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**An alternative intervention approach for nutrition
deprivation in Belize**

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Abstract

Nutrition deprivation is the principal driver of poverty in Belize, but the complexity and sparseness of nutrition data makes it hard to localize areas of intervention.

This study investigates the distribution of poverty in Belize and proposes an alternative approach that uses housing conditions as a proxy for localizing dense areas of nutrition deprivation, given that nutrition and housing deprivation are associated with a significant odds ratio of 1.7, adjusted for confounding variables.

An intervention investment plan is set up for Toledo, that stood out as as the most critical area.

1. Introduction

1.1 Our study

Poverty is one of the most pressing issues that the world faces today, affecting billions of people around the globe.

In 2015, according to the World Bank, 9.6% of the world's population were living in extreme poverty, defined as surviving on less than \$1.90 per day [1].

However, monetary deprivation shouldn't be the focal deprivation in defining such a multidimensional matter as poverty, as the poorest people are often undernourished, without access to basic services such as electricity and safe drinking water, education and sanitation.

Multidimensional Poverty Index (MPI) is an international metric that gauges acute multidimensional poverty in over 100 developing countries, seeking to understand poverty beyond monetary deprivations.

Poverty in Belize

In particular, our study focuses on poverty in Belize, a small country located on the northeastern coast of Central America, bordered by Mexico to the north, Guatemala to the west and south, and the Caribbean Sea to the east.

The aim of our study is to research and investigate the multidimensional aspects of poverty in Belize, in order to set up an intervention plan to improve the population conditions in terms of nutrition by providing food, agricultural and micro-nutrient interventions, and education on quality climate-smart agriculture and livestock in nutrition-deprived areas.

An alternative approach

Identifying and localizing densely populated areas with high levels of nutritional deprivation in Belize presents substantial challenges. Nutritional data can often be sparse, difficult to collect, outdated, and deprivation can vary significantly even within small geographical regions, complicating efforts to target specific areas for intervention.

This project provides an alternative approach to identify intervention areas: given that housing-deprived areas are much easier and straightforward to localize, the idea is to investigate the extent to which housing deprivation can serve as a proxy for identifying areas of high nutrition deprivation in Belize.

1.2 Our data

Our dataset is comprised of *Multidimensional Poverty Index (MPI)* measurements for individual residents of Belize.

The *MPI* evaluates poverty on an individual basis: a person is classified as '*MPI poor*' if they experience deprivations in at least one-third of ten (weighted) indicators. The severity, or intensity, of their poverty is measured by the percentage of these deprivations. The global *MPI* not only identifies who is poor but also explains how they are poor, creating a detailed picture of poverty. The breakdown of *MPI* by the ten indicators reveals the specific ways in which people are impoverished. This makes the *MPI* and its associated information platform an invaluable tool for analysis, pinpointing the most vulnerable populations and uncovering poverty patterns within countries over time, enabling policymakers to allocate resources and design policies more effectively.

Developed by the Oxford Poverty and Human Development Initiative (OPHI) in collaboration with the United Nations Development Programme (UNDP), the global *MPI* was introduced in

UNDP's Human Development Report in 2010 and has been published annually by *OPHI* and in the *HDRs* since then. It is computed using data from the most recent Demographic and Health Surveys (DHS), Multiple Indicator Cluster Surveys (MICS), Pan Arab Project for Family Health (PAPFAM), and national surveys. Therefore, our dataset is representative of the country, meaning it accurately reflects the demographic, health, and socioeconomic conditions of the population. This representativeness is crucial for ensuring that the findings and insights derived from the data are reliable and applicable for informing policy decisions and interventions aimed at improving the well-being of the entire population.

