

# Effects of the Built Environment on Health in a Floating Slum Community in Iquitos, Peru

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Abstract

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Environmental and Occupational Health Sciences

Background

The built environment affects the health of a community in a multitude of ways. One of those ways is through changing an individual's exposure to environmental contaminants, such as bacterial pathogens. Another is through the availability of food. This study looks at the impacts of an urban garden intervention on the population health of a floating informal urban community on the Peruvian Amazon called Claverito. A community participatory design process was used to assess what improvements community members wanted to see in their community. Together, the researchers and community members decided to create floating gardens attached to houses. This paper examines the possible short term community health effects that implementing these gardens had on the community.

Methods

Multiple interventions took place from 2016 to 2018. This paper focused on two interventions that involved garden building in the community. The first intervention was to put a large community garden on the hillside that everyone has access to. The second intervention involved two rounds of individual households building personal gardens. To assess health, a household survey was administered during sequential health fairs using a previously developed survey (Global Assessment of Zoonotic and Environmental Risks (GAZER)) to assess which members of the community self-reported having diarrhea or stomach problems. Surveys were conducted in February and July, 2018, and asked about the month preceding each survey. Reported rates of diarrhea and gastrointestinal (GI) complaints were compared between the two time points, and were also compared to use of gardens.

### Results

Among the study population as a whole, there was a moderate increase in garden use, for both fruits and greens (35% vs. 23%,  $p=0.32$ ) and herbal medications (48% vs. 23%,  $p=0.3$ ), between the two time points. This difference was only significant for herbal medication.

### Conclusion

During this study period there was an increase in the number of products acquired from household gardens. Although this did not translate into a change in community health outcomes there is potential for that change to come with additional time.

## **Introduction**

### **Urbanization and Health**

Since 1990 the world has been rapidly urbanizing, with the majority of that urbanization happening in the world's poorest countries(1). This change has led to a rapid increase in slum communities, which the UN defines by their "precarious legality and almost non-existent level of services such as community facilities, potable water, and waste removal"(1). Despite the large size of the slum-dwelling population world-wide, there is relatively little research done on the effects that living in a slum can have on health(2). This is partially due to the fact that gathering data in the slum setting can be challenging, and governments often lack formal statistics on slums due to their constant change and lack of recognition(3).

Living environments, including the built environment, have a profound effect on health in a myriad of ways(3). This is especially true in a slum setting where there is limited access to sanitation and clean water. These living conditions can drastically raise the rate of diarrhea and pneumonia which are the top two killers of children under five around the world(2). Within Peru, the rates of chronic malnutrition are 12.5 times higher among the lowest quintile than the highest quintile of wealth(4). In 2013, UNICEF's Child Survival and Development (CSD) Program identified lack of access to sanitation and safe water as "a significant barrier to the reduction of chronic malnutrition and to reducing the high level of diarrhea in the Amazon region, especially Iquitos"(4).

Diarrhea is a major health problem around the world and is one of the leading causes of death in children under five. In 2013, diarrhea killed 0.578 million children in that age group(5) globally, making diarrhea responsible for more deaths than HIV, Malaria, and measles combined(6). Diarrhea can lead to a dangerous cycle of malnutrition, as the diarrhea results in failure to uptake nutrients, and then those nutrient shortages in turn can cause and increase risk of diarrhea(7). Luckily diarrhea rates have been decreasing globally but, according to the Institute of Health Metrics and Evaluation(8), still accounted for .202 million deaths globally in children under 5 in 2017. The death rates in Peru have been dropping even more significantly leaving only 3.3 deaths/100K children under 5 in 2017. However, the incidence of diarrhea in

Peru is still very high, even with the lower death rate. There were nearly 2 cases per child under 5 in 2017.

#### Urbanization and the Epidemiological Transition

In 1980, as countries became wealthier, people living in these countries experiences a rise in their systolic blood pressure, putting them at an increased risk of cardiovascular disease(9). However by 2008 this trend had reversed, so that the countries with the lowest Gross Domestic Product (GDP) actually had the rates of high blood pressure (9). One explanation for this is the prevalence of blood pressure reducing medication in high income countries. However, another possible explanation is the growing availability of processed food high in sugar and salt that are sold cheaply around the world. Because these products have a long shelf life, they are easy to ship worldwide and keep in stock in local shops. Rapid urbanization, as has been happening in Peru led to large shifts in dietary intake (10), likely because populations moved away from the traditional foods grown in their towns and villages and towards these shelf stable convenient foods.

Other studies conducted in low and middle income countries have found that fruit and vegetable intake are below the recommended daily minimum in 57.3 - 88.1% of people in the Latin American countries in which they sampled(7). These numbers varied widely by country and there were no numbers available for Peru, so the scope of the problem is not well understood.

#### Urban food deserts, urban farming and gardening

The findings of this project could be important to the ongoing discussion around food deserts in the United States. One of the main barriers to eating sufficient fruits and vegetables is reported as the cost and availability of those vegetables(11). Urban farming and gardening can help improve the availability of those fruits and vegetables, and lower their cost, in both high and low income areas. Another commonly reported barrier is the short shelf life and the need to go to the store more frequently to purchase fresh produce(11). This is especially an issue in urban food deserts where groceries stores are not easily accessible. Having a supply of vegetables growing in your neighborhood can make accessing those products significantly easier.

