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PERSPECTIVES

Conceptualization of the Transmission Dynamic of Faecal-Orally Transmitted Diseases in Urban Exposome of Sub-Saharan Africa

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Abstract: In sub-Saharan Africa, many urban dwellers are at risk of faecal-orally transmitted diseases due to unplanned and growing urbanization with inadequate sanitation. Making it essential to understand the urban transmission of these diseases and the associated responses. This perspective paper discussed an approach to design a diagram of transmission dynamic from a combination of an urban exposome framework and transmission of faecal-oral diseases. The result is an exposome diagram displaying the interconnection of exposure components and potential barriers to stop the transmission of faecal-oral diseases in the urban area subdivided into public, domestic and individual. As an exposome diagram, it helps to follow the dynamics of exposure over time and to plan targeted surveillance and intervention.

Keywords: faecal oral diseases, transmission dynamic, exposome diagram, urban areas, sub- Saharan Africa

Background

Urbanization in sub-Saharan Africa generates a combination of conditions including environmental degradation, populated areas and economic deprivation, all conducive to unsafe sanitation and exposure to faecal-orally transmitted diseases (FOD).[1]

FOD mainly result from oral contact with water, food, and other vehicles contaminated with faecal matter.[2,3] These infections, caused by various bacterial, viral and protozoan pathogens, are preventable by interrupting the faecal-oral transmission pathways.[1]

Many models are developed to represent the faecal-oral route, among them the most important is the "F diagram" of Wagner and Lanoix.[4] This diagram illustrates the transmission of faecal-oral diseases and it could be useful to also describe water, sanitation and hygiene (WASH) interventions acting as barriers in the flow of faecal-oral pathogens.[1]

However, this diagram does not take into account the different domains of disease transmission (public, domestic and individual) discovered after.[5,6]

Displaying the "F-diagram" throughout the urban domains of diseases transmission can provide an alternate pattern and specify by domain the components of this diagram and the barriers acting as interventions.

This paper explores an alternative way to develop a diagram of FOD transmission in the urban areas of sub-Saharan Africa (SSA). First, it will investigate the combination of the "chain of infection", the "F diagram" and the "urban exposome framework of waterborne diseases". Then, it will analyze how to interrupt the transmission of FOD in the urban exposome of SSA.

Urban Areas of Faecal-Oral Diseases Transmission

FOD may occur in three areas transmission in urban setting: the public, domestic and individual areas. Public area referring to the domain under the control of the street, infrastructure, commerce, the domestic for the domain under the control of the household and the individual referring to the domain under the control of the individual.[5,6]

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Theoretically, urban areas of faecal-oral diseases transmission could be represented by three concentric circles where a, b and c represent public, domestic and individual areas respectively, as shown in the Figure 1.

Urban Exposomes for Faecal-Oral Diseases

The urban area of transmission of FOD could be perceived as areas of exposure to these diseases. This exposure in these areas varies over time, hence the concept of urban exposome as a continuum of exposomes of public, domestic and individual connected by external or internal domains.[6,7]

To better illustrate the urban exposome of FOD, a three-coordinate plane with exposure, space and time as coordinate axes is designed as in Figure 2.

Conception of Diagram for Faecal-Oral Infections Transmission in Urban Areas

From the three coordinates plane above of the urban exposome for FOD, a transmission dynamic within public, domestic and individual exposomes as well as the breaking point of the chain of this transmission could be considered.

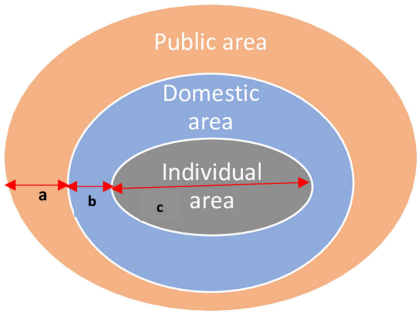

Figure 1 Urban areas for faecal-oral diseases transmission. [a]Public area, [b]Domestic area, [c]Individual area.

