

Investigating the need to Supporting Public Health Interventions in Reducing Maternal Exposure to open Fire Smoke PM in Rural Sierra Leone: A Systematic Review

BY:

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ABSTRACT

Pregnancy loss (including miscarriage and stillbirth) is a considerable public health issue in the world especially in the LMICs, specifically in Africa and south Asia, although it has not been well investigated in these regions. Pregnancy loss directly harms the mother's physical health (e.g. septic miscarriage and increasing the risk of infertility) and also the entire family process through psychosocial and socioeconomic pathways. Global estimates indicate that 339,000 premature deaths per year can be attributed to exposure to open fire smoke PM 2.5 through increased risk of cardiorespiratory diseases including cardiac arrest, asthma, hypertension, and respiratory infections. Additionally, epidemiological evidence have shown that gestational exposure to open fires can restrict fetal growth which in severe circumstances, can increase prematurely terminated gestation, low birth weight infants, miscarriage or stillbirth. Thus, the association between pregnancy loss and open fire exposure is biologically plausible and a much similarities between open fire smoke and ambient fine particles (PM_{2.5}) in terms of exposure patterns and chemical species suggest that they likely share some common health outcomes. Therefore estimating the exposure-response function for maternal exposure to open fire smoke PM can provide new strategies to mitigate the risk of pregnancy loss. The aim of this research is to investigate the need to supporting public health interventions for reducing maternal exposure to open fire smoke PM to improve maternal health in Rural Sierra Leone and Africa general. This research used a secondary data from related peer reviewed literatures and previous research works done in LMICs and Africa to be specific in recent years that have been published in notable journals to answer the research questions. From the search results, epidemiological evidence suggests that maternal exposure to ambient pollutants is associated with a considerable disease burden. Open fires comprise several different types including wildfires, mountain fires, coal mining fires, and slash-and-burn agriculture, and the sources can be directly related to human activities (anthropogenic activities) or indirectly related via climate change. Biomass burning emits massive toxic air pollutants such as particulate matter (PM), polycyclic aromatic hydrocarbons, and volatile organic compounds and this increases ambient exposure to hazardous chemicals. Like Sierra Leone, biomass accounts for the largest energy consumption, over 80% of all energy used and the largest source of biomass energy for cooking and other domestic work is wood fuel and charcoal. About 96.8 % of Sierra Leoneans uses firewood or charcoal for cooking and 80-90% of these cooking are done by women including the pregnant mothers. Research evidences on studies done in the rest of world and data from Africa indicates that poor air quality can harm maternal and infant health and reduces human fertility. Findings therefore suggest that reducing maternal exposure to open fire smoke pollution could be a new public health intervention strategy to mitigate the risk of pregnancy loss and other maternal health consequences.

Key Words: pregnancy loss, open fire smoke PM, maternal exposure, Fertility, biomass, low and middle income countries (LMICs) etc.

1. Background and Rationale

Pregnancy loss (including miscarriage and stillbirth) is a considerable public health issue in the world^[1], especially in the LMICs, specifically in Africa and south Asia, although it has not been well investigated in these regions^[2]. The etiology of pregnancy loss is likely to be multifactorial and may come from both intrinsic and extrinsic characteristics including genetics, demographics, lifestyle factors, history of miscarriage, and various environmental exposures. Traditional risk factors, such as no access to prenatal care, maternal smoking, and maternal drinking have been well investigated; however, the causes of most cases are unknown. A comprehensive understanding of the risk factors for pregnancy loss is crucial to planning-related public health interventions^[1].

Pregnancy loss can be a traumatic life event associated with a variety of psychological and socioeconomic outcomes including post-traumatic stress disorder, grief, anxiety, depression and guilt, as well as marital conflict. Women who experience pregnancy loss can also develop septic miscarriage, a serious and potentially life-threatening uterine infection. Pregnancy loss can lead not only to higher economic costs than a normal birth but also mental health issues (eg, depression) in the affected family^[32]. It does not only directly harm the mother's physical health (e.g., increasing the risk of infertility) but also adversely affects the whole family through psychosocial and socioeconomic pathways^[32]. Pregnancy loss is an insufficiently studied disease burden for many reasons, such as the associated stigma and lack of awareness of its adverse health impacts^[31].