#### Possible Mechanisms of dietary intake on health

Diets low in fruits and vegetables are linked to a wide variety of negative health outcomes, including vascular disease and cancer(12). Some of those effects seem to be mediated by fiber intake(13), which can have an effect on cardiovascular disease as well as many characteristics of the stool.

This paper will focus on gastrointestinal health and its relationship to the garden interventions. Given that the gardens contained both vegetables, fruits, and medicinal herbs, there is reason to believe they could have a positive effect on the digestive health of the community. Some of the medicinal plants are traditionally used to treat diarrhea.

#### Studies of urban garden interventions

We examined an intervention to build gardens in an informal urban community in the Peruvian Amazon. Gardens were built as part of this intervention because researchers believed they would help address many of the needs raised by community members during a needs assessment, including a number of health and social problems, such as mental health outcomes. Green spaces in urban areas provide a variety of benefits other than the edible products they produce(14).

The relationship between diarrhea and poor sanitation practices has been well documented(15). However, the complicated relationships between the health of humans, plants and animals in a shared slum environment has not been fully explored (3). More specifically, given a dearth of information on health outcomes of this marginalized population related to diet, sanitation, and implementation of household gardens, we undertook this study to assess whether a garden intervention would lead to improved health.

#### **Objectives**

We performed this analysis to determine the effect of the community garden intervention on health indicators, specifically those related to gastrointestinal health.

#### **Methods**

The garden intervention was part of a larger community based study carried out by the UW Informal Urban Community Initiative. This intervention received funding from the UW Population Health Initiative for an interdisciplinary effort termed InterACTION labs. In its first

three years this study has brought together more than 90 professionals and students, representing 16 different disciplines(16).

### Study Setting

This study took place in a slum community called Claverito, located on the outskirts of Iquitos, Peru. Iquitos is a city of a half million people that is located deep in the rainforest near the headwaters of the Amazon. Claverito contains 50-70 floating homes adjacent to an embankment near downtown Iquitos and is thus strongly influenced by both the Amazon on which it floats and the activities of Iquitos above.

As in many other parts of the world there has been rapid rural to urban migration(3) in Peru. This rapid migration has increased the population in Iquitos living in poverty to almost 70%. Many of these immigrants came from lush jungle communities and had lifestyles that were integrally connected to the Amazon river. When they moved to Iquitos in search of better economic opportunities they built floating communities on the river in such a way that they could maintain a close connection with nature, while also being in close proximity to the economic opportunities of the larger city.

Although people have been living in Claverito for as long as 45 years, it is not officially recognised by the city of Iquitos and does not have access to any public utilities(3). There is also a large amount of stigma around the community, with citizens of Iquitos often throwing trash onto the hill separating the community from the city. There are also frequent activities that negatively impact the environment surrounding Claverito such as urinating, defecating, drug use, drinking and crime. All of this led to over one meter of refuse ending up on the hillside, creating safety issues, negatively impacting water quality, preventing the natural ecosystem from flourishing, creating mosquito habitat and harming the mental health of the residents(3).

After a previous study in Lima(17), the primary researchers initiated this project in Iquitos. In order to qualify as a potential study population the communities needed to demonstrate a need that researchers were capable of helping fill, while also showing the desire and organization to work with the team to accomplish the project.

Researchers found that the impoverished conditions in Claverito had had a significant negative impact on the lives of community members. 42% had been injured on the

stairs/pathways, 87% were food insecure, 82% had parasites, and 93% reported indicators of depression or anxiety(18). Additionally the community was chosen because a large proportion of the community members were interested in investing time into the betterment of their environment.

### Specific Interventions

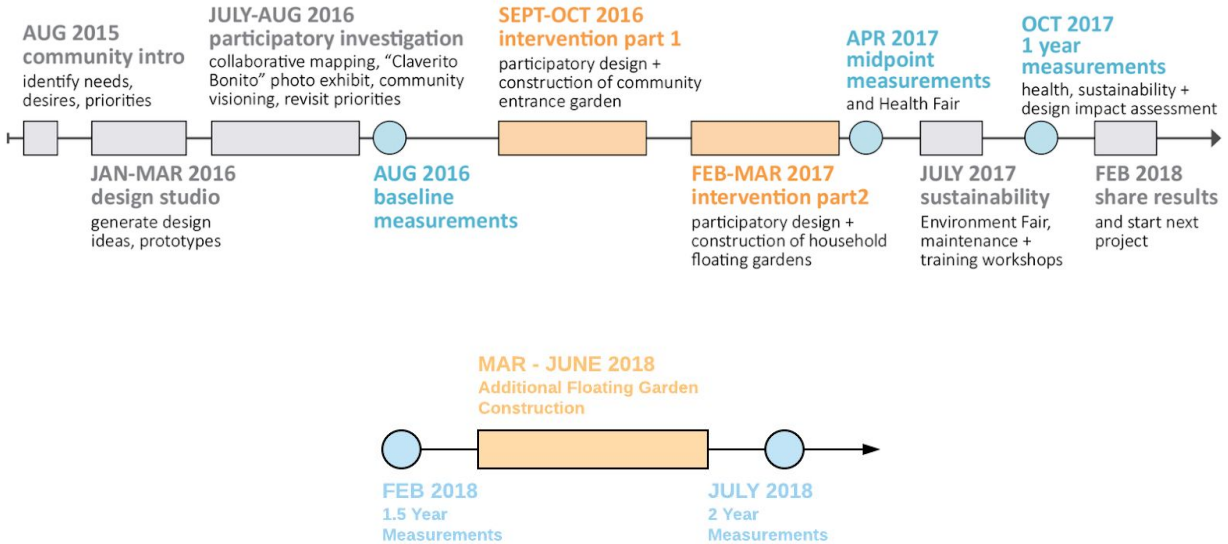
Participatory research builds on the assumption that any project that involves altering a community, needs to involve input from community members for optimal effectiveness and success(19), as the community will be the most affected by an intervention, as well as having the best intuition about what might be the most helpful to the community at large and its members(4). Research that is not informed by community needs may in fact do more harm than good(19).

