

Original Research Article

Supply Chain Management in Global Public Health Activities: Opportunities for Improving Sanitation and Preventing Malaria in Mali

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ABSTRACT

Introduction: Despite it now being the 21st century, poor sanitation continues to impact resource-poor populations in many developing countries, such as Mali. The availability of better sanitation and housing supplies has the potential to help Mali and other resource-poor populations improve their standard of living (including improving housing) as a way to help improve the health of the population. In this report, we consider a number of urban and rural households with improved or not improved types of toilet facilities and whether or not the household dwelling was sprayed for the prevention of mosquitoes to see if these have any effect on the incidence of malaria. Finally, we discuss this experience in the context of a public health supply chain.

Methods: Using a cross-sectional study design and utilizing methods consistent with secondary data analysis, we examined secondary data related to the control of malaria in Mali from the perspective of residential housing and basic household sanitary plumbing. The dataset comprised 4,240 Malian households, and the unit of analysis was the concept of the household. Two groups were constructed on the basis of the study households classified as either belonging to rural districts or urban districts in Mali. The outcome variable chosen was whether or not a household was sprayed for mosquitoes. We examined the differences in the incidence of malaria in rural and urban households, and then performed a chi-square analysis of two independent samples. The SPSS Statistics software package was used to analyze the survey data.

Results: For a household with improved toilet facilities, whether in an urban or rural setting, if the household had been sprayed with insecticide, the risk of exposure to malaria is lower: Improved (OR) = .404, 95% CI (.280 - .582) and Unimproved (OR) = .118, 95% CI (.017 - .836). If household had not been sprayed, the risk is greater: Improved (OR) = 1.066, 95% CI (1.040 - 1.093) and Unimproved (OR) = 1.059, 95% CI (1.040 - 1.078).

Discussion: The results showed that the incidence of malaria among members of a household living in a household with improved sanitation that has also been sprayed to prevent mosquitoes will likely be lower than for households that have not been sprayed. The effect is different in rural and urban centers if the household sanitation facilities had not been improved. Spraying made an obvious difference. However, a challenge in Mali, at present, might be ensuring an adequate supply of insecticide and materials to evacuate liquid and solid waste in a safe manner at an affordable cost to the communities. In Mali, there is an urgent need to encourage the development of small trash-hauling services equipped with mobile solid and liquid waste removal containers and tools such as trash trucks.

Key Words: Fecal Pathogens, Public Health Supply Chain, Sanitation environment Improvement

INTRODUCTION

The improvement of public health in the industrial countries of the "First World"

was brought about, in part, by the control of garbage and improved sanitation. [1] These resulted in a reduction in disease; for

example, the control of cholera in London with removal of "the Broad Street 'water pump handle'".^[1] General improvements in the environment and housing have also resulted in the improvement in health in the human population as well.^[1]

However, despite this now being the 21st century, poor sanitation continues to impact the health of resource-poor populations in many developing countries, such as Mali. Mali, according to the World Health Organization, has the highest burden of malaria via *Anopheles* mosquitoes, which are responsible for 92% of the deaths from malaria in Africa.^[2] Malaria is commonly associated with poor sanitation.^[3] In developing countries, poor sanitation and poor health are closely related.^[4] Open defecation is a common occurrence in Sub-Saharan Africa (2017). The number of people practicing open defecation actually rose from 181 to 229 million during the period 1990 to 2015. Harris et al. (2017) found that households practicing open defecation in a 200 m radius had a significant association with the increased prevalence of underweight children, and it is known that fecal pathogens are harmful to humans. Hence, it is important to find ways and means to protect households. It is beneficial for health protection to ensure that fecal material is controlled so that it does not end up spilling into households and their community environments.

The availability of adequate sanitation and housing supplies has the potential to help Mali and other resource-poor populations improve their standard of living (including improved housing) as a way to improving the health of the population. Mara et al.^[5] defined sanitation as disposing of human excreta in a safe manner. The safe handling of human excreta demands a community-level effort that involves resolving supply-side intervention in good sanitation practices.^[5] The authors call on the private sector in poor countries to ensure a good supply of sanitary toilets at a low cost.^[5] Supplying these would require production, marketing, and maintaining a

stock of low-cost toilets.^[5] The supply activity by the private sector will necessitate the safe removal, transport, treatment, and/or disposal of excreta.^[5] Currently, global public health efforts are mostly focused on immunizations and the distribution of insecticide-treated nets but has not seized on the cost-effectiveness of public health intervention into sanitation and hygiene promotion.^[5]

In this report, we examined secondary data related to the control of malaria in Mali from the perspective of residential housing and basic household sanitary plumbing. We described households that completed the survey, with a special emphasis on spraying a household dwelling to prevent mosquitoes as a community control method to help eliminate malaria in Mali households. We describe the number of urban and rural households with improved or not improved types of toilets and whether or not the household dwelling was sprayed for the prevention of mosquitoes. Finally, we discuss this experience in the context of a public health supply chain.

