Impact of Housing and Infrastructure on Handwashing in Peru

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Abstract

Background: The metropolitan area of Lima, Peru has a third of the nation's population living in slum dwellings hypothesized to contribute to inefficient household hygienic practices. The purpose of this study was to quantitatively assess which living conditions have the greatest impact on handwashing practices.

Methods: A cross-sectional epidemiological design of participants ages 16 years and older from San Juan de Miraflores, a slum on the outskirts of Lima, Peru, was used. Poisson regression was applied to assess the impact of living conditions on handwashing practices.

Results: We could not demonstrate a relationship between living conditions (home structure, overcrowding, water, gray water disposal) and reported handwashing. The reported lack of handwashing is associated with the number of children in the home (those with children under the age of 5 were more likely not to report washing their hands) and length of stay in the slum in years.

Conclusion: Living conditions play an important role in one's health, therefore, more improved study designs are needed to determine which strategies are likely to be the most effective in improving outcomes for slum dwellers.

1. Introduction

Our world has been undergoing a radical ecological change with growth in cities rising from 5 percent to 50 percent in the last couple of centuries(1). In many low-income and middle-income nations, this urban growth has been accompanied by slum settlements in the cities and at the outskirts, creating the urbanization of poverty(1, 2). Slums, as defined by the United Nations Human Settlement Programme, "is a group of individuals that live under the same roof that lack one or more of the following conditions: access to improved water, access to improved sanitation, sufficient living space, durability of housing and secure tenure"(2). The United Nations estimates that 32 percent of the world's urban population lives in slums; a population that is expected to double by 2030(2). In Peru, slum dwellers make up a third of the nation's population(3), living in substandard housing with environmental conditions hypothesized to promote inefficient hygienic practices(4, 5).

Improvements on social determinants of health such as economic stability, health care, living conditions, and education, generally have been shown to improve health(6, 7). For instance, access to clean water has been shown to reduce bacterial infections and promote health and well-being(8) and epidemiological research in Peru has argued for a distribution of social and economic development to address health issues(9). However, because many of these factors have occurred at the same time (e.g., improved public safety, literacy & living conditions), the specific impact of any single intervention is difficult to measure. Additionally, such interventions are typically evaluated relative to urban or rural health(10), but less is known about the impact on slum health. This is particularly the case for living conditions in regard to personal hygiene and handwashing.

Slums are synonymous with poor living conditions and with health outcomes that are worse when compared to neighboring urban or rural areas(1). Conversely, improved hand hygiene practices at the individual and community level have had a major role in reducing morbidity and mortality(11, 12). Hand-washing with soap is the most cost-effective intervention for many illnesses, can reduce diarrheal disease by 47 percent and has the potential to improve millions of lives(13). Several studies have highlighted that handwashing accompanied with basic hygiene behavior(respiratory, food, laundry, personal, and oral hygiene) can prevent cholera, norovirus, listeria, salmonella, diarrheagenic *E. Coli* and acute respiratory infection(13-17). But, despite the extensive research on hygiene practices, poor living conditions, and their association to health, there is limited information on the extent to which living conditions affect household hygiene practices such as handwashing or cleaning. Therefore, this study aimed to assess the impact different living conditions have on hand hygiene in an urban slum settlement. The authors hypothesized that: 1) better housing and infrastructure will yield better handwashing practices, and 2) mothers will have better handwashing practices because their hygiene behavior directly impacts the health of their children.

2. Methods

2.1 Study Population

This study population consisted of 251 families living in the Minas 2000 area of San Juan de Miraflores, Lima, Peru; a young town populated by people who moved to the urban area in order be close to the urban center of Peru. The Minas 2000 community is an informal settlement with community defined boundaries that is located on the perimeter of the city of Lima in the San

Juan de Miraflores District shown in Figure 1. In 2011, the Minas 2000 community was organized as a commune with a community kitchen that resident family households could use for meals.

Most residents lived in homes made of a variety of materials; some had electricity, but many lacked running water or plumbing. Additionally, residents in San Juan de Miraflores used 10 times less water than families with running water but paid nearly 10-15 times more for it and were forced to store it in private cisterns, plastic barrels or garbage cans outside their home (17). The area is a high risk due to frequent landslides as a result of soil instability and homes are mostly built with precarious materials such as mats, triplay, calamine or cardboard without technical criteria to evaluate the homes' potential for low durability.