Accordingly, project researchers decided to use a participatory design strategy so that community members were an important part of choosing what interventions should be implemented in their community(3). They first met with residents of Claverito in July 2015. Since then, they have been working with community members to identify their largest problems. A needs and priorities assessment was conducted with the community in August of 2016 to help determine what the most effective projects would be. Together, the researchers and community members have been working to implement interventions and investigate the effects that these interventions have had on various aspects of health in the community. These interventions have included removing the trash from the hillside, replanting the hillside with a variety of plants, improving the stairs down to the community, and helping any household that wanted to build a personal garden that floats next to their house.

Interventions took place in October of 2016, March 2017, and June 2018. The first intervention to take place was the construction of the hillside garden and the improved stairs, with the other two interventions being waves of household gardens.

Participants chose what they wanted to plan in their own garden. Overall the community planted 902 plants:90.8% were edible, while the remaining 9.2% were planted for aesthetic reasons; 54.3% of the plants fell into the category of “herb.” The cultural usage of these herbs was mixed, with 23.1% of the herbs used for flavoring, 61.5% used as medicine, and 15.4% used

as either, depending on the situation(20). In this study, plants were divided into fruits and greens versus herbal medication based on self report. Therefore, there may be some overlap between the categories. For this study the distinction was used to get at the intent of the user.



**Figure 1:** Timeline of the project. 2015 - 2017 timeline was made by Leann Andrews.

Data Collection Surveys started taking place in the community in August of 2016, and were done twice a year in 2017 and 2018. Several survey tools were used and everyone in the community was invited to participate. The primary tool examined in this paper was the Global Assessment of Zoonotic and Environmental Risks (GAZER) Survey. Due to changing participation and survey forms, this sub-study looked at the results of the GAZER survey given in 2018.

This survey was administered to one member of each household as researchers went door to door around the community. The surveys were answered orally by that household member, while answers were recorded on paper by a researcher. In order to maintain confidentiality, each household was assigned a number, and each person within the household was given a letter. This survey was used to gain insight into demographics, general health complaints of each family member and family food and water sources. Out of the 50 households in the community 44 took

the GAZER survey. The remaining six households did not qualify due to insufficient Spanish ability, or not meeting consent needs due to either age or repeated intoxication.

All questions were asked in Spanish, which was the first language of the researchers asking the questions. However Spanish was not the first language for most of the residents of Claverito, who speak a variety of indigenous languages. It was also not the first language for many of the researchers working on analysis so there were multiple levels of translation.

Survey questions related to the use of gardens:

The exposure came from the questions “Where did you get your fruits and vegetables?” and “Where do you get your herbs and medicinal plants?” The values were used from the responses “Produced in the community (Hillside park)” and “Produced at home or the home of my neighbors.” For both of those sub-questions participants answered if they used these sources “a little”, “a lot” or “not at all.” These answers were then coded as 1, 2, or 0 respectively.

Where did you get your fruits and vegetables? (Check all that apply)	None (0)	A little (1)	A lot (2)
The market			
The jungle			
Produced in the community (hillside garden)			
The household garden of you or a neighbor			
Where did you get your Herbal Medications? (Check all that apply)	None (0)	A little (1)	A lot (2)
The market			
The jungle			
Produced in the community (hillside garden)			
The household garden of you or a neighbor			

**Table 1:** Table showing the questions asked on the survey with regards to food source and quantity..

For the time varying of the analyses we looked at whether the amount of fruits and greens or herbal medication that came from the combination of these two sources, hillside and home garden, increased between February and July. When only one time point was being examined, each household was assigned a binary value for each exposure based on whether they said they used the garden “not at all” or either “a little” or “a lot.”

Additional questions were asked regarding which medicinal plants were used in each household, why they were used, and where they were acquired. These data were not used in this study. A full 24-hour dietary recall was also taken for each household but that data will be analysed in another paper.

Survey questions related to health outcomes

Four health outcomes were assessed in the GAZER survey. They are shown in table 2. For this thesis the only outcome that was used was regarding diarrhea and stomach issues. For these questions the respondent was asked if anyone in their household had experienced any of the conditions in the last month.

Condition	Yes/ No	Who in the Family?	Date Started	Did you go to the health center?	Notes
Diarrhea or stomach problems, not related to menstruation or pregnancy.					
Fever					
Respiratory, or Symptoms of Asthma					
Rash					

**Table 2:** GAZER Survey questions about health concerns of family members.

Survey questions related to animal ownership

A set of questions was included to ask about whether each household owned livestock or pets. For every animal that a household owned they were asked what type of animals, how many of those animals, and how old they were.

