Perspective article

Conceptual frameworks regarding waterborne diseases in sub-Saharan Africa and the need of a new approach to urban exposomes

Alexandre Zerbo , Rafael Castro Delgado, Pedro Arcos González

Unit of Research in Emergency and Disaster, Faculty of Medicine and Health Sciences, University of Oviedo.

Corresponding author: Alexandre Zerbo, crateva@yahoo.fr , Unit of Research in Emergency and Disaster, Faculty of Medicine and Health Sciences, University of Oviedo.

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Abstract

Sub-Saharan African countries, like many other low-income countries, experience urban socio-economic inequalities due to rapid and unplanned urbanization. As a result, there is the creation of poor urban areas lacking basic sanitation, water and hygiene facilities, and subjacent public health issues such as the spread of waterborne diseases. The demarcation of disease transmission areas already exists, but is less appropriate in sub-Saharan Africa, making the need to divide these urban areas more adequately. In addition, the construction of frameworks tools more specific to waterborne diseases issues is essential.

We propose a restructuring of sub-Saharan urban areas into more specific areas of exposure to waterborne diseases and associated exposomes. Then we use this restructuring of urban areas of exposure to waterborne diseases in a conceptual framework taken account causes of exposure, impact and interventions.

The division of the urban area into public, domestic and individual exposure areas eases the understanding of the dynamics of waterborne exposomes. Moreover, the inclusion of this division in the DPSEEA(Driver-Pressure-State-Exposure-Effect-Action) framework allows a effective stratified implementation of urban public health policies.

Keywords: Exposomes; Urban areas; Waterborne diseases, Sub-Saharan Africa

Introduction

The African continent is expected to home nearly 60% of its population in urban areas by 2050[1]. Its sub-Saharan region, particularly, is experiencing increasing urbanization which does not keep pace with the improvement of public health[2].

Public health challenges, associated mainly with migration and the creation of poor areas, threaten the development of cities[3]. Indeed, this urbanization generates poor urban areas where the living conditions, such as unsanitary housing, inadequate sanitation and hygiene and unsafe drinking water, exacerbate the transmission of communicable diseases and pose a threat to public health [4].

In 2017, 45% of the world's population (3.4 billion people) used a safe sanitation service, while 2 billion worldwide lacked even basic sanitation facilities. Moreover, globally, at least 2 billion people use a source of drinking water contaminated with faecal matter, and 485,000 deaths from diarrhoea each year are due to contaminated drinking water[5], [6].

The concentration of pathogens, vectors of pathogens, hosts and toxic chemicals in the environment could be the result of many factors, including changes in land use, climate, demographics and inadequate water, sanitation and hygiene services. All of these are interconnected and relevant to public health[7].

Health and environment issues must be addressed holistically for urban concerns, and interventions must be carried out through a multidisciplinary and sustainable approach. Moreover, a better understanding of the dynamics between human health and the urban environment makes it possible to predict health hazards and effective strategies to prevent them. Therefore, new ideas and concepts could federate and consolidate efforts to solve environmental urban health problems[8], [9].

A subdivision of urban areas in areas of exposure helps to understand the dynamic of transmission of waterborne diseases. The waterborne exposome is a central determinant of health, as water is fundamental to human existence and in a polluted or contaminated ecological state, it may present a risk to health[4], [10].

In addition, the conceptual Framework provides that system context tool that collects, visualizes, and analyses the connection between environment, human health, and potential intervention policies[11], [12]. It is not only an effective tool to display the relationship between the factors that have an impact on

environmental changes and the underlying consequences on public health; but it is also a tool that shows potential interventions throughout a system[13].

Furthermore, the development of a public health information and decision-support tool requires an organization of the connections between human health, the environment, and socio-economic parameters in a systemic approach[14].

Given the current subdivision of disease transmission domains and the concept of urban exposome, we see a need to propose a new paradigm in subdivision of exposure areas to waterborne diseases in sub-Saharan Africa. This, with regard to the establishment of new framework tools that deals more specifically with urban public health issues and interventions, in particular waterborne diseases in sub-Saharan Africa.

