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Case study on impact of secondhand smoke on asthma and other related diseases in human population

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Abstract
This is a study focusing on epidemiologically linked health outcomes of asthma and other related diseases in the population due to exposure to secondhand smoke. The objective is to unravel the risk factors of exposure to secondhand smoke implicated in the disease conditions and the public health significance of such health outcomes in the population. The methodology applied were traditional review of published literatures and extracting the empirical evidence linking secondhand smoke exposure to the disease conditions. Findings showed that, agent factors include chemicals/particulate matters from; burning cigarette, burning cigar or pipe tip and exhaled smoke from smokers; host factors were; age, asthmatic people, gender, pregnant women, asthma heredity, singles, alcohol consumption; while environmental factors include; the home, workplace and school, private or public transportation system, leisure time associated with bar, restaurants etc. The estimated cost attributable to exposure to secondhand smoke was $79.35 million (N24, 598.5 million), accounting for 5.94% of local healthcare costs. Epidemiological evidences showing cause-effect association between exposure to secondhand smoke and asthma and other related diseases are strong, consistent, coherent and plausible to give room for putting in place deliberate regulatory policies and laws by countries and ensuring enforcement of such policies and laws to limiting exposure to secondhand smoke wherever people live or engage in an occupation.

Keywords: epidemiological triad, asthma, related diseases, secondhand smoke, cause-effect, exposure, public health

1. Introduction

The impact of a disease and its distribution is usually derived from an estimate of the burden of such disease in a population which goes to providing important information for taking steps in defining and putting in place appropriate strategies to protecting population health. The estimates of the avoidable burden of such disease/s arising from targeted interventions provide an indication of the gains in health achievable within stipulated period.

A case study is a platform for indicating an effect of an event or events over time on health outcome. In this case, an event may mean activities of humans, either by way of behavioural style, occupation or otherwise that lead to exposure to secondhand smoke to provide basis for epidemiologically linked negative health outcome associated with asthma and other related diseases.

Asthma is a chronic non-communicable disease that affects the airways of the lungs. During an asthma attack, airway tubes of the lungs become swollen, making breathing difficult. As the walls of the airway swell, they narrow, and less air gets in and out of the lungs. Cells in the airway can make more mucus (a sticky, thick liquid) than usual, which can make breathing even harder [1]. Signs and symptoms of an asthma attack include;

- Coughing
- Shortness of breath or trouble breathing
- Wheezing
- Tightness or pain in the chest

Asthma attacks can present in patterns of mild, moderate, or serious – and even life threatening [2]. It is triggered from irritants to the airway from various origin and source. Smoke is known to be one of the most common asthma triggers. Secondhand smoke is unhealthy for everyone, people with asthma in particular [3]. Other health risks associated with inhaling secondhand smoke include cancer, heart disease, among many more. Secondhand smoke is a mixture of gases and fine particles that includes; smoke from a burning cigarette, cigar, or pipe tip, smoke that had been exhaled (breathed out) by someone who smokes [4].

Secondhand smoke had also been reported as one of the most important and most widespread exposures in the indoor environment. It affects a large proportion of the population, as smoking is prevalent (up to three quarters of adult men in some countries) whereas it is hardly restricted to outdoor settings [5].

Secondhand smoke contains more than 7,000 chemicals, including hundreds that are toxic and about 70 that can cause cancer [6]. Inhaling secondhand smoke, also called "passive smoke" or "environmental tobacco smoke," may be even more harmful than actually smoking. The explanation is that, the smoke that burns off the end of a cigar or cigarette contains more harmful substances (tar, carbon monoxide, nicotine, among others) than the smoke inhaled by the smoker.

The effect, smoking had on those who were exposed to it (secondhand smoke) had been less obvious. The exposure can be significant, particularly, for those who live or work with a smoker. In the real sense, most of the smokes from a burning cigarette do not get sucked down into a smoker's lungs; it escapes into the air, where it can be inhaled by anyone unfortunate enough to be nearby.

Secondhand smoke is particularly harmful to people who already had asthma. When a person with asthma is exposed to secondhand smoke, he or she is more likely to experience the wheezing, coughing and shortness of breath associated with asthma [7].