Other variables

The GAZER survey also included questions about the age and gender of everyone in the household, as well as age and number of animals in each household. Each respondent gave

information about their feelings about the community on a scale from one to six, with one being not at all happy and six being very happy. These questions were:

- 1) Safe areas to walk in Claverito
- 2) The water contamination or quality
- 3) The soil contamination or quality
- 4) The environmental smell
- 5) Availability of parks and gardens
- 6) Availability of places to play
- 7) The number and quality of plants and nature in Claverito
- 8) Availability of spaces for community gatherings and events.

Other questions in the survey asked what families did with leftover food, and other waste. The survey concluded with questions assessing the food security of the household.

#### Data from Previous Surveys

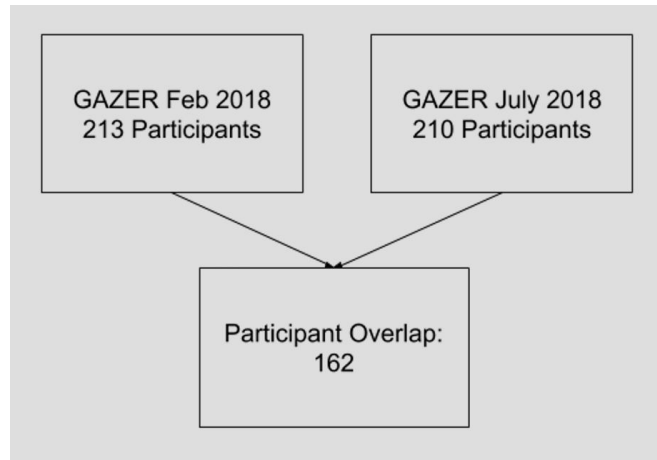
The information on employment was collected in the 2016 GAZER survey. This survey included an open-ended question on the profession of every individual in the household. In order to look at the effects of employment on the rates of diarrhea in the community this data was combined with the health outcome results collected in 2018 based on the individual codes of each participant.

#### Data Management

Researchers input the data into RedCap from the physical forms. For this project, data was downloaded into excel for initial cleaning. Open-ended questions were translated from Spanish into English and then coded into categorical answers. After data was cleaned in Excel it was important into R for all data manipulation and analysis.

#### Selection of Study Participants

Every household in the community was invited to participate in the surveys. Not all individuals had data from both time points, and therefore could not be used in analysis. This is represented in figure 2.



**Figure 2:** Selection of final study participants to be used in the analysis.

### Ethics

Community members all gave their consent to participate in, and approve the study. Additionally the Institutional Review boards of both of the universities involved, the University of Washington and Universidad Nacional de la Amazonia Peruana, approved of the study.

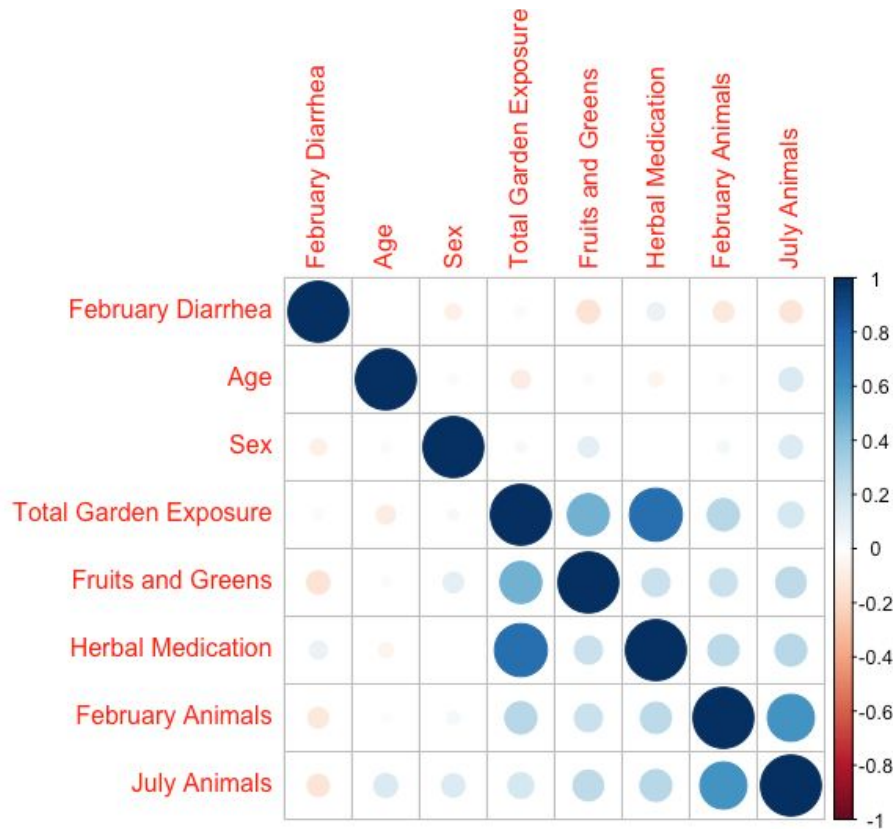
### Descriptive Statistics

Variables included in this analysis include age, gender, whether the participant reported having diarrhea in February and garden exposure. The exposure definition used in this model was whether the household to which that participant belonged reported an overall increase in garden use increased between February and July, or if it stayed constant or decreased. Age was included because it has been shown to be closely tied to diarrheal rates worldwide, with children being more prone than adults(8). In many populations, including Peru, women have a higher rate of diarrhea than men, so gender was also included in the model(8).