Figure 1.1 visualises the composition of the MPI:

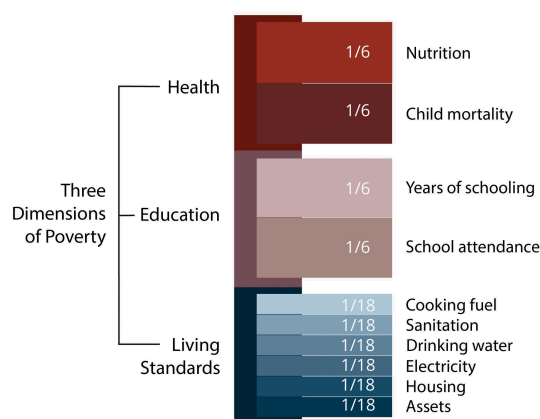


Figure 1.1: *MPI* Composition

- **Nutrition:** Any person under 70 years of age for whom there is nutritional information is undernourished.
- **Child mortality:** A child under 18 has died in the household in the five-year period preceding the survey.
- **Years of schooling:** No eligible household member has completed six years of schooling.
- **School attendance:** Any school-aged child is not attending school up to the age at which he/she would complete class 8.

- **Cooking fuel:** A household cooks using solid fuel, such as dung, agricultural crop, shrubs, wood, charcoal, or coal.
- **Sanitation:** The household has unimproved or no sanitation facility or it is improved but shared with other households.
- **Drinking water:** The household's source of drinking water is not safe or safe drinking water is a 30-minute or longer walk from home, roundtrip.
- **Electricity:** The household has no electricity.
- **Housing:** The household has inadequate housing materials in any of the three components: floor, roof, or walls.
- **Assets:** The household does not own more than one of these assets: radio, TV, telephone, computer, animal cart, bicycle, motorbike, or refrigerator, and does not own a car or truck.

In addition to these dimensions, we added two custom variables. We first calculated the number of components each household was composed by, and calculated the severity of poverty for each individual/household according to the criteria we defined earlier.

Severity

An individual is considered *vulnerable* to poverty if they experience deprivation in 20 – 33.33% of the weighted indicators. Meanwhile, an individual is regarded as living in *severe poverty* if they are deprived in 50 – 100% of the weighted indicators.

Table 1.1 presents the distribution of poverty levels within the country of Belize:

Severity	Count	Frequency
Not poor	16443	0.853
Vulnerable	1803	0.093
Poor	869	0.045
Severely poor	143	0.007

Table 1.1: Distribution of Poverty Levels

We can see that the vast majority of the population (85.3%) is not experiencing poverty. However, 9.3% of the population is classified as vulnerable to multidimensional poverty, and a combined 5.2% of the population are poor or severely poor.

Figure 1.2 and Table 1.2 visually represent the indicators of deprivation across the different severity levels:

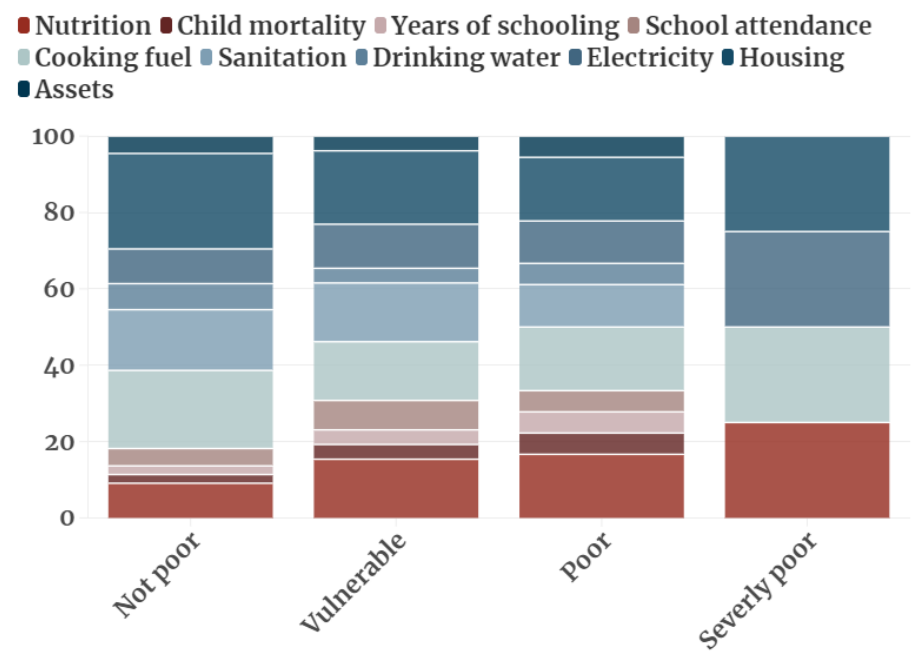


Figure 1.2: Severity distribution

Severity	Child mortality	Nutrition	School attendance	Years of schooling	Electricity	Drinking water	Sanitation	Housing	Cooking fuel	Assets
Not poor	0.01	0.04	0.02	0.01	0.04	0.03	0.07	0.11	0.09	0.02
Vulnerable	0.01	0.04	0.02	0.01	0.03	0.01	0.04	0.05	0.04	0.01
Poor	0.01	0.03	0.01	0.01	0.02	0.01	0.02	0.03	0.03	0.01
Severely poor	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.00

Table 1.2: Severity Levels and Associated Factors

Nutrition, electricity, sanitation, housing, and cooking fuel access are the primary areas where significant disparities exist.

2. Multi-Poverty Index in Belize

In the analysis of poverty in Belize, we employed a multi-step approach to ensure the accuracy and reliability of our findings. First of all, we adopted a multiple imputation technique by chained equations (*MICE*) using Random Forest method with 50 iterations to address missing data. This method allowed us to generate multiple imputed datasets, which were then combined to produce a single, comprehensive dataset for our analysis.

Next, we calculated the Multidimensional Poverty Index using the formula $MPI = H \times A$, in which H is the incidence of poverty and A the average intensity of poverty.

The following values were obtained: $A = 0.404$, $H = 0.052$. As expected, the results of this computation confirms that 5.2% of the population in Belize is considered to live under the condition of poverty. The global MPI value was calculated to be 0.021 indicating that approximately 2.1% of the population in Belize is multidimensionally poor. Hence, this percentage of the population experiences deprivations in multiple dimensions of well-being. Since these dimensions are considered to have different weights, it would be important to calculate the percentage of contribution of each dimension of poverty. From table 2.1, it is possible to understand that the dimension that had the highest impact on the final index score is *Nutrition*, which indicates households that have at least one malnourished individual.

Dimension	Value
Nutrition	0.26450220
Housing	0.14144761
Cooking Fuel	0.12670340
School Attendance	0.11650160
Sanitation	0.09613523
Child Mortality	0.07964108
Electricity	0.07290193
Years of Schooling	0.03741902
Drinking Water	0.03481272
Assets	0.02993521

Table 2.1: Percentage Contribution of Each Poverty Dimension

In order to gain a deeper understanding of the problem of nutrition in Belize, we further analyzed the data by creating a new categorical variable indicating the range of members belonging to a household. For interpretability, we could assume that 1-2 household members represent families without children, 3-4 and 5-6 members represent average-size families and 7+ families are above size average, given that Belize fertility rate in 2015 has an average of 2.44 children per woman [2]. By looking at Table 2.2 we could expect that an increase in household size, implies an increase in the risk of malnutrition. This is crucially important to understand as interventions aimed at reducing malnutrition in Belize should particularly focus on larger households, as they are more at risk.

	1-2	3-4	5-6	7+
0 (No malnourished)	99.84%	93.06%	87.77%	80.60%
1 (At least one malnourished)	0.16%	6.94%	12.23%	19.40%
Column Total	100%	100%	100%	100%

Table 2.2: % of households with at least one malnourished member across different family sizes

By examining the contribution of each dimension, we were able to gain a deeper understanding of the specific areas where poverty is most prevalent and where targeted interventions may be most effective.

3. Localizing nutrition-deprived areas

Among the *MPI* dimensions, nutrition deprivation is the one with the highest impact. An adequate nutrition is not only essential for maintaining health and productivity but also plays a pivotal role in breaking the cycle of poverty.