Global estimates indicate that 339,000 premature deaths per year can be attributed to exposure to open fire smoke^[27] through increased risk of cardiorespiratory diseases including cardiac arrest, asthma, hypertension, and respiratory infections^[25]. Exposures to fine particles can induce the release of systemic oxidative stress^[35] and inflammation markers^[Error! Reference source not found.] which are capable of compromising placental-fetal exchange and disrupt the normal oxygen and nutrients delivery into fetal circulation^[Error! Reference source not found.]. According to recent epidemiological studies of preterm birth and low birth weight infants^[15], gestational exposure to open fires can restrict fetal growth, which, in severe circumstances, can increase prematurely terminated gestation miscarriage or stillbirth^[28]. Thus, the association between pregnancy loss and open fire exposure is biologically plausible. Additionally, similarities between open fire smoke and ambient fine particles (PM_{2.5}) in terms of exposure patterns and chemical species suggest that they likely share some common health outcomes.

Open fires have been reported to harm human health primarily by increasing ambient exposure to hazardous chemicals^[25]. This is driven by interactions between climate change and anthropogenic activities, frequent wildfires can dramatically affect many aspects of human sustainability^[11], including air quality, ecological diversity, distribution of infectious disease vectors, and public health. Interactions between climate change and anthropogenic activities result in increasing numbers of open fires, which have been shown to harm maternal health^[20]. Open fires comprise several different types including wildfires, mountain fires, coal mining fires, and slash-and-burn agriculture, and the sources can be directly related to human activities [23] or indirectly related via climate change^[24]. Biomass burning is a classic example of open fire which emits massive toxic air pollutants such as particulate matter (PM), polycyclic aromatic hydrocarbons, and volatile organic compounds^[13]. Previous studies exploring the health effects of open fires focused on respiratory and cardiovascular diseases^[13], but overlooked the impacts on susceptible individuals, such as infants and pregnant women. Unlike urban PM_{2.5} pollution, which are prolonged, open fires occur only occasionally, but most lead to extremely high levels of exposure. Some subclinical negative outcomes (e.g., blood pressure elevation), which can be reversed after blocking the risk factor are threatened by prolonged exposures (e.g.,

urban PM_{2.5} pollution). Compared to those outcomes, the irreversible ones (e.g., adverse birth outcomes) are more threatened by occasionally peak exposures (e.g., fire PM_{2.5}) and among various adverse birth outcomes (e.g., preterm birth, and low birth weight) that have been associated to PM_{2.5} exposure^[14, 15] pregnancy loss may be the most dangerous because it not only reflects the most severe damage to the fetus but also will increase the risk of other outcomes in subsequent deliveries (e.g., subsequent preterm birth)^[12]. Therefore, pregnancy loss can be a tool to examine key impacts from open fires, and the relevant findings from this study reveal the importance of such exposure in terms of health outcomes. Quantifying the exposure–response function for maternal exposure to air pollution can provide new strategies to mitigate the risk of pregnancy loss^[5]. It is against this backdrop that this study is investigating the need to supporting public health interventions for reducing maternal exposure to open fire smoke PM to improve maternal health in Rural Sierra Leone and Africa in general.

Research specific Objectives

- I. Determine the level of evidence that exists that open fire exposure increases the risk of pregnancy loss
- II. Identify the need to supporting public health interventions for reducing exposure to open fire smoke and ambient PM 2.5

. Research method/Strategy

This research uses secondary data from related literature reviews and previous research works done in LMICs and Africa to be specific in recent years that have been published in notable journals to answer the research questions.