### Collinearity

A correlation matrix was used to look at the correlation between each of the variables in order to insure that none were collinear. This correlation matrix is shown in figure 3. The correlation between the increased usage of fruits and greens from the garden and the increase in usage of herbal medication for the garden was only 0.21 meaning that they could both be put into the multivariate model. Meanwhile the correlation between having animals in February and having animals in July was 0.59 which determined to be too collinear to include both in the model. The

exposure of having animals in February was chosen to represent animal exposures because it more clearly predated the outcome of having diarrhea within a month of the July survey.



**Figure 3:** All of the variables used in the model, were put into a correlation matrix. The correlation between all of the exposure variables was high, but the correlation between all the other variables was quite low.

Regression

A generalized mixed logistic model from the lme package in R was created to look at the effects of the garden intervention on gastrointestinal issues. The mixed model was used to account for the non-independence and clustering effects of members of households. Households likely had a large effect on the incidence of gastrointestinal issues given the shared food and water exposure, as well as close proximity. This means that the data points were not independent. To account for this, the mixed model allowed each household to have their own intercept. This model was used with a variety of factors in both the bivariate and multivariate analyses.

Bivariate Analyses

In order to look at the effects of individual factors, each factor was put into the mixed model individually, with the outcome of diarrhea in July.

### Multivariate Analysis

After all of the variables were run in their own independent bivariate model they were combined into one multivariate model.

## **Results**

### Demographics

Using the definition of any household who had an overall increase in garden use, there were 20 exposed households and 20 unexposed households. The demographic data for these two groups is shown below in table 3.

	Averaged Increased Garden Use	Averaged Constant or Decreased Garden Use
Households (Individuals)	20 (86)	20 (76)
Mean Age (Range; Years)	22.18 (.1 - 79)	26.06 (0.8 - 81)
% Male	46.5%	43.4%

**Table 3:** Demographic data for the exposed and unexposed groups.

### Occupation

The majority of female participants reported that they were housewives, while the men had a wide variety of jobs including fishing, farming. The top 5 reported occupations are shown in the table below. Unfortunately many of the participants for whom we had 2016 employment data did not have 2018 health data. Some of this discrepancy was due to difficulty connecting the 2016 data to the 2018 data due to people moving households and changing codes.

In addition to very few participants in each category, there was a large translation barrier in the occupational data. Although a majority of participants fish and farm, very few specified that as their occupation-possibly because it was not something they were making money doing. Given these factors no additional analysis was performed with the occupational data.

Occupation	N (2016)	N of those remaining in 2018
Student	62	35
Housewife	37	25
Pre-School Child	35	21
Generic “Worker”	9	7
Vendor	9	2

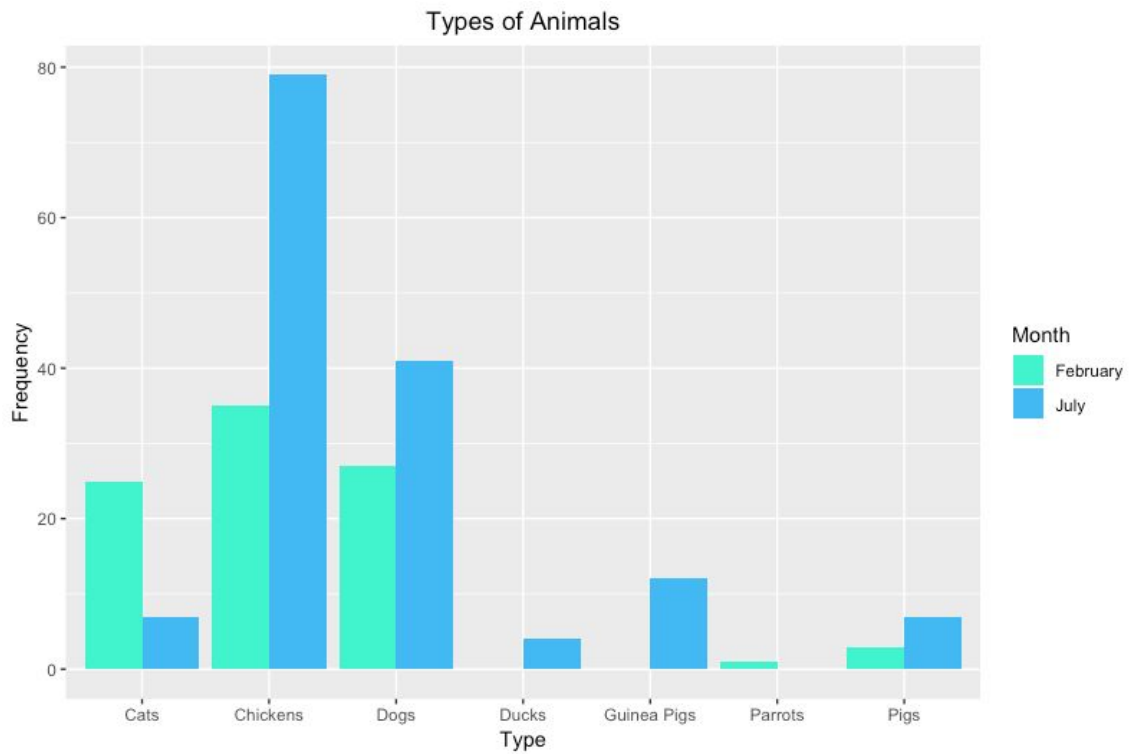
**Table 4:** Occupational differences between the surveys taken in 2016 and 2018

