Moving Forward: The Role of Housing Improvements in Breaking Long-Term Poverty Traps in Urban Slums*

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Abstract

This paper aims to examine the impact of comprehensive housing improvements on intergenerational income mobility and school attendance in Ciudad Bolívar, Bogotá, a locality characterized by severe qualitative housing deficits. The intervention addresses critical in-home deficiencies such as roofing, flooring, and sanitation, aiming to transform living conditions and foster long-term mobility. By employing a randomized controlled trial with neighborhood-level randomization, the study isolates causal effects on economic and educational outcomes. Intergenerational income mobility serves as the primary outcome, with an expected effect size of a 10% increase in household income, reflecting the potential to break poverty traps. School attendance is analyzed as a secondary outcome, with an anticipated 16% reduction in missed school days, illustrating the mechanism through which economic improvements may occur. This research fills critical gaps in the urban economics literature, providing experimental evidence from a developing-country context and highlighting the role of targeted interventions in promoting economic mobility. The findings have significant implications for policymakers designing strategies to address urban poverty, emphasizing the importance of integrated solutions to improve both immediate living conditions and long-term outcomes.

Key words: Slums, Income, Social Mobility, School Attendance, Housing.

JEL Classification: O15, O18, R28, R58.

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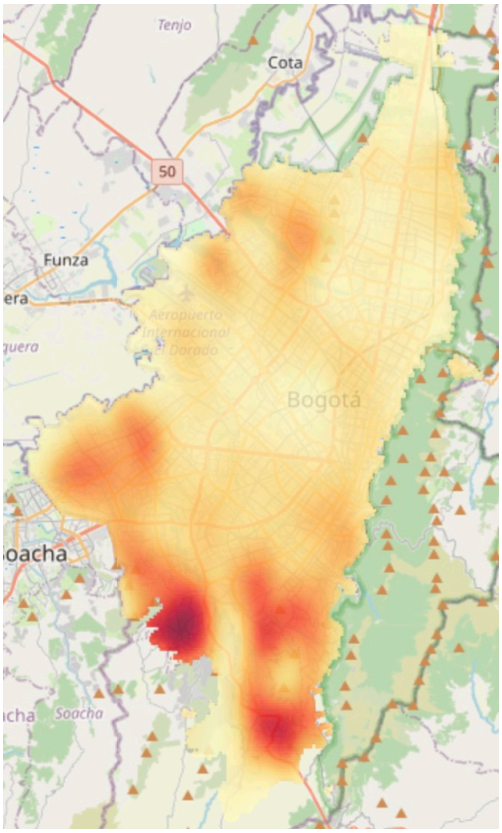
1 Introduction

The rapid urbanization of the developing world in the 20th and 21st centuries has fundamentally reshaped global settlement patterns. Driven by rural-urban migration and natural urban population growth, cities in low- and middle-income countries have expanded at unprecedented rates, accommodating more than 50% of the world's population today (Henderson, 2002). However, this shift has often outpaced governments' ability to provide adequate infrastructure, housing, and public services, leading to the proliferation of slums. Defined by overcrowding, inadequate access to basic services, and poor-quality housing, slums are now home to over 860 million people globally, reflecting one of the most visible forms of urban poverty (UNHabitat, 2012). The prevalence of slums varies widely across regions, yet they remain a persistent challenge in the developing world. Sub-Saharan Africa, for instance, holds the highest concentration of urban slum dwellers, with 62% of its urban population living in such conditions (UNHabitat, 2012). Similarly, Latin American cities continue to struggle with slum prevalence, where approximately 23% of the urban population resides in informal settlements (CAF, 2022).

Historically, slums have been conceptualized as temporary phenomena linked to rapid economic growth and urban expansion. The modernization theory based on Frankenhoff (1967), Turner (1969) suggests that slums serve as transitional spaces, providing the urban poor with access to opportunities that ultimately enable their integration into the formal economy. This narrative portrays slums as pathways to socio-economic mobility, where the benefits of agglomeration, economies of scale, and urban networks gradually improve residents' labor productivity and living standards. However, the persistence of slums challenges this optimistic perspective. In many cities, the expected transition from informal to formal neighborhoods has stalled, and slums have become enduring fixtures of the urban landscape. While Glaeser (2011) acknowledges the opportunities slums can offer, he also emphasizes their role as sites of public sector failure. Insufficient infrastructure, limited access to education and healthcare, and inadequate connectivity to the urban core often exacerbate cycles of poverty rather than alleviate them. Moreover, slum growth frequently reflects "urbanization without growth", where population expansion outpaces economic development, leaving many residents trapped in substandard conditions.