An intervention plan aimed at providing food, agricultural and micronutrient interventions, and education on quality climate-smart agriculture and livestock in nutrition-deprived areas would have a strong positive impact on poverty in Belize.

However, identifying and localizing dense areas in terms of nutrition deprivation in Belize poses significant challenges. Data on nutritional status is often sparse, difficult to gather, and not always

up-to-date. Furthermore, nutrition deprivation can vary widely even within small geographical areas, making it difficult to pinpoint specific areas of intervention.

This project provides an alternative approach to identify intervention areas: given that housing-deprived areas are much easier and straightforward to localize, the goal is to investigate the extent to which housing deprivation can serve as a proxy for identifying areas of high nutrition deprivation in Belize, by analyzing the association between the two deprivations.

A significant positive association would allow us to intervene in areas that are dense in terms of nutrition-deprived and, simultaneously, multidimensionally poor households.

3.1 Related deprivations

To compare all the deprivation variable classes with their baseline we will use odds ratio, a statistical effect measure which has the property of being symmetric with respect to the exposure and the outcome.

An odds ratio significantly higher than 1 means that the odds of having the outcome deprivation are higher in an individual that has the exposure deprivation with respect to an individual without the exposure deprivation. Vice versa, an odds ratio significantly lower than 1 means that the exposure deprivation is protective with respect to the outcome deprivation.

In our study, we use nutrition as the outcome deprivation and the other variables as exposures, obtaining an odds ratio significantly higher than 1 (Fisher exact test - 95% significance) for all the tested variables, as reported in Table 3.1.

Factor	Point Estimate	Lower Bound	Upper Bound	P-value (95%)
Child Mortality	1.891469	1.568525	2.280903	< 0.001
School Attendance	1.755941	1.495495	2.061744	< 0.001
Years of Schooling	1.410498	1.052969	1.889424	0.02
Electricity	3.315886	2.970706	3.701175	< 0.001
Drinking Water	2.169595	1.848755	2.546115	< 0.001
Sanitation	2.905359	2.623528	3.217466	< 0.001
Housing	2.824078	2.574784	3.097508	< 0.001
Cooking Fuel	3.476148	3.166554	3.81601	< 0.001
Assets	2.763546	2.349038	3.251198	< 0.001

Table 3.1: Odds Ratios Between Nutrition and Living Standards before adjusting for the living standards deprivations

3.2 Housing as a proxy for nutrition deprivation

In particular we focus on the odds ratio of nutrition with respect to housing, which is 2.83 (2.58, 3.11). We can say that the odds for an individual of having nutrition deprivation are about 3 times higher if he has housing deprivation with respect to if he doesn't. By stratifying the sample by numerosity of the families (3-4, 5-6 and 7+, while we didn't have enough nutrition-deprived data for 1-2 members families) we obtained odds ratios of 3.17 (2.55, 3.93) for 3-4 members families, 2.34 (1.97, 2.77) for 5-6 members and 2.52 (2.20, 2.88) for 7+ members. We fail to reject Woolf's chi-square homogeneity test null hypothesis ($p\text{-value}=0.122$), which means that the strata odds ratios are not significantly different between each other. The Mantel-Haenszel odds ratio adjusted for family size is 2.56 (2.32, 2.81).

This ratio, however, is not adjusted by all the other deprivation variables that we took into consideration in this study. In particular, living standards deprivations such as lack of electricity, cooking fuel, sanitation standards, drinking water and assets can have a confounding effect on the association between nutrition and housing.

To adjust for these variables, we performed a logistic regression with nutrition as the outcome variable and housing as a covariate together with the aforementioned living standard variables, in order to adjust for their effect. The resulting estimates are exponentiated to obtain the odds ratios

and 95% confidence intervals for each covariate with respect to their baseline 0 (no deprivation). The results ¹ are shown in Table 3.2 and also in the forest plot in Figure 3.1.