### Animal ownership

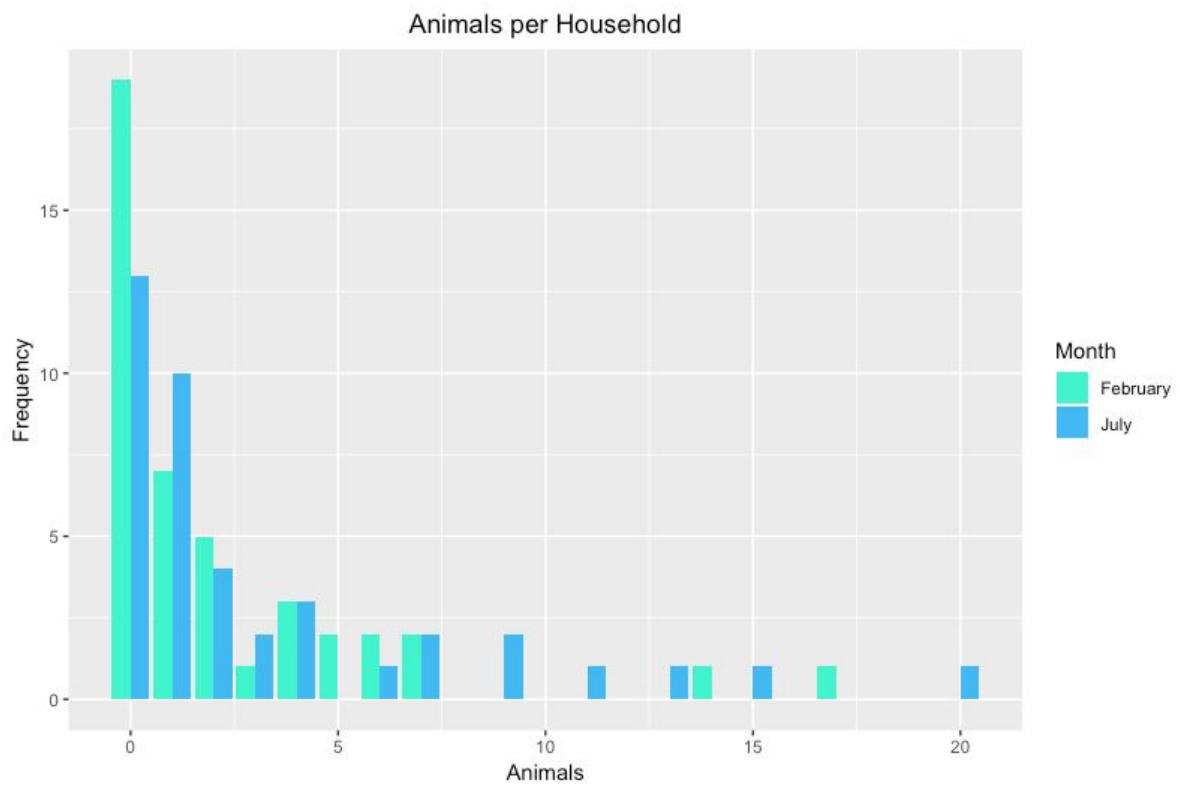
About half of the households in Claverito owned animals. Animals owned include dogs, cats, chickens, pigs, parrots, ducks and guinea pigs. Animal ownership increased between February and July and there was a shift in what type of animals were present.

Animal	February	July
Dogs (Households)	27 (15)	41 (16)
Cats (Households)	25 (7)	7 (2)
Chickens (Households)	35 (7)	79 (21)
Pigs (Households)	3 (1)	7 (1)
Parrots (Households)	1 (1)	0 (0)
Ducks (Households)	0 (0)	4 (2)
Guinea Pigs (Households)	0 (0)	12 (1)

**Table 5:** Counts of animals in Claverito, by species



**Figure 4:** Animals in Claverito by Species



**Figure 5:** Animals per household in Claverito, between February and July

### Reported behavior with regards to gardens

One of the questions asked in the GAZER survey asked about where households obtained different food types, including asking if they harvested fruits and greens or herbal medications from either the hillside garden or one of the household gardens. Although most households had not changed the sources of their food between the two time points, more people started getting items from the gardens than stopped. This was true for both herbal medications and fruits and greens but the difference was only significant for the herbal medications. These data were used to assess which families were making use of the intervention and is shown below in Tables 5 and 6.

	Fruits and Greens		Herbal Meds	
	Hillside	Home/Neighbors	Hillside	Home/Neighbors
A lot less (-2)	0	0	1	0
Less (-1)	6	7	5	7
Same (0)	24	23	22	19
More (1)	9	9	10	12
A lot more (2)	1	1	2	2

**Table 5:** Changes in household sources of food between February and July, 2018 based on the GAZER survey questions. Colors represent the frequency of each category with yellow being most frequent and blue being least frequent.

	Percent Increased (n)	Percent with no Change (n)	Percent Decreased (n)	P-value (Increased to Decreased)
Fruits and Greens	35 (14)	43 (17)	23 (9)	0.32
Herbal Medications	48 (19)	30 (12)	23 (9)	0.03

**Table 6:** Changes in garden use collapsed into either fruits and greens or herbal medications, with a p-value for the difference between the increasing and the decreasing groups.