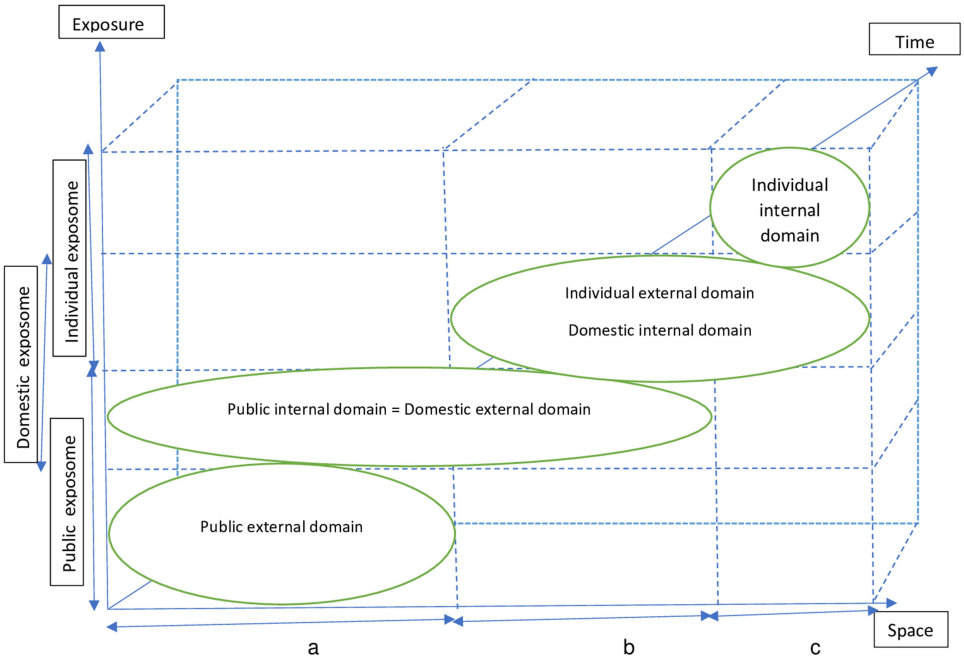

Figure 2 Urban exposome for faecal-oral diseases in sub-Saharan Africa. [a]Public area, [b]Domestic area, [c]Individual area.

The "F-Diagram" and the "Chain of Infection" have been applied in this three-coordinate plane in order to have a new diagram. This new diagram has been simplified so as not to encumber it. It's not so respectful of a three-dimensional plane. Figure 3

For each exposome constituting the urban exposome, the components of the exposure and the intervention measures are mentioned in Figure 3

Public Exposome

As an exposome related to exposure in area under control of "public places of work, schooling, commerce and recreation as well as the streets and fields", the disease transmission occurs through faecal contamination of the environment, soil and water source.[5] Therefore, the measure to interrupt the chain of infection would be the prevention of faecal contamination of the environment and water sources. A public environmental sanitation policy is more appropriate.[8]

Domestic Exposome

The transmission occurs when contaminated water is used in food preparation, washing utensils and drinking water storage containers.[9] Furthermore, flies frequent both faeces and food, so they can contribute to the transmission of FOD as a vehicle of the pathogen.[2]

Domestic exposome as exposure in area under control of household, food hygiene (food handling, preparation and storage practices) may interrupt the chain of transmission because food acts as a vehicle in the spread of FOD.[8] In addition, safe excreta disposal prevents faecal-oral pathogens from entering the household environment.[8]

Individual Exposome

The spread of faecal-oral pathogen may occur through contaminated fingers and hands. Then an ingestion of contamination of drinking water and contamination of food expose to FOD, if there are not practice of personal hygiene.[9]

Individual exposome refers to exposure in an area under the control of individuals, such as behavioral practice (personal hygiene in the case of FOD), but also the non-genomic factors such as immunity and physiology that play a role in susceptibility to infection.[3]

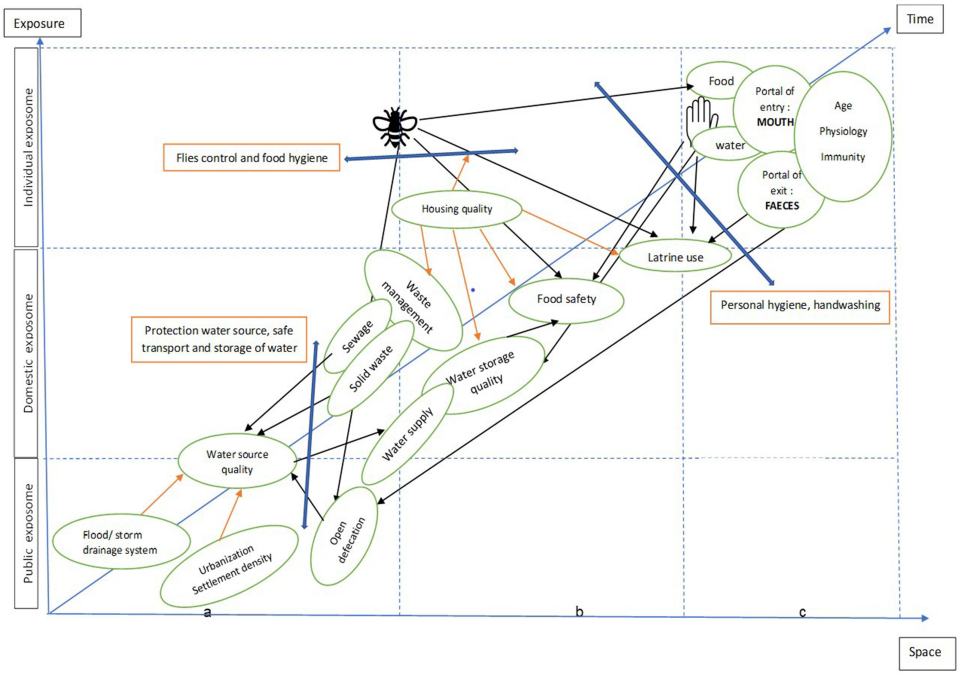

Figure 3 Diagram of faecal-oral diseases transmission dynamics in urban exposome of sub-Saharan Africa. [a]Public area, [b]Domestic area, [c]Individual area. Impact: ⟶ Flow of pathogen: ⟶ Barrier: ⟷.