We can therefore conclude that all the living standard variables, except for assets, have a significant risk effect on nutrition. In particular, adjusting for the living standards variables, housing has a significant odds ratio of 1.70 (1.52, 1.89), suggesting that housing deprivation increases the odds of having a nutrition deprivation by 70% with respect to individuals without housing deprivation.

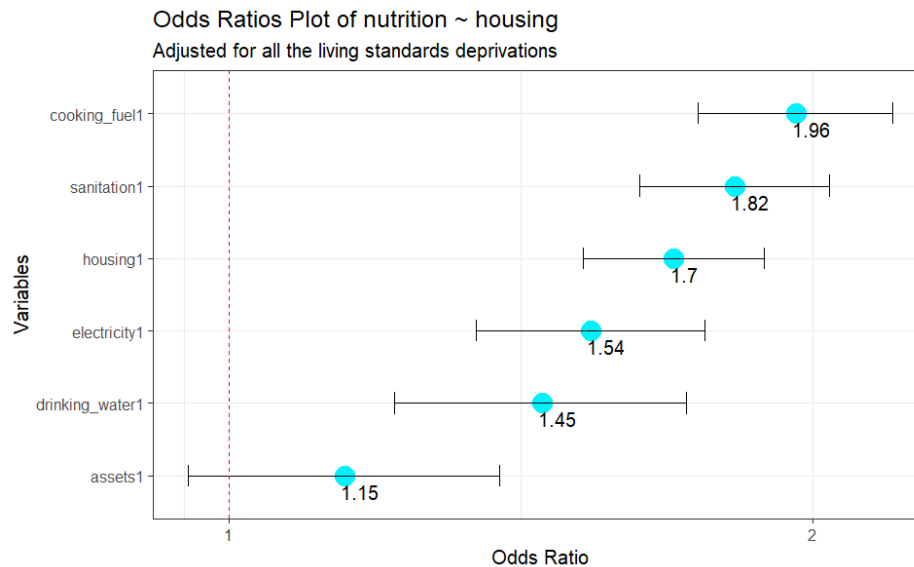


Figure 3.1: Logistic regression odds ratios with 95% C.I. (dashed line represents OR=1)

¹Numerosity of the family is not shown as an adjusting covariate of the regression due to highly inflated estimates given by the lack of nutrition-deprived 1-2 members families data. However, we confirm that the housing odds ratio obtained both by adjusting the regression for family members and by performing logistic regression on separate family numerosity stratas did not change the direction of the odds ratio or its significance.

	Odds Ratio	2.5 %	97.5 %
(Intercept)	0.08439659	0.07951749	0.08957507
housing1	1.69631881	1.52302402	1.88933166
electricity1	1.53704317	1.34234447	1.75998171
cooking_fuel1	1.96072335	1.74668278	2.20099269
sanitation1	1.82424332	1.62937195	2.04242113
drinking_water1	1.45059243	1.22007624	1.72466141
assets1	1.14785618	0.95397209	1.38114502

Table 3.2: Odds Ratios with 95% Confidence Intervals

4. Localizing critical housing areas

From last section, we arrived to the conclusion that households with inadequate housing are more likely to experience nutrition problems. Areas with severe housing conditions can be more straightforward to identify and localize compared to using direct nutritional deprivation data, which can be more sparse and complex to collect. Furthermore, examining housing issues can not only pinpoint areas where nutritional aids are needed, but also allows to accurately direct interventions towards households which are nutrition-deprived and, simultaneously, multidimensionally poor.

A study by Belize and UNICEF on the Multiple Indicator Cluster Surveys (MICS) held in 2015-2016 [3] provided valuable data about the aforementioned dimensions of poverty across the country. This data, as shown in Figure 4.1, revealed that poverty predominantly afflicts rural regions of Belize, thus revealing structural differences in urban and rural poverty. By focusing particularly on the housing dimension data, we were able to confirm our initial findings and gain detailed insights into the specific conditions in each region of Belize.