This study is intended to look at the epidemiological perspective of several research works on causal association between secondhand smoke and asthma and other related diseases in the population. The objective is to bring to fore the epidemiologically determined risk factors of exposure to secondhand smoke implicated in asthma and other related diseases and the public health significance of such adverse health outcomes in the population. In carrying out this, we seek to give explanation about the risk factors of exposure to secondhand smoke implicated in the diseases/conditions by applying the concept of inter-relationship and interaction between Agent-Host-Environment factors (epidemiological triad) in the cause of a disease in epidemiology to establish a cause-effect association between secondhand smoke and asthma and other related diseases. The impact of secondhand smoke on the disease conditions as well as financial cost as a specific public health significance implicated is equally highlighted.

2. Materials and Methods

The materials and methods applied were traditional review of published literatures and extracting the empirical evidence linking exposure to secondhand smoke to asthma and other related diseases, principally in the perspective of epidemiological triad associated with disease occurrence in human population.

2.1 Concept of epidemiological triad

From epidemiological point of view, a disease or its epidemic or outbreak will only occur if the equilibrium is changed between the population's *susceptibility* (host or reservoir), the *virulence* of the infectious/causative agent (bacteria, viruses, parasites, or fungi or their products or any other agent – chemical/particulate matter) and the environment that promotes the exposure are upset. This is referred to as epidemiological triad illustrated pictorially in fig. 1. This implies that whenever there is a shift in the attribute/s of the three entities that kept them in equilibrium, the reference disease process and manifestation characteristics will be apparent in the population (host) exposed to the infectious/causative agent in the respective environment.

However, our concern here is the exposure potential of the host (human population) to chemical/particulate matter (causative agent) from secondhand smoke by virtue of place of residence, occupation/work or otherwise (the environment), that is capable of producing characteristic ill health conditions associated with asthma and other related diseases and their burden in the population.

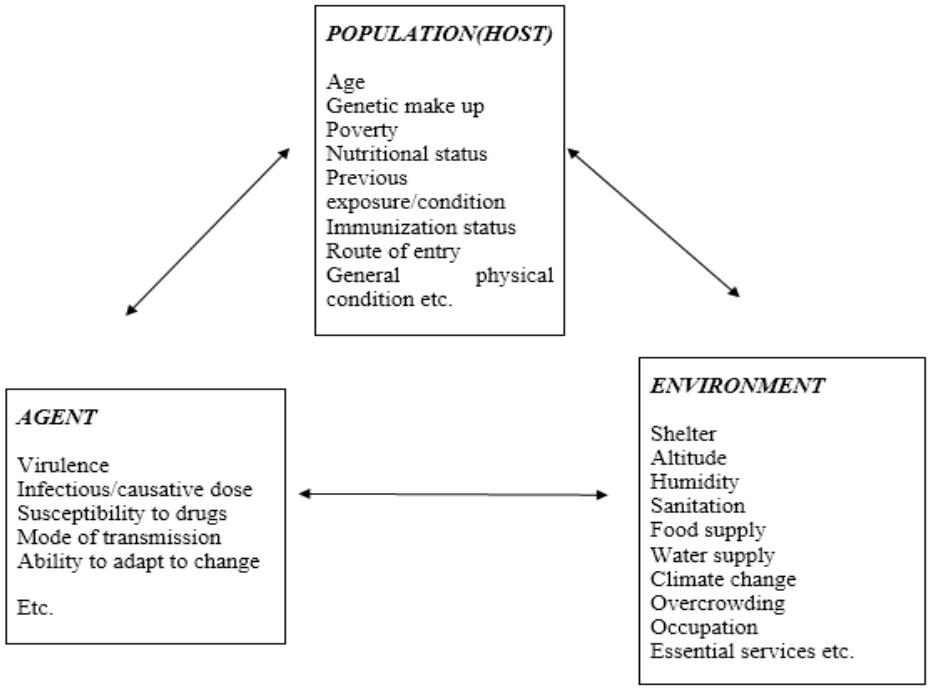


Fig 1: Equilibrium between the population (host), infectious/causative agent, and the environment.