Table 1 Exposure and FAECI Indicators

	Exposure	**FAECI Indicators**
Public	Open defecation	S_1
	Urbanization, Water source quality, drainage system	S_4
Domestic	Housing quality	H_1
	Water storage and supply	W_1, W_2
	Waste management, food safety, latrine use	S_2, S_3
Individual	Food consumption, drinking water	H_2

Abbreviations: S, sanitation; H, hygiene; W, water; FAECI, Faecal Environmental Contamination Index.

Personal hygiene such as handwashing before eating and after defecation may break the chain of transmission of oral faecal infections.[8]

Potential Application of the Diagram: Surveillance of Faecal-Oral Diseases in Sub-Saharan Africa

Surveillance of FOD helps to prevent outbreaks or reduce the burden of these infections in urban areas. One of the potential applications of this diagram is the surveillance of FOD which mainly involves monitoring indicators of faecal contamination.

Indeed, the faecal contamination is the cornerstone of the spread of FOD, so monitoring indicators of this contamination reveals its state, the performance of the existing water sanitation and hygiene (WASH) services and interventions to be taken.

The Faecal Environmental Contamination Index (FAECI) is based on eight indicators of the WHO-UNICEF and is suitable for monitoring indicators of faecal contamination and WASH services.[10]

The indicators of this index are:

For water: basic drinking water services (W_1), and safely managed drinking water services (W_2).

For sanitation: open defecation (S_1), basic sanitation services (S_2), safely managed sanitation services (S_3) and community coverage with basic sanitation services (S_4).

For hygiene: basic handwashing facilities (H_1) and handwashing with soap after potential faecal contact (H_2).

These indicators could be linked to the components of the diagram and be monitored over time in public, domestic and individual areas of transmission of FOD (Table 1).

Thus, a FAECI index could be obtained for each area of transmission of FOD (public, domestic and individual). Therefore, faecal contamination and WASH services conditions could be known. Accordingly, appropriate interventions could be taken at the public, domestic or individual level.

Discussion

This diagram allows the panorama of factors of exposure to FOD throughout the urban exposome, these factors can then be quantified and measurable over time as components of the exposome.[7]

This diagram also presents the barriers to break the transmission of FOD in each of the urban transmission areas (public, domestic and individual). Therefore, it shows where the WASH interventions could take place and what type of interventions.

An advantage of this diagram is the potential surveillance of FOD in urban areas with the faecal contamination indicators (FAECI).[10]

The FAECI indicators could be monitored in public, domestic and individual areas to get the status of the WASH services and the effectiveness of the interventions. Indeed, these indicators are related to water (W_1, W_2), sanitation (S_1, S_2, S_3, S_4) and hygiene (H_1, H_2) and may be monitored over time in public, domestic and individual areas.

In the public area, public policies could be taken for the municipal management of sanitation, the security of the water supply, while in the domestic area, there could be a community intervention for the promotion of health in household sanitation, water security and food hygiene.[10]

In an individual area, there could be a health promotion intervention for personal hygiene such as hand washing to avoid contact and ingestion of faeces, as well as an intervention to treat infections based on physiology, age, and immunity of individuals.[3]

Vulnerability to exposure to infections depends on factors such as hygiene behavior, socio-economic status and environment. This vulnerability increases susceptibility to infections by inducing physiological changes in an individual.[2,3]

In the case of FOD, drinking water is a key route through which individuals are exposed to faecal-oral pathogens.[8] Therefore, monitoring of exposomics data on drinking water quality (e.g, *E. coli* per 100 mL) remains important.

When in individual exposome, drinking water is highly compromised, water treatment and safe distribution of the public exposome are the main concerns.[1] This diagram also illustrates the possibility to trace the source of an exposure and planning a targeted intervention, because the exposures are interrelated.

Conclusion

This diagram gives an overview of the connection between the exposure components of the urban exposome for faecal-orally transmitted disease in sub-Saharan Africa.

In the form of an exposome diagram, it allows to measure the exposomics data over time of faecal-orally transmitted diseases in public, domestic and individual areas, thus allowing targeted interventions in these urban exposure areas.

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Disclosure

The authors declare no conflicts of interest.

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