METHODS

Study design and data source

This examination of data utilized a cross-sectional study design and utilized methods consistent with secondary data analysis. The data used were taken from Demographic and Health Surveys (DHS)^[6] for Mali, performed as part of a USAID survey contract; specifically a public-use data set was used in the analysis.^[6]

A questionnaire was developed to obtain the most representative sample possible for the population of Mali. The questionnaire was administered in various regions of Mali, covering both rural and urban households. The survey was limited to the Malian administrative regions of Kayes, Koulikoro, Sikasso, Segou, Mopti, and Bamako, while the regions of Tombouctou, Gao, Menaka, Kidal, and Taoudenit were excluded; the last four being administrative regions in the desert regions

of Mali where no malaria has been found. [7] The dataset included 4,240 Malian households; the unit of analysis was the concept of the household according to DHS. [6] Each household member was an individual record, with their demographic variables, such as sex, age, and characteristics of the household where they lived. [6]

Main Variables

Outcome: The outcome variable was whether or not a household had been sprayed for mosquitoes; defined as “Has the household been sprayed for mosquitoes in the last 12 months?” This variable was recorded in the database as HV253.

Grouping: Two groups were constructed on the basis of households being classified as either belonging to a rural district or an urban district in Mali. This was coded in the database as HV02. We followed Smith et al.’s [8] approach to utilizing two groups at the extreme of choices from no-preference to high preference. Tustin et al. [9] set the stage for urban/rural grouping stratification.

Data analysis

Using descriptive statistics, we recorded the basic demographic composition of the households included in this study. Then, we examined the differences in the incidence of malaria in rural and urban households by performing chi-square analysis of two independent samples. The SPSS Statistics software package was used to analyze the survey data.

RESULTS

Table 1 presents the demographic composition of the study respondents, including whether they live in an urban or rural center, the level of modernity of the toilet in each household, the administrative region where they reside, and if their dwelling had been sprayed against mosquitoes.

In this study, there were 4,240 households surveyed, of which 94.4 % were led by males and 5.6% by females. 25.4% of

the households were classed as being in urban centers and 74.6% in rural areas. In our sample, 24.6% of respondents shared toilets, while 75.4% did not. The samples were drawn from six administrative regions, each with 477 to 768 households taking part in the study. Finally, 6.4% of the households were reported to have been sprayed against mosquitoes, while the vast majority (93.6%) had not been (Table 1).

Table1. Household profile in Mali, 2015 (n=4240)

Household variables	Frequency
Sex	
Male led	4003 (94.4%)
Female led	237 (5.6%)
Type of Residence	
Urban	1075 (25.4%)
Rural	3165 (74.6%)
Toilet type	
Improved	1877 (44.3%)
Unimproved	2363 (55.7%)
Region	
Kayes	648 (15.3%)
Koulikoro	477 (17.5%)
Sikasso	695 (16.4%)
Segou	768 (18.1%)
Mopti	717 (16.9%)
Bamako	668 (15.8%)
Dwelling sprayed against mosquitoes	
Yes	272 (6.4%)
No	3968 (93.6%)

Data source: DHS Health Survey Results/Mali, 2015

Table2. Examination of anti-mosquito spraying of dwellings classified by urban vs. rural dwellings among the different types of toilet, 2015 (n=4,240)

	Outcome: Dwelling has been sprayed against mosquitoes in the past 12 months	
	Yes	No
Improved toilet*: urban	38 (0.9%)	901 (21.3%)
Improved toilet*: rural	94 (2.2%)	844 (19.9%)
Unimproved toilet: urban	1(^)	135 (3.2%)
Unimproved toilet: rural	139 (3.3%)	2088 (49.2%)

*Chi-square (continuity correction)=18.018; $p \leq 0.001$; ^ ($\leq 0.9\%$)

Table 2 overwhelmingly shows that the vast majority of households in the study sample had not been sprayed against mosquitoes in the past 12 months. Also, although the numbers were small, more rural households than urban households had been sprayed against mosquitoes in the past 12 months. The study analysis resulted in a chi-square (stat) of 18.018; $p \leq 0.001$. These results are statistically significant. Hence, it can be noted for households with improved toilet facilities, whether in an urban or rural

area, if the household has been sprayed with insecticide, the effect is different compared to households with unimproved toilets in urban and rural areas. The frequency count for the urban unimproved toilet was less than 5 and the Fischer Exact Test was significant as $p \leq 0.001$, which strengthened our previous findings so that we can state with certainty that urban improved and unimproved toilets will give different effects when sprayed against mosquitoes.