3. Findings and Discussions

3.1 Agent factor of exposure to secondhand smoke implicated in asthma and other related diseases

An agent factor in this study refers to chemical substances and or particulate matters/gases emanating from secondhand smoke, which presence or excessive presence is essential for the trigger of asthma and other related diseases.

Secondhand smoke is a mixture of gases and fine particles that includes; smoke from burning cigarette, cigar or pipe tip, smoke that had been exhaled (breathed out) by someone who smokes [4]. It contains more than 7,000 chemicals, including hundreds that are toxic and about 70 that can cause cancer [6]. It had been reported that, the smoke that burns off the end of a cigar or cigarette contains more harmful substances (tar, carbon monoxide – a poisonous gas found in car exhaust, nicotine, among others) than the smoke inhaled by the smoker.

According to [8], below are just a few other chemicals that float into the lungs when exposed to secondhand smoke:

- Hydrogen cyanide – a highly poisonous gas used in chemical weapons and pest control
- Benzene – a component of gasoline
- Formaldehyde – a chemical used to embalm corpses

It is important to note that these chemicals are known

toxicants or carcinogens.

Tobacco smoke damages tiny hair-like structures in the airways called cilia. Normally, cilia sweep dust and mucus out of the airways. Tobacco smoke damages cilia, so they were unable to work, allowing dust and mucus to accumulate in the airways. Smoke also causes the lungs to make more mucus than normal. As a result, even more mucus can build up in the airways, triggering an attack [7].

Health risks associated with breathing in secondhand smoke include cancer, heart disease, asthma attacks and many more. While most discussions about passive smoking had centered on lung cancer and breathing, the effects on heart disease were more important. This is so because, the chemicals in secondhand smoke poison the heart muscle, interfere with the ability of blood vessels to adjust themselves to control blood pressure and flow; increase the buildup of blockages of blood vessels (which lead to heart attacks) and make blood sticker. The net effect was that there were about 15 times more reported deaths from heart disease caused by passive smoking – 35,000-62,000 deaths annually in the United States –as lung cancer [9].

Therefore, the agent factors of secondhand smoke, implicated in asthma and other related diseases as identified in this study include chemicals/particulate matters from;

1. Burning cigarette
2. Burning cigar or pipe tip
3. Exhaled smoke from smoker/s

3.2 Host factors of exposure to secondhand smoke implicated in asthma and other related diseases

Host factors are the endogenous attributes of individuals, their behavioural style and or environmental circumstance that predisposes or make them susceptible to a disease and or remain healthy within the concept of epidemiological triad. Host factors could also be exposure and or vulnerability potentials of individuals to causative agent/s that increase the risk of a disease. In the present context, exposure potential to secondhand smoke that is capable of producing ill health conditions associated with it.

Children are the most likely to be exposed to secondhand smoke [10], primarily through their caregiver/s [11] and they are particularly vulnerable to the effects of secondhand smoke because their body is still growing while they breath at a faster rate than adults, therefore inhale much more of the poisonous chemicals associated with secondhand smoke. According to [12], all the conditions listed below, had been attributed to secondhand smoke exposure among children;

- Sudden infant death syndrome (SIDS)
- Increased number of respiratory infections (such as bronchitis and pneumonia)
- More severe and frequent asthma attacks
- Ear infections
- Chronic cough

They were attributed to secondhand smoke because when a child is exposed to tobacco smoke, his/her lungs are capable of becoming irritated and to produce more mucus than normal. This pathophysiology is indispensable noting that children's airways are smaller and so the side effects of secondhand smoke affect them faster and can equally affect lung function in later life [8].

Among people with asthma, exposure to secondhand smoke had been reported a risk factor for asthma exacerbations and the development of severe asthma [13, 14]. Secondhand smoke is particularly harmful to people who already had asthma, noting that when a person with asthma is exposed to secondhand smoke, he or she is more likely to experience the wheezing, coughing and shortness of breath associated with asthma [8].

Similarly, researchers had found that women, who had been exposed to secondhand smoke, face a 69% higher risk of heart disease and a 56% higher risk of stroke than those who have not been exposed [12].