### Bivariate Regression

Table 7 shows the results of mixed models run with each of the variables individually. Keeping the outcome diarrhea in July and allowing for random intercepts based on household in each model. None of the variables were significant.

Variable	OR	95% CI
Age	0.99	0.97 - 1.01
Male Gender	1.21	0.51 - 2.89
Diarrhea in February	1.30	0.45 - 3.74
Increased garden use for fruits and greens	0.84	0.28 - 2.58
Increased garden use for herbal medications	1.20	0.40 - 3.65
Presence of Domestic Animals in February	1.71	0.57 - 5.24

**Table 7:** Results of the logistic generalized mixed model run with each variable independently. All analyses included mixed effects for household and used diarrhea in July as the outcome.

Multivariate Model Result

The multivariate model was run twice, once with the presence of domesticated animals included, once without. The results of the mixed model with all of the variables except domestic animal exposure are in the table 8 below. In this model garden usage had opposite effects depending on if it was used for fruits and greens or herbal medication. The confidence interval was quite large for both exposure groups. This indicates that more data is needed in order to draw conclusions about their effects. Surprisingly, age also showed no correlation with diarrhea in this model. The largest predictor of diarrhea in July was diarrhea in February. The odds of having diarrhea in July were 30% higher for those participants who had diarrhea in February, compared to participants who did not, after adjusting for age, garden usage and gender. However, the confidence interval was wide, and crosses one, indicating that these results were not significant. Also surprising is the fact that males were 23% more likely to have diarrhea in July than females, after adjusting for the other factors in the model.

Variable	Estimate (Odds Ratio)	95% Confidence Interval
Increased Garden Usage - Fruits and Greens	0.82	0.26-2.61
Increased Garden Usage -	1.18	0.38-3.66

Herbal Medication		
Diarrhea in February	1.27	0.43-3.74
Age	0.99	0.97-1.01
Male Gender	1.23	0.51-2.96

**Table 8:** Results of the logistic generalized mixed model run with all of the variables except February domestic animal exposure. Mixed effects were included for household diarrhea in July was used as the outcome.

The model was run a second time, adding in the variable of whether or not households had domesticated animals at the time of the February survey. The results of this regression are in table 9. There were still no significant variables. However adding exposure to domestic animals did greatly attenuate the estimate the estimated effect of herbal medication use from the gardens on diarrhea.

Variable	Estimate (Odds Ratio)	95% Confidence Interval
Increased Garden Usage - Fruits and Greens	0.75	0.24 - 2.34
Increased Garden Usage - Herbal Medication	1.04	0.33 - 3.22
Diarrhea in February	1.36	0.46 - 4.02
Age	0.99	0.97 - 1.01
Male Gender	1.22	0.51 - 2.93
February Domestic Animal Exposure	1.82	0.57-5.71

**Table 9:** Results of the logistic generalized mixed model run with all of the variables, including exposure to domesticated animals in February. Mixed effects were included for household diarrhea in July was used as the outcome.

**Discussion**

Occupation

Due to the amount of information work done in the community, looking at occupation as an exposure was not feasible. This was exacerbated by the fact that the occupation question was dropped from the GAZER survey after 2016. In order to include work behaviour in future studies

questions should be altered to ask about job tasks rather than the occupation. This would address the fact that many residents of Claverito have many informal jobs and thus may have many job based exposures that would be covered by one occupation umbrella.

#### Reported behavior with regards to gardens

This section of the project did not assess dietary changes, which will be evaluated in another upcoming paper. This study did look at self reported usage of the gardens in the acquisition of fruits, greens and herbal medications. The majority of household reported that they had not changed their garden usage between February and July. However, more participants increased their garden usage than decreased. This difference was statistically significant for the herbal medications, but not for the fruits and greens. In order to get a better understanding of what these numbers mean the dietary recall data will need to be examined so that actual changes in diet can be looked at.

#### Bivariate Regression

When each of the variables were run independently, none had a significant effect on the odds of a participant having diarrhea. Surprisingly, age had the smallest confidence interval and showed almost no effect on the rates of diarrhea with an estimated OR of 0.99. This result is very surprising considering that children under 5 are usually at a much higher risk of diarrhea than other members of the population(8). It is possible that this is an artifact of lumping together reports of any stomach discomfort including diarrhea. Adults may be more likely to suffer other stomach conditions such as constipation or ulcers. Therefore each age group may be experiencing different types of gastrointestinal issues that are getting lumped together.

In this regression, being male increased the participant's odds of having diarrhea or gastrointestinal issues by 21%. This result is also very surprising because women in Peru generally have a higher risk of diarrheal disease(8). Similar to the findings in children it is quite possible that this finding was the result of lumping different concerns together. However, conditions such Irritable Bowel Syndrome (IBS) and constipation are also more common in women(21)(22). One possibility is that women may have considered GI issues that they had around the time of their menstruation as related to their menstruation and therefore did not report it. It is also possible that men were more prone to other non-diarrheal GI concerns.

Another possibility for the difference between the genders could be tied to sensitive nature of diarrheal issues. Health outcome data was collected by speaking with one person for every household, who was more likely to be female than male. It is possible that the respondent would feel more comfortable telling the researcher about the gastrointestinal issues of someone else in her house, than she would speaking about her own issues.

