuel (35).

Incomplete combustion is influenced by poor ventilation and the poor quality of cooking devices used in lower-income countries (6). Improved cooking devices are associated with less pollution. Furthermore, factors such as higher education is associated with the usage of improved cooking devices than traditional ones (36). In return, negative respiratory effects are less when improved cooking devices are used (37).

Respiratory infections

Respiratory infections are associated with bio-mass fuel consumption (38). It is mentioned that more than one tenth of the deaths attributed to household air pollution caused by solid fuels is due to pneumonia (3). A study had been done in rural Kenya to explore the respiratory association of particulates <10 μm diameter generated from bio-mass fuels. It concluded that respiratory infections including acute lower respiratory tract infections have significant associations with this exposure (39). The burden of these infections is higher among children, as explained by many pathophysiological elaborations (40). The high inspiration rates, not well-developed epithelium and immune systems, narrow airways and spending more time at home at cooking times are some of the hypotheses for this (41-42).

Being exposed to polluted air within households almost doubles the likelihood of getting childhood pneumonia (3). Particulate matter due to household solid fuels is responsible for more than half of the mortality due to lower respiratory infections among children less than five years (3). In a follow-up study of a cohort of new-borns in India, it was documented that exposure to bio-mass fuel is associated with 34% excess risk of getting respiratory illnesses (4).

Impaired lung functions

Negative effects of household cooking on the lung functions have been documented (43). In a study done in Cameroon, using wood as a fuel was found to be a significant risk factor for lung function impairment in addition to the other factors such as chronic bronchitis, height and age (44). In a study done in Ecuador, it was concluded after the multivariate analysis that the children exposed to bio-mass fuel within households had reduced forced vital capacity and forced expiratory volume in one second (45). Yet, in the same study, a significant difference was not detected between the pulmonary functions and fuel category among women. An increase in lung functions following the reduction of PM has been documented in more global literature (46). Contradictory evidence was found based on a Nigerian study, in which airway obstruction was not reported to be an effect due to firewood consumption (p=0.41) (47). Significantly improved lung functions were not observed following 12-18 months of indoor air pollution reduction in an experimental study done in Guatemala, though there was a significant reduction of respiratory symptoms (48). Higher lung functions among smoke-exposed women were observed in another group of women in Guatemala (49).

Effects on wheezing, asthma and chronic obstructive pulmonary disease (COPD)

A cross-sectional study has been done in Columbia to describe the risk factors of asthma and wheezing among adults. Following the logistic regression analysis, the study concluded indoor wood smoke exposure as a risk factor along with other factors such as occupational exposure to dust particles, gases or fumes (50). Longer exposure to wood smoke (p=0.04) was found to be a risk factor for getting COPD among females in Brazil. Respiratory symptoms were commoner in this group with COPD. Even among the women in whom COPD was not diagnosed, there was a higher prevalence of respiratory symptoms (p<0.001) (51). In a study done in Venezuela, it was reported that wood smoke is a risk factor for asthma among children compared to cooking with gas (adjusted odds ratio (aOR)=2.12; 95% confidence interval (CI)=1.18, 3.84) (52). Studies done in Sri Lanka too point towards the indoor cooking smoke causing respiratory symptoms among children (53-54).

A negative association was observed in a Nigerian study done on 299 village children. The study concluded that using firewood daily did not significantly increase the likelihood of getting asthma-related symptoms (OR=2.36; 95% CI=0.66, 8.44) (47). A German study done among 5078 children explored the association between asthma and cooking with LP gas. With logistic and multinomial regression, asthma and wheezing were not found to have significant associations with gas cooking. However, a positive association (p<0.05) was observed between exposure to gas cooking and the exposure to other indoor factors such as dampness, tobacco smoke and pets. It was highlighted that in assessing the effects of gas cooking, the other indoor factors must be considered (55).

Cancer

A case-control study was done in China to determine the association between PM and the occurrence of lung cancer among non-smoking women. It was found that the solid fuel usage for cooking (aOR=4.08) and higher frequency of cooking (aOR= 3.30) were risk factors for lung cancer. The PM (1) level among

cases was three times higher than in controls (35). In an Indian study following multivariate analysis, it was found that bio-mass fuel exposure was a significant risk factor (OR=3.59; 95% CI=1.07, 11.97) after adjusting for smoking (56). This association between the indoor cooking fuels and lung cancer was further proven by a meta-analysis done in China (57).

Comparison of the ends of energy ladder

In a cross-sectional study done in Nepal, it was found that the average smoke level (PM10) in kitchens was three times higher when using bio-mass fuels compared to cleaner fuels (kerosene, LPG, bio-gas). Bio-mass smoke was significantly associated with more respiratory disorders than cleaner fuels (58). In a study done in India comparing the effects of wood, cattle dung, coal and kerosene, LPG was regarded as the control group. The ill effects of using bio-mass as the prime domestic fuel were highlighted (34). Kerosene is traditionally considered as a safer fuel than bio-mass fuels. There is a scarcity of the literature on its usage as a fuel for cooking. Despite discrepancies in the findings, there is a potential that it may cause respiratory infections including tuberculosis, asthma, cancer and other negative effects (59).

The way forward

Improved access and correct use of cooking fuels would have contributed to achieving the Millennium Development Goals (6). The importance of selecting a safe energy source at household level has been even highlighted in the Sustainable Developmental Goals (8). Currently, air pollution including its indoor domain has been a neglected public health issue in many developing countries (60). Policy decisions on incorporating financing with energy governance have been identified as vital in the advancement (24).

Several studies have documented the novel techniques including the introduction of modified cooking devices in Asian region (23, 32). Furthermore, a research done in five countries has concluded that there are non-plantation bio-mass products such as municipal waste and industrial waste water which can be used as energy sources. Also, it has suggested the replacement of fuel wood with mechanisms such as LPG. The potential fuel wood savings with modification of the energy appliances of the total non-plantation bio-mass had been noted as 24% and 35% of energy in Philippines and Sri Lanka, respectively (16).

The strategies which can be adopted in minimizing the smoke are highlighted under three categories by WHO namely changing the source of pollution, improving the living environment and modifying user behaviour (6). Improving the devices used for cooking, using better fuel-cooker combinations and reducing the need for fire are grouped under the first category. Ventilation improvements and designing the kitchen and stove placement are mentioned under the second category. Changing cooking practices and avoiding smoke are mentioned under the third category (6). Hence, it is essential that the low- and middle-income countries seek the possibility of reducing the indoor air pollution due to cooking.

One limitation of this review is being a narrative-review without quantification of the effects. Yet, it covers a comprehensive scope addressing all aspects of respiratory effects due to indoor cooking including the way forward.

Conclusions

Bio-mass fuels are found in the primitive category of the energy ladder. Energy poverty is commonly found in developing countries and expected to become worse in the coming years. The associations between cooking smoke and negative respiratory consequences have been well-established in most research studies with the exceptions of only a few. Initiatives on the reduction of household smoke and promotion of cleaner energy are essential in achieving the expected global targets such as Sustainable Developmental Goals.

Author Declarations

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