Also, studies in the United States among others had found that smoking and exposure to secondhand smoke among pregnant women had been a major cause of spontaneous abortions, stillbirths and sudden infant death syndrome (SIDS) after birth [15, 16].

Study had equally shown that individuals with asthmatic heredity had a considerably increased risk of adult-onset asthma when exposed to secondhand smoke. Secondhand smoke had dose-dependent synergism with family history of asthma, the joint effect being stronger with higher exposure levels. This was a result of a population-based incident case-control study of clinically defined adult-onset asthma and randomly drawn control subjects (adults' 21-63years old) from a geographically defined area in South Finland. After excluding current and ex-smokers there were 226 cases and 450 disease-free control subjects. The main findings were, parental asthma and recent secondhand smoke had a synergistic effect on risk of asthma, the adjusted odds ratio being 1.97 (95% confidence interval, 1.12-3.45) for secondhand smoke; 2.64 (1.65-4.24) for parental asthma and 12.69 (3.44-46.91) for their joint effect (relative excess risk due interaction, 9.08 (-0.22 to 43.18). Synergistic effect followed a dose-dependent pattern with both recent and cumulative secondhand smoke exposure of 6.17 (0.57-19.16) [17].

However, in Nigeria, few of the studies carried out were basically focused on prevalence and pattern of exposure to secondhand smoke, among such was the study conducted by [18] on prevalence and pattern of secondhand smoking in Abia state wherein findings revealed that exposure to tobacco smoke was more common in respondents who were young, males, unmarried or used alcohol.

In view of the foregoing, the host factors of exposure to secondhand smoke, implicated in asthma and other related diseases were;

1. Age (children than adults)
2. People with asthma (pre-existing asthmatic condition)
3. Gender (Males than Females)
4. Pregnant women
5. Family history of asthma
6. Being single (unmarried)
7. Alcohol consumption/use

3.3 Environmental factors of exposure to secondhand smoke implicated in asthma and other related diseases.

The environmental factors in this study refer to the domain in which the reference disease (asthma and other related diseases) causing agent (secondhand smoke) may exist or originate from that is external to the individual host. The pattern of exposure and level of interaction with the agent in such domain may necessarily be implicated in the occurrence and prevalence of the ill health condition. In this case, the

situate of the host and pattern of exposure to secondhand smoke that were implicated in the trigger of asthma and other related diseases as a consequence of air pollution – a prominent component of environmental factor in disease process and propagation.

Secondhand smoke had been reported as one of the most important and most widespread exposures in the indoor environment. It affects a large proportion of the population, as smoking is prevalent (up to three quarters of adult men in some countries) whereas it is hardly restricted to outdoor settings [5].

The home is probably the most important place to keep secondhand smoke-free, particularly when children live there. However, report had indicated that an estimated 21 million children live in homes where a resident or visitor regularly smokes and more than half of all American children had detectable levels of cotinine (the breakdown product of nicotine) in their blood. Urinary cotinine is associated with decreased lung function, mainly in children with asthma. [19] Keeping children exposed to close source of secondhand smoke increases their risk of developing respiratory infections, severe asthma, cancer and many other dangerous health conditions [12]. It was reported that 126 million nonsmoking Americans were exposed to secondhand smoke at home and work place [8].

Although, some countries including Nigeria had passed legislation that prohibits smoking in the workplace, but it is important to note that, workers in the entertainment and food industries are frequently exposed to secondhand smoke on a daily basis [5], and we see this continuing except aggressive awareness campaigns and enforcement of appropriate legislations are given priority attention.

In Nigeria [20], conducted a cross-sectional study from October 2009 to April 2010 among nonsmoking adult population of two cities (Enugu and Ilorin) and out of the 585 nonsmoking adults who participated in the study, 38.8% had regular exposure to SHS, mostly in public places (24.4%). More men were exposed at public places when compared with women (27.0%vs.19.5%).

Similarly, in the works of [18] on prevalence and pattern of secondhand smoking in Abia state, Nigeria, females were less frequently and intensely exposed to secondhand smoke both at home and public places than males. Predictors of secondhand smoke at home were gender, odds ratio (OR) =1.85 (95% confidence interval [CI] 1.20–2.83) and use of alcohol OR = 2.06 (95% CI 1.04–4.09); and in public places were age OR = 1.55 (95% CI 1.10–2.20), gender OR = 2.73 (95% CI 1.96–3.81), and use of alcohol OR = 2.55 (95% CI 1.51–4.28).