The objective of this article is to propose a new approach in the definition of urban exposomes and conceptual frameworks for waterborne diseases in sub-Saharan Africa to improve the accuracy and utility of this tool in public health planning.

Reasonings for a new approach to urban exposomes

According to Cairncross et al, transmission of the disease could occur in the public domain which refers to the public workplace, school, street, commerce and land; and also a in the domestic domain which includes areas occupied by or under the control of the household[15].

These domains could be also considered as urban areas. Therefore, we could have a public area broader than the domestic area, and in continuity with the domestic area, we have a third area: the individual area.

This third area considers individual human specificities of exposure in urban environment. The individual area refers to biological and behavioural patterns of an individual such as physiology, age or personal hygiene that modulate the exposure to health risk. Consequently, the urban area could be divided in three areas: the individual area, the domestic area, and the public area.

Theoretically, from this subdivision of urban areas, and the exposure to waterborne diseases, we could have the individual, domestic and public areas of exposure to waterborne diseases.

Adapting exposomes for urban areas of exposure to waterborne diseases in sub-Saharan Africa

The urban exposome has been defined as the continuous qualitative and quantitative environmental indicators that map the dynamics of urban health and its interactions with the climate, built environment, and small areas (neighbourhoods) characteristics[4].

Moreover, the exposure in urban areas could be considered as a continuum of exposomes, where the internal exposome domain of the higher exposome is anchored to the external exposome domain of the next one[16].

To apply the concept of exposome to urban areas of exposure to waterborne diseases, there would have each urban area as an exposome with an external exposome domain (general and specific) and an internal exposome domain. (Figure 2)

Public exposome:

- External public domain(general and specific): wider parameters having an impact on the dynamic of natural and built-environment such as climate/ climate change, policy decision, socioeconomic and cultural determinants, migration
- Internal public domain: parameters having direct impact on the organization of the urban setting such as the migrations, urbanization, demographic change, deforestation, disaster events (floods, droughts), water source quality.

Domestic exposome:

- External domestic domain (general and specific): parameters having direct impact on the organization of the urban setting such as the migrations, urbanization, demographic change, deforestation, disaster events (floods, droughts), water source quality.

- Internal domestic domain: parameters having an impact on the vulnerability and exposure to water-related disease such as housing quality, household sanitation (latrine, waste management), hygiene practice (water storage, handwashing), drinking water and food quality(faecal contamination), vectors and infectious agents

Individual exposome:

- External human domain (general and specific): parameters having an impact on the vulnerability and exposure to water-related disease such as housing quality, household sanitation (latrine, waste management), hygiene practice (water storage, handwashing), drinking water and food quality(faecal contamination), vectors and infectious agents
- Internal human domain: “ non-genetic” parameters internal to the human body that affect the susceptibility to water-related diseases such as age, physiology and immunity.

Each parameter as component of the various exposomes of waterborne diseases in urban areas evolves dynamically over time. For example, the climate as a component of the public exposome may change over time, just as age as a component of individual exposome may also vary over time. This continuum of urban exposomes is in constant flux.

Selection of conceptual framework to waterborne diseases for sub-Saharan urban areas

From the literature, we have mainly three conceptual frameworks dealing with environmental issues: the Pressure- State- Response (PSR), the Driving forces- Pressures – State – Impact – Response (DPSIR) and the Driving Force – Pressures – State – Exposure – Effect – Action (DPSEEA)[13].

The PSR framework is primarily focused on the environment rather than human health, while the DPSIR framework does not provide for the possibility of targeted interventions across the framework[7], [12].

Among all these frameworks, the DPSEEA is the most suitable to address urban waterborne diseases issues. Because “ *a conceptual framework is required to accurately and precisely identify relationship between sources that*

influence change in the environment, and health impacts that can be linked these causes support effective intervention”[13].