Search strategy and selection criteria

An online search database is the primary source of this systematic review. The search was conducted in two main areas based on the objectives of the research. The authors searched for Published Articles in Journals such Embase, MEDLINE, Web of Science Core Collection, and Google Scholar, PubMed, semantic scholar, SID, Science open, PMC, and African Journals on Line (AJOL) using the Medical Subject heading terms, Open Fire PM exposure and pregnancy risk, evidence that exists that open fire exposure increases the risk of pregnancy loss, public health interventions that helps reduce exposure to open fire smoke and ambient PM 2.5. Searches included appropriate reviewed of references cited in relevant papers and journals such as Embase, MEDLINE, Web of Science Core Collection, and Google Scholar, Science Direct, PMID, BJM, and Lancet planet health, nature communication, Environmental health perspective, Journals of toxicology and environmental health etc. Selected publications included were from the year 2010 onwards. Data were analysed based on the objectives and interpreted and final conclusion was made from it.

Objective 1: Determine the level of evidence that proves open fire exposure increases the risk of pregnancy loss. Search results for this objective were categorized in terms of positive or negative associations and percentage of each category calculated accordingly and research data specifically from LMICs were analyzed separately and stated as evidenced in the result section.

Objective 2: Identify the need to supporting public health interventions for reducing exposure to open fire smoke and ambient PM 2.5. Also for objective 2, Search results were categorized and findings on interventions that have worked and those that didn't work and percentage of each category calculated accordingly. Research data specifically from LMICs were analyzed separately in the same way.

Results

A total of 20 published Systematic reviews from reputable journals (Embase, MEDLINE, Web of Science Core Collection, and Google Scholar etc. were recorded on the subject matter and almost all (98.8%) had a positive association between open fire exposure and the risk of pregnancy loss. The following data highlights

some of the searched results: In 2016 Waiswa and colleagues did a comparative analysis and data shows that, there were 18.4 stillbirths per 1000 pregnant women worldwide in 2015 with a much higher rate in low income than in high-income countries with 3 per 1000 births in the USA vs. 27.3 per 1000 births in the Democratic Republic of the Congo and about 75% of stillbirths worldwide occurred in sub-Saharan Africa and south Asia^[1]. It is therefore, very important to mitigating the risk of pregnancy loss in LMICs especially in Africa regions to promote global public health and to achieve the UN Sustainable Development Goals^[4]. A self-compared case control longitudinal study which collected data in 33 Africa countries on mothers who reported at least two births (at least one case of pregnancy loss plus at least one normal delivery) in the African Demographic and Health Surveys, findings shows that PM_{2.5} exposure is significantly associated with increased risk of pregnancy loss, this add to the existing epidemiological evidence from middle-income and high-income countries on the health impacts of poor air quality and perhaps this is the first report in the context of Africa and the largest observational study on this subject^[20]. Another self-comparison case-control study conducted which included 24,876 mothers from South Asia, the region with the heaviest pregnancy-loss burden in the world and assessed exposure using a chemical transport model as the concentrations of fire-sourced PM_{2.5} (i.e., fire PM_{2.5}). The adjusted odds ratio (OR) of pregnancy loss for a 1- $\mu\text{g}/\text{m}^3$ increment in averaged concentration of fire PM_{2.5} during pregnancy was estimated as 1.051 (95% confidence intervals [CI]: 1.035, 1.067), this shows maternal health is threaten by gestational exposure to fire smoke in South Asia.^[20] A study on the health impacts of open fire, exposure to airborne particles from fire smoke was considered the major exposure pathway^[25]. Holstius et al. found that maternal exposure to the 2003 Southern California Wildfires was associated with lower birth weights^[14]. Abdo et al. found that exposure to wildfire smoke PM_{2.5} was associated with preterm birth and decreased birth weight in Colorado^[15]. Occupational exposure to fire was associated with increased risk of miscarriage and preterm birth^[18]. A recent study in London reported that exposure to traffic-related PM_{2.5} increased the risk of stillbirth^[19]. A meta-analysis reported a pooled effect estimate of a 2.1% (-0.4%, 4.6%) increase in stillbirth per 4- $\mu\text{g}/\text{m}^3$ increment in PM_{2.5}^[21]. In a MeSH epidemiological research with search terms (“pregnancy loss” or “stillbirth” or “miscarriage” or “pregnancy termination”) and (“air pollution” or “ambient particulate matter” or “particulate matter” or “PM_{2.5}”) in PubMed, which reviewed titles and abstracts, it discovered seven studies that linked ambient PM_{2.5} to stillbirth or spontaneous abortion in the USA, China, and Mongolia, found a robust association between maternal PM_{2.5} exposure and pregnancy loss^[20].