In a study conducted to analyse the association between tobacco smoking, exposure to secondhand smoke and reports of wheezing and asthma in a sample of school children at 25 schools in Terrassa, Spain in 2006. The result revealed that 53.9% children reported exposure to secondhand smoke at their leisure time, 41.1% at home, 40.0% at school, and 33.25 while using private or public transportation. Wheezing was reported by 9.2% of children, also 9.2% reported asthma. Exposure to secondhand smoke while using transportation had been shown to associating with wheezing (OR = 1.4; 95% CI 1.0-2.0) [21].

From the above indications, the environmental factors associated with exposure to secondhand smoke, implicated in asthma and other related diseases include;

1. The home
2. The workplace
3. The school
4. Private or public transportation system
5. Leisure time associated with bar, restaurants etc.

3.4 Impact of secondhand smoke on asthma and other related diseases

Secondhand smoke had been shown to having a number of serious health effects on nonsmokers, cancer and heart diseases in particular. A report from [8] confirmed that secondhand smoke (also called involuntary or passive smoking) can kill, and the report further stated that no amount of exposure to secondhand smoke is safe. Inhaling secondhand smoke is bad for the heart, and research showed that it takes as little as 10 minutes for the smoke to start causing damage. This is so because, exposure to smoke makes blood platelets sticker, raises the level of artery-clogging low density lipid (LDL) also known as "bad" cholesterol and damages the lining of the blood vessels. Eventually, these changes were likely to cause development of blockage to the blood vessel that leads to a heart attack or stroke [12].

Cancer is a significant problem with secondhand smoke exposure. Lung cancer may be the most talked about effect of secondhand smoke exposure, but the risk of breast cancer, cervical cancer and other types of cancers were also thought to be higher [12].

Report had shown that secondhand smoke or environmental tobacco smoke (ETS) had a very serious form of indoor air pollution. For instance, in the United States, secondhand smoke exposure causes about 3,000- lung cancer deaths a year, compared to less than 100 lung cancer deaths per year from traditional forms of outdoor air pollution [9]. Report also states that secondhand smoke equally causes and aggravates asthma and other breathing problems, particularly in children.

Evidence for an increased cancer risk from environmental tobacco smoke stems from studies examining nonsmoking spouses living with individuals who smoke cigarettes, exposures of nonsmokers to environmental tobacco smoke in occupational settings and exposure to parents' smoking during childhood [13, 22]. Also, their epidemiological studies, including large population-based case-control studies, had demonstrated increased risks for developing cancer following prolonged exposure to environmental tobacco smoke. Similarly, a meta-analysis found an overall increase in risk of 20% for exposure to environmental tobacco smoke from a spouse who smokes. Exposure to environmental tobacco smoke from spousal smoking or exposure in an occupational setting appears most strongly related to increased risk.

In the year 2000 [23], issued the following summary of current knowledge on health harms from workplace exposure to secondhand smoke as thus: "Environmental tobacco smoke (ETS) contains numerous toxins. Robust epidemiologic evidence implicates ETS as a cause of lung cancer and as a primary cause as well as a source of exacerbation of excess respiratory disease. Also, increasing evidence showed that ETS may be associated with other outcomes, including heart disease. Reiterating that, doubt about ETS as an important and avoidable health hazard remained insignificant. However, ETS continue to be frequently encountered in the workplace,

where it is no safer than in other environments where it presents hazards to exposed workers and others."

In the study conducted by [24] and published in the journal *Pediatrics* revealed that exposure to secondhand smoke through the mother in utero was associated with increased rates of hospitalization in infants with nonsmoking mothers and that use of tobacco products by household members had an enormous adverse impact on the health of children.