Furthermore, an advantage of this framework over PSR and DPSIR is its distinction between "exposure" and "state" parameter which allows potential interventions targeting one or both[17].

DPSEEA framework is a descriptive representation of how various driving forces generate pressures that affect the state of the environment through the way people come into contact with the environment[18].

Moreover, the exposure in the urban environment and the resulting health effects can be represented in the DPSEEA framework. In addition, the DPSEEA framework captures the lifestyle and behavioural parameters which influence the exposure[18].

Adapting urban areas for waterborne diseases dynamic in the DPSEEA conceptual framework

Concretely, it is a model comprising six parameters: the driving forces (societal, economic and political factors); pressures (resulting factors that modify the environment); states (altered environmental quality), exposure (human interaction with the environment), effect (human health outcomes) and actions (policies and intervention against the effects)[17], [19].

The exposure in the urban environment and the resulting health effects can be represented in the DPSEEA framework. In addition, the DPSEEA framework captures the lifestyle and behavioural parameters which influence the exposure.

We therefore consider a combination of the DPSEEA framework and the three urban areas for waterborne diseases(Figure 3):

- Driving forces such as climatic and socio-economic factors and associated policies, which have a large-scale impact on the environment and ultimately on human health. Indeed, climate, poverty, social inequity demography, educational level may be drivers for faecal-orally transmitted waterborne diseases[10].
- Pressures resulting from the driving forces exerted on the urban areas (public, domestic, and human), considering that the public area affects the domestic area and the domestic

area in turn affects the individual area. The pressures are generated by economic activity, agriculture, housing, social attitudes, and the release of pollutants, waste and pathogens into the environment[18].

- States or quality/degradation of urban level under the effect of the pressures exerted. The changes of the urban environment can affect the public level in unplanned urbanization, inadequate environmental sanitation and also the domestic level in overcrowded housing, contaminated water storage, unsanitary latrines and, in ultimately, the human level with contaminated drinking water and food.
- Exposure in urban areas to environmental hazard (waterborne pathogens) through drinking water or food consumption. People are at health risk from exposure to pathogens in drinking water, through food, fingers and flies, through recreational activities in a contaminated aquatic environment[20], [21].
- Effects, as health effects resulting from exposure to environmental hazards in urban areas. (burden of diarrhoea in sub-Saharan Africa)
- Action, such as the implementation of strategies in urban levels to prevent and control the spread of environmental health hazards. Actions are based on reducing exposure to waterborne pathogen through the supply of safe drinking water, management of health risks, sanitation policies, health promotion[22].

Discussion

Before this commentary, no report has mentioned the incorporation of public, domestic, and individual areas in conceptual and exposome framework.

Cairncross mentioned public and domestic regarding the domain of transmission of diseases while Adrianou mentioned urban and human for the concept of exposome[4], [15].

The interest of dividing the urban area into public, domestic and individual, is to consider the dynamics and specificities of the exposomes in and between these urban areas. Another interest of this restructuring of the urban areas exposomes, is potential interventions which could be more targeted, and effective. Particularly in the case of waterborne diseases issue in sub-Saharan African urban areas.

The DPSEEA framework determines the source and causes of the spread of waterborne pathogens in the interconnection between change in the urban environment and the burden of waterborne diseases[13]. This helps to have a proactive approach that targets actions to be taken earlier in the causal chain of the framework. Subsequently this involves the reduction of environmental occurrence of waterborne pathogens and the prevention of risk of related diseases[23].

Conclusion

The division of urban areas into individual, domestic and public; is essential to better understand the specificities of urban exposures to waterborne diseases.

It implies taking into account the urban exposome in individual, domestic and public exposomes.

This restructuring of urban areas could be considered in the DPSEEA conceptual framework. It shows the interconnection between the causes, the change of the sub-Saharan urban environment and the potential public health intervention against the spread of waterborne diseases.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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Figure 2: urban exposomes for waterborne diseases in sub-Saharan Africa

Figure 3: Conceptual framework (DPSEEA) for urban Waterborne diseases

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