2.2 Study Design

Data collection occurred from August to November of 2011. Approval from the Institute of Nutritional Research Institutional Review Board (IRB) for the protection of human subjects was obtained to perform the study. All 270 households within the Minas 2000 boundary were included in the assessment. The entire community was recruited for the study through their contacts with project facilitators employed at the Institute for Investigational Nutrition (IIN) located in La Molina of Lima, Peru. The Minas 2000 community's commune chief ensured that all residents participated in the study with 19 of the initial 270 not answering the primary outcome variable about handwashing with soap. Employees and consultant field-staff of the IIN were trained with the required human ethics course (IRB) and trained to administer the survey questionnaire. The Spanish language questionnaire contained closed and open-ended questions that were pre-tested on a comparable population not participating in the study and later modified to improve questions found unclear. The topics covered in the questionnaire included hygiene

and sanitation practices, water for drinking, disposal of used water, people living in the home and materials used to build the house. An additional observational study and a microbial surface sampling study took place while this survey questionnaire was administered.

Additional data were collected through in-home sampling (swabbing of frequently touched surfaces in latrines and kitchen areas) and direct observations that lasted for a typical 8-hour workday (18). The results of the in-home sampling are published(18) and they indicated an increased risk for *Listeria monocytogenes* infection as the proportion of clean surfaces decreased.

The outcome variable in this study, handwashing with soap, was collected through a self-reported response to the question that asked "how many times per day did you wash your hands with soap and water or detergent?". Two methods were used in this study to minimize bias in self-reported handwashing. The first method was written into the survey questionnaire process and asked the question using the strategy of activity recall to reduce over-reported handwashing behavior (19). To activate the memory of handwashing, the survey asked several related questions about hygiene practices in the home before asking for the frequency of handwashing with soap.

The second method to minimize self-report bias used an internal validation of the primary outcome variable. This internal validation relied on the sub-study that was part of the larger parallel risk assessment (18) published earlier. The sub-study validated the handwashing variable by conducting 48 in-home observations among randomized households within the survey population. Each observation lasted 8 hours in the home with an investigator who was trained by the lead social scientist at the IIN to document hygiene-related observations. The observed and non-observed groups were measured for significance on the handwashing frequency variable. The study used Mann-Whitney U test of independent means within IBM

SPSS Statistics for Windows, version 26 (IBM Corp., Armonk, N.Y., USA) and did not find a significant difference (U=3857, p=0.323). This established that the self-reported frequency was not significantly higher than the mean rate among the observed households that had handwashing frequencies validated by trained personnel. The sample size and power assumptions for this internal validation were checked with G*Power 3.1 (20) *A priori* for the Wilcoxon-Mann-Whitney test assuming an A.R.E. method distribution. The actual power was calculated to be 0.99 with a Type I error probability of assumed to be 0.05 for the given sub-sample size of 48. This power was found to be sufficient in detecting a difference in means using the above self-report validation method.

2.3 Statistical Analysis

The outcome variable (the number of times a person washed their hands with soap per event (using the restroom, cooking, eating, sneezing), was created by summing reports of whether respondents washed their hands after defecating and urinating, before cooking, before eating and while sneezing in the midst of cooking. For instance, if a person was to use the restroom once in the 8hr recall period, begin cooking, eat and potentially sneeze in a day, they should have washed their hands 4 times in that day. This variable was created from multiple synchronous variables to help minimize recall bias as described above. This variable was then inversed for analysis and therefore predicted the number of times a person did not wash their hands.

A Poisson regression was used to analyze the relationship between hand washing and living conditions. Hand washing was adjusted for confounding factors such as age, education, income, parental status, number of children under the age of 5 in the home and length of stay in the slum(in years), while measuring the impact of crowding within the household and water

availability per day and home infrastructure (wall and floors makeup, the presence of a *hueco* in the front yard to dispose of gray water and if a bathroom was within the house). Some of these variables, overcrowding (21,22) , water (23,24), children under 5 years (24), hueco (gray water disposal) (25) and education (26), were associated with hygiene practice and health in previous studies. Crowding related to the conditions of the dwelling as well as the space it provides, in this case was measured in terms of the average living area per person in the place of residence (27).

Two models were evaluated in the analysis. The first assessed if the amount of water each household had, predicted handwashing, whereas the second model assessed if the living conditions themselves (type of house, location of bathroom, make-up of bathroom) predicted handwashing.