Garden usage for fruits and greens had a protective effect against the risk of developing gastrointestinal issues in July 16% lower among those who increased their garden usage compared to those who did not. Meanwhile increased usage of the garden for herbal medication indicated a 20% higher odds of GI issues amongst those that used their gardens. This could indicate residents of Claverito were using their medicinal garden in order to self treat their gastrointestinal issues. Although the 95% confidence interval for both of these values crossed one, indicating that they were not statistically significant.

The strongest predictor of having diarrhea in July was whether a participant had diarrhea in February. This makes sense, given that these people were more prone to diarrhea overall.

#### Multivariate Model Result

Although none of the variables were significant on their own, the decision was made to add all of them to the multivariate model. The results of the multivariate model were almost identical to the results of each of the bivariate models for age, sex, and diarrhea in February. This makes sense because none of those variables were highly correlated with any other variables in the model. However, adding the domestic animal exposure to the multivariate model had a large effect on the association between diarrhea in July and the use of herbal medications. After adding the presence of animals to the model the effect of the herbal medication almost disappeared. Since the confidence intervals on all of these numbers were very wide, and none of them were statistically significant, more research needs to be done to determine if these effects were real.

#### Study limitations

##### Case definition

One of the main limitations of this study was the definition of diarrhea that we used. Participants were asked to self report if they experienced any diarrhea or stomach problems in the last month. This is a very broad question that could be interpreted differently by different people, leading to

misclassification. A more exact definition of diarrhea may have yielded more conclusive results. Additionally, since the question asked for self reports of events over the last month, there could be a large recall bias. Given that talking about stool can be a sensitive subject in many cultures it is also possible that respondents underreported the incidence in their household.

#### Timing of Survey

Although both surveys were taken during dry season they were taken six months apart. The February survey was given right before the river level rose, and the July measurement was taken immediately after the river fell. This could influence what was growing in the gardens at the time of survey, as well as the amount of diarrhea in each group. As further data is collected from this community it would be useful to compare the data from the same months across the years to hold these factors constant. In 2018, the water receded more rapidly than in other years, which could have drastically changed the sediment on which the houses are sitting, as well as the garden productivity. Having more years to account for this variation would also be useful.

Many of the plants grown in the gardens would not have hit maturity by the time this analysis was performed. Although this is accounted for by classifying the exposure as using plants from the garden, it could indicate that the results will get more significant over time. Hopefully more people will be able to use produce from their gardens, and the gardens will be yielding more produce.

#### Sources of bias

The groups that used more or less materials from their garden were not randomly assigned, rather they were self selected. This could add confounding as there are likely other behavioural factors that differ between the two groups.

#### Sample Size and Controls

The small size of this community is a large part of what made this intervention possible. However it also means that the statistics do not have as much power to detect changes in the population. Extending this intervention to an additional community would help lend weight to the findings in this study.

Another way to add statistical power to this study, as well as to pin point neighborhood effects, would be to add a control community. However this was deemed unethical by the

researchers due to the idea of withholding a beneficial intervention. One way to work around that ethical dilemma would be to implement a stepwise intervention in which both groups would get the intervention, but one of them would be delayed. Unfortunately this would require many more resources and finding a suitably matched control could be difficult (3).

### High Baseline Rate of Diarrhea

One predominant source of diarrhea in this community is likely the water source. Water source was asked in the survey, however the answer was that water came from the river for 100% of participants at both time points. Even though it did not change throughout the study the risks of diarrhea from the water may dwarf any positive results that would be seen from garden usage. There are other aspects of the project looking at creating a cleaner water source for the community and future studies on this population may be able to identify more of a change in diarrhea.

Overall, this project aimed to investigate whether the construction of floating gardens in the floating slum community of Claverito could improve the digestive health of the community. The current study did not find evidence that this has been the case so far, but there are a variety of factors that could have contributed to that. Additional data, gathered over a longer period of time, and with a clearer definition of diarrhea could be used to further test this hypothesis.

### Strengths of the study

#### Sustainability

Many projects implemented by groups coming into a community that is not their own, suffer from a lack of insight into what the community actually wants/needs. Likewise often the community does not feel ownership of the project and may not have the desire, or skills, to maintain the project. This project was based on a participatory design in which community members both communicated what they needed and worked together to make it happen. This ownership is seen in the fact that 78% of residents invested their own money and resources in supplies to build the gardens. This fact will make this project more sustainable in the future, as residents seek to make the effort to continue the upkeep of the gardens and community. A year after the initial floating gardens were built all but two of the gardens were still being maintained, as 62% had increased the number of plants in them(3).

### Changing Stigmas

There were many negative stigmas towards Iquitos from other members of the Iquitos community. This could be seen in part by the buildup of trash on the hillside above the community. Soon after the start of this project the community was invited to participate in the city census for the first time in the 45 years since the first resident moved in(3). This may have been in part due to the attention that the city saw that Claverito was getting. It may also be related to the change in physical appearance of the community and the fact that the community showed a desire to improve their living space.

### **Direction for Further Research**

Overall, this project aimed to investigate whether the construction of floating gardens in the floating slum community of Claverito could improve the digestive health of the community. The current study did not find evidence that this has been the case so far, but there are a variety of factors that could have contributed to that. Additional data, gathered over more time, and with a clearer definition of diarrhea could be used to further test this hypothesis.

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