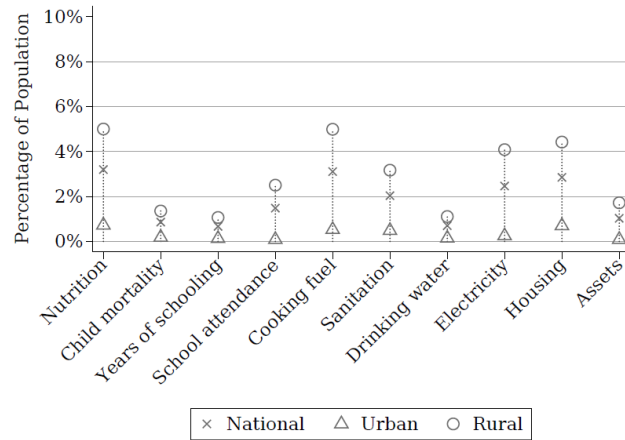


Figure 4.1: Deprivations by Area

In particular, there is one Belize region, Toledo, that performs drastically worse on some housing dimensions which we decided to focus on. As a matter of fact, Figure 4.2, reports that with respect to the whole country, Toledo region has less access to electricity, less houses with finished floors, walls and roofs. In addition to that, it is also the region with the highest average number of people sleeping in one room.

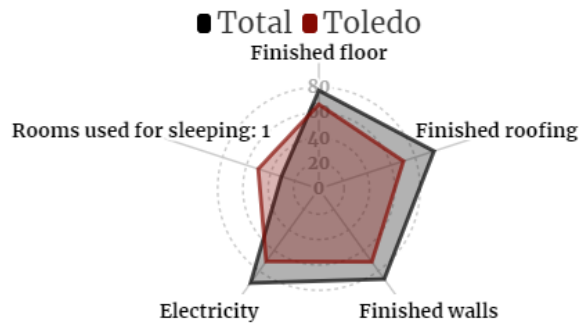


Figure 4.2: Comparing housing dimensions of Belize vs Toledo region.

The data from Toledo highlighted significant deficiencies in housing quality and access to basic services, correlating strongly with high levels of nutritional deprivation. For these reasons, our decision is to concentrate humanitarian aid efforts on the Toledo region. This targeted approach aims to address both housing and nutritional deficiencies, ultimately improving the well-being of households most in need.

5. Our investment plan

As a non-profit organization, our aim would hence be to detect the number of people suffering from deprecated housing condition and contributing on their nutritional needs.

From a study conducted by the University of Oxford [4], it emerged that around 10% of people resident in the Toledo district suffered from housing deprecation in 2015, corresponding to an amount of around 3580 people.

To estimate the investment required to effectively intervene on nutritional problems in Belize, we considered the daily food requirements for individuals. The minimum food basket in Belize, as determined by the Statistical Institute of Belize, amounts to BZ\$7.26 daily, which is approximately US\$3.63 per day (adjusted per inflation, in 2015 it would be US\$2.80). This amount is based on the minimum food requirements for a person to maintain a healthy diet. Thus, in order to provide food assistance for these group of people for one year we would need [5].

$$\$2.80 \cdot 3580 \cdot 365days = \$3,658,760$$

This figure is overestimated, but with an investment of this kind, we would make a significant impact on the nutrition problem in the Toledo district for one year.

6. Conclusion

In conclusion, this study addressed the complex issue of poverty and nutritional deprivation in Belize by adopting a multidimensional approach to identify the most needy areas for intervention. By analyzing the Multidimensional Poverty Index (*MPI*), the study highlighted that 5.2% of the Belizean population lives in conditions of multidimensional poverty, with nutrition identified as the dimension of poverty with the greatest impact.

Our research demonstrated that housing conditions, for which critical areas are more straightforward to localize, can indeed serve as a proxy for identifying areas with high levels of nutritional

deprivation, thanks to its significant association with nutrition, thereby overcoming the challenges associated with the collection of direct nutritional data.

This approach allowed the identification of the Toledo district as a priority area for humanitarian interventions, due to its critical housing conditions and poverty in multiple dimensions. By focusing efforts on improving nutrition and educating on diets and food quality in these areas, we can make a significant impact on the well-being of this country.

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