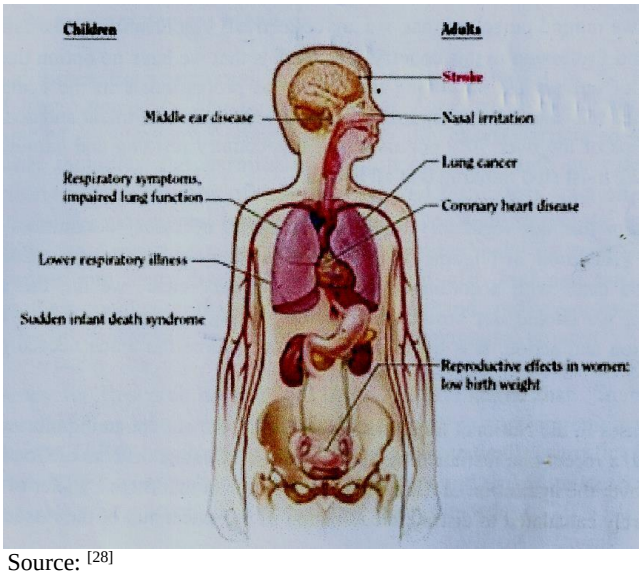
The report of [22] stated thus, "involuntary smoking (exposure to secondhand or environmental tobacco smoke) is carcinogenic to humans (Group 1)." The report further stated and concluded that there were "statistically significant and consistent association between risk of lung cancer in spouses of smokers and exposure to secondhand tobacco smoke from spouse who smoke. The excess risk was in the order of 20% for women and 30% for men."

Also, [22] declared that "epidemiological studies had demonstrated that exposure to secondhand tobacco smoke is causally associated with coronary heart disease" and they estimated that involuntary smoking increases the risk of an acute coronary heart disease event by 25-35%. The agency noted that for adults, the strongest evidence for a causal relation exists for chronic respiratory symptoms.

The report of a 2004 study published in the *British Medical Journal*, revealed that exposure to secondhand smoke increases the risk of heart disease among nonsmokers by as much as 60 percent. This was the first study to show a direct physical link between secondhand smoke exposure and an increased risk of heart disease. The study was conducted over 20 years by researchers at St. George's Hospital Medical School in London, wherein they measured exposure to secondhand smoke from all sources; including in bars, restaurants and other workplaces as well as in homes, based on blood levels of a nicotine byproduct called cotinine. The study was one of the few that had sought to account for all sources of exposure to secondhand smoke, not just home exposure [25].

In January, 2005 [26], issued her *11th Report on Carcinogens*, and declared unambiguously based on a thorough review of available scientific and medical evidence as thus: "Environmental tobacco smoke is known to be a human carcinogen based on sufficient evidence of carcinogenicity from studies in humans that indicate a casual relationship between passive exposure to tobacco smoke and human lung cancer. Some studies also supported an association of environmental tobacco smoke with cancers of the nasal sinus [13].

According to [27] in her report, *Proposed Identification of Environmental Tobacco Smoke as a Toxic Air Contaminant*, reiterated and strengthened many of its previous findings regarding the harms associated with exposure to secondhand smoke, including the harmful effects on children, such as sudden infant death syndrome, induction and exacerbation of asthma, increased respiratory tract infections, increased middle ear infections, developmental toxicity resulting in lower birth weight and impaired lung function. In adults, the Agency equally reiterated and strengthened her prior findings, including lung cancer and heart disease. The new report also included two significant, new findings in addition to their conclusion that exposure to secondhand smoke causes nasal sinus cancer as well as breast cancer in younger, primarily premenopausal women.



Source: [28]

Fig 2: Pictorial View of Effect of Secondhand Smoke on Human.

Note: The condition in red in fig. 2, is a new disease causally linked to secondhand smoke in the report of [28]. It had been stated that the more secondhand smoke is inhaled, the more the health risk increases. According to [8], below were few notable statistics on the effects of exposure to secondhand smoke:

- Exposure to secondhand smoke causes nearly 50,000 deaths in adult nonsmokers in the United States of America each year.
- It increases nonsmokers' risk of developing lung cancer by 20 to 30 percent and heart disease by 25 to 30 percent.
- It causes about 3,000 deaths from lung disease in nonsmokers each year.
- An estimated 46,000 nonsmokers who live with smokers die each year from heart disease.
- Between 150,000 and 300,000 children under the age of 18 months get respiratory infections (such as pneumonia and bronchitis), 7,500 to 15,000 of them must be hospitalized.
- More than 40 percent of children who visit the emergency room for severe asthma attacks live with smokers.