3. Results

Participants ranged from age 16 to 69 years, with 51% having an education less than high school and the majority (45%) of participants having a monthly income of 600-899 soles ($183 - $273). Table 1 outlines the characteristics of the study population. There was an average of 5 people in each home with a range of 2-14 people. Using the minimum acceptable living area per person, 44% of the participants lived in crowded environments. How homes were designed, constructed and maintained (their physical characteristics) influences health and the ability of people to participate fully in hygiene-based practices such as washing hands (28). In this community, homes were built by materials such as cardboard (4.38%) and timber (86.85%) to more sustainable materials such as brick (3.59%) and noble material [corrugated iron roofs](5.18%). The floors of the homes ranged from dirt flooring (19.52%) and false floors

[earthen floors] (22.71%), to cement flooring (54.98%) or other better material [tile floor] (2.79%). Living conditions of participants, from kitchen/cooking arrangement to bathrooms varied between all participants. There was no indoor plumbing and therefore each home purchased water. The amount of water each home had was dependent on household income. Water was delivered to a plastic barrel outside the family home. Residents of San Juan paid 10-15 times more for water than those with running water living in Lima. The storage containers were sometimes covered and other times exposed to the elements where mosquitoes could lay eggs. If possible, residents boiled the trucked-in water before using it for cooking or drinking, but this added to the financial strain they already experienced.

The majority of participants (51.79%) homes received 0 -100 liters of water per day, 31.47% received 101-200 liters of water per day and the remaining few (16.73%) received more than 201 liters, but less than 643liters of water per day. At a recommended rate of 50-100liters of water per person a day needed to ensure that most basic needs are met and few health concerns arise (29) (27), only 42% of the homes had sufficient water per day. The water received was used for cooking, cleaning, bathing and other household needs but was unfortunately not potable.

Mothers are hypothesized to have better handwashing practice because their hygiene behavior directly impacts the health of their children (30). With this in mind, the presence of other adults' handwashing practice was assessed in comparison to the mother. As outlined in table 2, other adults in the home who were not a parent or a grandparent were surprisingly more likely to wash their hands (Relative Risk [RR]=0.86; Confidence Interval [CI], 0.16 – 0.88) when compared to the mother. Education and income were not significantly associated with hand washing. Those with one or more children under the age of 5 were less likely to wash their hands. Additionally, although the relative risk indicates little difference, duration of stay in the

slum(in years) was also associated with the likelihood of not washing hands (RR=1.05, CI, 1.01, 1.09); longer tenure resulted in less handwashing after defecating, and urinating, before cooking and eating and while sneezing in the midst of cooking. The amount of water each household received, however, was not a significant predictor nor was the number of people in the home.

In the second model shown in table 3, longer tenure in San Juan de Miraflores (RR=1.06; CI, 1.01, 1.10) and number of children (one child under the age of five: RR=2.00, CI, 1.43, 2.85; two or more children under the age of five: RR=1.95, CI, 1.17, 3.20) in the home was associated with less hand washing. There was no significance, however, in variables that accounted for the infrastructure of the home such as the wall make-up, floors, hueco, location of the restrooms or make-up of the restrooms.

4. Discussion

This study aimed to assess the impact different living conditions have on reported hand hygiene in an urban slum settlement and discovered that although some do, others do not. Slum dwellers spend most of their time in housing and environmental conditions that have a direct link to their health. Unhygienic practices affect quality of life, education development and in many cases can result in diseases (24, 31) that are preventable. Previous research (32, 33) has shown that changes to one's environment, whether in the home or at school, enable improved handwashing behavior and structural factors such as time, accessibility of water, and high-quality facilities, influence how likely people wash their hands. Therefore, since a key motivating factor for adoption of handwashing is environmental conditions (such as house-structure, access to water supply and excreta disposal sources) (34) (32), our hypothesis sought to assess if those with poor house structures, less access to water supply and excreta disposal sources would have

poor hand hygiene practices. Previous studies in other populations (35, 36) have indicated that lower water access is associated with lower handwashing rates. However, our results showed no significance in spite of the low levels of water available.

Although we tested for a relationship between the home infrastructure and handwashing, we could not demonstrate an association between the home infrastructure and handwashing. Living in a house made of cardboard as opposed to brick showed similar hand hygiene behaviors. In this population, a house infrastructure had no bearing on one's hygienic practices. As a factor of the built environment, building and housing structures have a major influence on health (37). With areas in the home serving as reservoirs for microbial colonization, hand hygiene is important especially in slum environments (38). Our results reveal that although hand hygiene behavior is a complex interaction of many factors, no one theory can reliably predict handwashing behavior (39). Studying hand hygiene has to take into consideration the behavioral, cultural and social factors in the context of housing and infrastructure. Although a home structure might influence factors of health such as handwashing, understanding what motivates hand hygiene behavior in a slum culture(38) might be critical in understanding if housing and infrastructure truly play a role in handwashing. For instance in Bangladesh, there is a culturally acceptable time in a day for personal hygiene (40), in a study among Koreans, cultural normative attributes were identified as factors that predict hand washing (41) and in settings where people are internally displaced, the disruption of cultural norms can alter handwashing practices (42). Culture, to some extent, strongly influences attitudes to inherent community handwashing and is worth exploring in this community. Additionally, we could not find our hypothesized associations with overcrowding, water, gray water disposal practices and education.