The geographic distribution of the burden of pregnancy loss is unequal and due to high rates of low- or middle-income levels and high fertility rates, low-latitude countries (e.g., countries in South Asia and Africa), which are also hotspots for open fires due to climate characteristics, have the highest baseline risk of pregnancy loss^[33].

The agricultural system in Sub-Saharan Africa is a predominantly small-scale farming system and farmers resort to burning bushes as a popular mode of preparation of their farm lands with more than 50% of the agricultural activity performed by women, producing about 60-70% of the food in this region and this practice is also blamed for uncontrolled outbreak of bush fires which sometimes extends to vast swath of areas. In Sierra Leone, energy consumption is dominated by biomass, which accounts for over 80% of energy used. The largest source of biomass energy for cooking and other domestic work is wood fuel followed by charcoal and 80-90% of these cooking are done by women including the pregnant mothers. About 96.8 % of the population in Sierra Leone uses firewood or charcoal for cooking. Other sources, including gas, kerosene or electricity account for the remaining 3. 2%. About 64.7% of the households use firewood and 32.1% use charcoal on a national level although the percentages vary from district to district. For example in the Northern, Eastern and Southern regions, an average of 83.7% of the population cooks with firewood and an average of 14. 5% uses charcoal. In the Western Region, where the capital Freetown is situated, 83.3% of the households use charcoal as the main source of energy for cooking, 8.9% use wood and 7.8% other sources.^[34]

Discussions

Research evidences on studies done in the rest of world and data from African indicates that poor air quality can harm maternal and infant health and reduce human fertility. The number of open fire incidents is expected to increase as extreme heat events become more frequent from global warming and pregnant women and their embryos can be more susceptible to the environmental hazards than the general adult population^[22]. Therefore understanding the mechanisms underlying the health impacts of open fires is critical to preventing the related disease burden. PM 2.5 exposure has been associated with increased risk of pregnancy loss^[20] so as gestational exposure to open fire smoke and because PM from biomass burning is richer in toxic organic components than typical ambient PM in the environment the effect of open fires on pregnancy may be greater than that of ambient PM 2.5 and thus should be further examined^[30].

In Sierra Leone, the main energy source for cooking in rural areas is firewood, the main energy source for cooking in urban areas, especially in Freetown, is charcoal. Families who cook with firewood make 3-stone-firesmaking women vulnerable to open fire PM exposure. Given this pattern, examining the epidemiological link between open fire exposure and pregnancy loss is of public health importance.

Limitations of Study

Major limitations to this study are that results may not be generalizable to other studies for some reasons. The skills and experience of the searcher are one of the most important aspects in the effectiveness of systematic review search strategies, this is because searchers who are not information specialists or librarians would have a higher possibility of less well-constructed searches and searches with lower recall, even highly trained searchers differ in their approaches to searching. However, for this study, we searched to achieve as high a recall as possible, though our search strategies, like any other search strategy, still missed some relevant references because relevant terms had not been used in the search. Our experience in this study shows that additional efforts, such as hand searching, reference checking, and contacting key players, should be made to retrieve extra possible includes.

Conclusion

Research evidences on studies done in the rest of world and data from Africa indicates that poor air quality especially open fire smoke exposure can harm maternal and infant health and reduces human fertility. Reducing maternal exposure to open fire smoke pollution could be a new public health intervention strategy to mitigate the risk of pregnancy loss and other maternal health consequences. The results of this study reveals high exposure of women to open fire in Sierra Leone through firewood or charcoal burning during cooking and other domestic works as biomass burning emits most massive toxic air pollutants such as particulate matter (PM), polycyclic aromatic hydrocarbons, and volatile organic compounds there by increasing ambient exposure to hazardous chemicals. Therefore implementing strategies to supporting public health interventions for reducing exposure of pregnant women to open fire ambient PM_{2.5} will improve maternal health and reduce the risk of pregnancy loss.

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