In the report of [29] – *Protection from Exposure to Secondhand Tobacco Smoke – Policy Recommendations*, it states that, scientific evidence had firmly established that there is no safe level of exposure to secondhand tobacco smoke, a pollutant that causes serious illness in adults and children. This shows consistency with the earlier statements in this work.

It is important to reiterate that, though, published works showing burden of secondhand smoke on asthma and other related diseases in the context of Nigeria and indeed sub-Saharan Africa region were difficult to access, we believe, even if readily available, the situation may not be different. This review may therefore, provide a framework for further empirical study on the subject in the context of our country, Nigeria and indeed sub-Saharan Africa region.

3.5 Financial cost as specific public health significance of asthma and other related diseases implicated in exposure to secondhand smoke

It had been reported that uncontrolled asthma significantly

affects quality of life and incurs substantial medical expenses as well as opportunity costs in missed days of work and school, even premature deaths, estimated at $56 billion (N17,360 billion) in United States in 2007 [30, 31].

The total annual cost of treatment in Minnesota for conditions for which the 2006 surgeon general's report found sufficient evidence to conclude a causal link with exposure to SHS was $228.70 million dollars (N70,897 billion) in 2008 – equivalent to $44.58 million dollars (N13,819.8) per Minnesota resident. Sensitivity analysis showed a range from $152.10 million (N47, 151 million) to $330.00 million (N102, 300 million) [32].

In a population study on "The economic burden of smoking and exposure to secondhand smoke in rural South-West China," the prevalence rate of exposure to SHS was 38.2% for males and 43.4% for females, respectively. The total costs of illness were $25.85 million (N8, 013.5 million) for COPD (chronic obstructive pulmonary disease), $18.80 million (N5, 828 million) for asthma, $37.25 million (N11, 547.5 million) for cardiovascular heart disease (CHD), $17.91 million (5,552.1 million) for stroke, $264.35 million (N81, 948.5 million) for hypertension and $17.11 million (N5, 304.1 million) for peptic ulcer. The estimated cost attributable to exposure to SHS was $79.35 million (N24, 598.5 million), accounting for 5.94% of local healthcare costs. Of the total cost of tobacco, direct costs and indirect costs were $78.22 million (N24, 248.2 million) and $1.36 million for exposure to SHS. It is important to state that the conversion rate used for the dollar was N310:00. However, smoking contributes more cost of illness than exposure to SHS in men, whereas exposure to SHS contributes more cost of illness than smoking in women [33].

It is also important to state that such financial cost implicated in the management of asthma and other related diseases from exposure to secondhand smoke is quite auspicious, especially in a dwindling economy, such as ours in Nigeria, which we believe if data were available the situation may not be different, therefore, sustainable public health measures are needed to be put in place to addressing the situation in the interest of public health.

4. Recommendations

a) Findings of this study should provide the basis for further empirical studies in our context, Nigeria and indeed the sub- Saharan Africa region.
b) Targeted and intensified population based awareness creation on impact of exposure to secondhand smoke on asthma and other related diseases should be given priority attention to ensure public health.
c) Based on glaring epidemiological evidence on causal association between exposure to secondhand smoke and asthma and other related diseases as reviewed in this work, we are left with no alternative than to adopt the California Environmental Protection Agency (CalEPA) recommendation, based on their latest comprehensive review of scientific literature, that secondhand smoke be declared a toxic air contaminant and therefore be subjected to emissions control regulations to be promulgated by countries in the interest of public health, noting the enormous burden and economic impact.

5. Conclusion

The available epidemiological evidences showing cause-effect association between exposure to secondhand smoke and asthma and other related diseases are strong, consistent, coherent and plausible to give room for putting in place deliberate regulatory policies and laws by countries and ensuring enforcement of such policies and laws aimed at limiting exposure to environmental tobacco smoke wherever people live or engage in means of livelihood as an occupation.

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