DISCUSSION

The study sample comprised 4,240 households. Only 6.4% of the households had been sprayed against mosquitoes. Of those, 3.1% only had improved toilet facilities. The number of households that had been sprayed and that could be classed as improved toilet facilities in both urban and rural areas was about equal to the number that had been sprayed but not improved. The effect was different in rural and urban centers if the household toilet facilities had been improved. Thus it was clear that spraying improved toilets had a beneficial effect.

Improving sanitation and the health status of the population

The history of public health shows that, as starting basic activities, the removal of trash and improving the water supply can help to improve the health of a population, especially among the poor. [10,11] Certainly, the story of how John Snow improved the health of the people of London by recognizing that the water supply from a particular water pump station may be the cause of a cholera outbreak is a classic example of the importance of sanitation as a means to improve population health. [10] We should therefore consider the history of public health and efforts made in other, especially similar, places as we reflect upon the importance of sanitation to improve health status in Mali.

Improved sanitation includes the proper removal of solid and liquid wastes. Furthermore, improved sanitation should

signify that the right infrastructure is in place over the whole community to evacuate all wastes, so there is no pooling of waste waters, rain waters, and no accumulation of solid waste. The challenge in Mali, at present, might be ensuring an adequate supply of insecticide and materials to evacuate liquid and solid waste in a safe manner and at an affordable cost to the communities.

Ensuring that all households have improved sanitation and that they are also sprayed to prevent mosquitoes will be key to reducing the incidence of malaria among households. Tusting et al. [9] explained that malaria reduction efforts may also be most effective when the mosquito population can be reduced through “larval source management (LSM).” Their study aimed to “evaluate the effectiveness of mosquito LSM for preventing malaria”. [9] The approach taken was to manage “water bodies” where mosquitoes develop, especially in areas where water does not drain off, and constitutes a habitat for larva. [9] They also recognized that improved sanitation would likely reflect in less water pooling and consequently less mosquitoes. Spraying adds an even greater protective effect. [9]

Supply chain management as an essential for improving sanitation and the health status of a community

The availability of adequate relevant materials in a community to improve sanitation can improve the overall health status of resource-poor communities. [5] Community members partnering with other organizations can facilitate improving housing and the overall health status of the community when adequate material resources are available.

This project added a layer to the current investigations about malaria control and prevention. [12] In Mali, it is easy to observe perfectly built houses in rural and urban areas, but the reality is the existence of a large population of mosquitoes and a high prevalence of malaria. Adequate water

channels are non-existent. Trash is often piled up across towns with no systematic way to stop it blocking water runoffs. An archaic land distribution system has led to undisciplined construction locations that add to water pooling conditions.

In Mali, there is an urgent need to encourage the development of small trash-hauling services equipped with mobile solid and liquid waste removal containers and tools such as trash trucks.^[12] Municipalities need to invest in water running trenches in close coordination with the government land planning services in charge of land distribution.

Limitations of the Present Study

The data utilized in this study was obtained from secondary sources. The frequency counts of dwellings (urban and rural) that were sprayed might be considered too low at only 6.4% of the sample size. The true effect of a broader spraying campaign was not assessed in light of the poor community sanitation conditions and practices.

CONCLUSION

The study evaluated the protective effects of spraying rural and urban dwellings against mosquito population growth in Mali. Mali needs a strong supply chain management system geared toward building a strong distribution network to supply its general population with the right tools to erect improved sanitation infrastructures with proper drainage and improved toilets with plumbing. Additionally, a network of small businesses should be encouraged to invest in trash-hauling services to ameliorate the sanitation issues and support improving the health status of the population. The public health officials' intervention strategies should aggressively address other environmental controls through putting in place a well-structured surveillance system with feedback channels for the municipalities.

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How to cite this article: Keita A. Supply chain management in global public health activities: opportunities for improving sanitation and preventing malaria in Mali. *Int J Health Sci Res.* 2018; 8(8):261-266.