The handwashing associations that we did confirm are related to the number of children in the home and the length of stay in the slum. Those with one or more children under the age of 5 were less likely to wash their hands. Past findings have indicated that with children under the age of 5 in the home, the gap between knowledge and the practice of handwashing is more apparent (43). One's length of stay in the slum (in years) although significant to handwashing, had little increased difference in risk. It has been found that people born within slums, in close proximity to slums, or who have resided in slums for a longer time, tend to remain in them or move to them due to social ties related to common culture, language, and similar income-generating activities (44). Behavioral practices, such as handwashing within such a context also happens to be uniform; and since poor handwashing among slum residents has been shown to be prevalent (45, 46), based on our results we inferred that as one stayed in the slum for an extended time, their poor hand hygiene practices became habits that are difficult to break as a result of socio-cultural ties. Additionally, the longer one is immersed in an environment the more prone they are to adopting the cultures and norms of the environment they are in and the more their health is to be affected. For instance, in a study assessing two types of slums in Kenya - one where a quarter of the residents were born in the community and have resided there longer and the other where only 5 percent of the residents were born in the community and are more recent residents – discovered that demographic indicators such as length of stay affects economic and health outcomes (47). Without a clear understanding of the cultural context that influences individual and societal behaviors, health and hygienic practices are only going to be understood partially (48). In literature, crowding has been reported to be an indirect measure of hand hygiene practice (49, 50), however, in our study we were not able to find such a significance.

In comparison to mothers, other adults in the home were found to have better handwashing habits. This could be influenced by the fact that handwashing appears to be an aspirational behavior rather than a health concern and therefore the perception of handwashing among non-mothers might be different (51). Mothers with more younger children also are more likely to not wash their hands as opposed to mothers with older children (52) and that may be the reason why these mothers are less likely to wash their hands. Another reason could lie in the fact that due to scarcity of water, mothers use less water on themselves in order to preserve the little they have for their children and family. Additionally, although mothers may have intended to improve their handwashing behavior, their physical environment, social relations or constructed attitude to handwashing may have hindered their practice (51). For instance, perception of poor water quality may affect why some hand wash and others do not.

We believe this study provides important background for additional research into the effects of living conditions on hygienic practices. Past studies have indicated that one crucial motivating factor for the adoption of safe hygienic practices is living conditions. As population growth continues to be particularly rapid in urban areas of less developed regions, health burdens will continue to rise unless an intervention is set in place to affect all determinants of health. Understanding how hand hygiene and living conditions are correlated will allow for better-built interventions to assist in the health burdens among slum dwellers.

The results of the current study should be interpreted in light of several limitations. First, we relied on self-reporting; it is possible that social desirability and recall bias might have influenced the response of our participants. To rectify this, we relied on an observational sub-study to validate the reported handwashing rate. This is one of many methods (19) that could be used to help explain the over-reporting of handwashing that commonly occurs in hygiene

assessments. The data was also collected through an interview procedure which may have added some interviewer bias into the study. Therefore, in light of such biases, further detailed investigation, is needed.

There are many issues concerning all aspects of hand hygiene that remain unresolved. While hand hygiene practices are simple, compliance with handwashing is about human behavior and discovering what influences such behaviors. Living conditions could influence hygienic practices and therefore more improved study designs on how living conditions affect hygiene practices within slum populations need to be conducted. Living conditions should also be assessed past the house infrastructure and neighborhood, and into security, safety, family and social relations, conditions in school and economic and material resources. A better understanding of such factors will provide gateways into understanding which strategies are likely to be the most effective in improving outcomes for slum dwellers.

Author's Contribution: KR and RS contributed to the study design. The implementation of the study was done in Peru by GB, MP and RS. The data was analyzed by NM and RS and the interpretation of the results was a collaborative effort between NM and RS. NM wrote the first draft of the manuscript and GB, MP, KR and RS assisted in formulating the manuscript to the final product. All authors read and approved the final manuscript.

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