Addressing the challenges posed by slums requires more than just recognizing their existence; it necessitates targeted interventions aimed at breaking these poverty traps. Upgrading programs that improve housing, infrastructure, and access to essential services are critical in transforming slums into spaces of opportunity. Other approaches, such as relocation and property rights initiatives, offer additional strategies to tackle this issue. The global scale of this challenge underscores the urgency of understanding what works and what does not in transforming slums into viable urban communities (Brakarz and Jaitman, 2013).

Figure 1. Qualitative Deficit in Bogotá



Source: Datos CEDE, Universidad de los Andes

The challenges posed by slums are not foreign to Colombia, yet the problem remains poorly understood and insufficiently documented at the national and local levels. Slums, or informal settlements, exist across the country, but data on their prevalence and characteristics are scarce. In Bogotá, one of the most unequal cities in Latin America, the housing deficit underscores the severity of urban deprivation. According to the 2021 Multipurpose Survey by DANE, the city's overall housing deficit stands at 31%, encompassing two distinct dimensions: the quantitative and the qualitative deficits. Quantitative deficits arise from critical overcrowding, where additional housing units are urgently needed to accommodate families, while qualitative deficits reflect substandard living conditions requiring structural improvements to the existing housing stock. Both deficits often coincide with inadequate access to essential services and infrastructure, such as clean water, sanitation, and electricity, exacerbating the challenges faced by affected households.

Notably, Bogotá's housing deficit appears to be driven more by qualitative deficiencies, a trend most acutely observed in Ciudad Bolívar. In this locality, approximately 31,000 households experience qualitative deficits, while an additional 6,000 suffer from critical overcrowding and quantitative deficits, making it one of the city's most vulnerable areas. *Figure 1* shows how qualitative deficits concentrates in Ciudad Bolívar. Although the academic literature has explored various interventions to address slums—ranging from property rights reforms to relocation programs—the most impactful and relevant approach

in contexts like Ciudad Bolívar appears to be structural housing improvements. This is particularly significant given the absence of legal tenure issues in the locality, as residents already possess property rights. Moreover, one critical gap in the literature is the lack of research on the intergenerational effects of slum interventions. Understanding how structural improvements to housing influence outcomes for the next generation, such as income mobility and educational attainment, is crucial for evaluating the long-term efficacy of such programs. These variables are particularly compelling because they capture not only immediate improvements in living conditions but also the potential for these interventions to break cycles of poverty over time. With this in mind, this study seeks to answer the following question: How do comprehensive housing and infrastructure upgrades in Ciudad Bolívar affect intergenerational income mobility?

Governments have long struggled to improve the quality of life for slum dwellers, testing various policy approaches over the decades. In the 1970s, one prominent strategy, known as "sites-and-services", involved relocating families to urban lots on city peripheries. As Brakarz and Jaitman (2013) notes, these initiatives often disrupted the opportunities and networks built within the original slum communities, while the new settlements lacked adequate infrastructure and connectivity, eventually becoming "new slums". This failure fueled a debate on whether to upgrade existing slums or create new developments for rural migrants. Programs like the Moving to Opportunity (MTO) in the United States illustrate the potential of relocation strategies, with Ludwig et al. (2012) showing significant long-term gains in subjective well-being and income. However, these strategies often overlook critical challenges in developing countries, where issues like insecure land tenure and inadequate infrastructure remain central barriers to progress.

Another prominent approach to addressing slums has been the provision of property rights, as the lack of legal land titles is often seen as a major obstacle to incentivizing housing investments. Field (2005) and Galiani and Schargrodsky (2010) argue that land titling programs encourage residents to improve their homes and invest in environmental upgrades, fostering both individual and community development. However, this solution is not without its challenges. In densely populated urban areas, land titling can lead to unintended consequences, such as rising land prices that increase the opportunity cost for governments and attract speculative pressures. This dynamic may result in evictions or discourage public investment in formalizing informal settlements, as highlighted by Brueckner and Selod (2009) and Jimenez (1984, 1985). Compared to relocation strategies, which often disrupt social and economic networks, land titling aims to strengthen residents' attachment to their neighborhoods, but its success depends heavily on the broader urban context and market conditions. These limitations further underscore the complexity of slum interventions and the need for alternative solutions tailored to local realities.

Other studies have shifted focus towards in situ housing improvements as a viable alternative to relocation or land titling. These programs aim to enhance the physical living conditions of slum dwellers without displacing them, targeting the root causes of poor quality

of life directly within existing settlements. Research by Cattaneo et al. (2009) and Devoto et al. (2012) demonstrates that interventions such as providing improved flooring, access to clean water, and better sanitation significantly improve mental and physical health, as well as overall satisfaction with life. Proper housing infrastructure can also shield residents from environmental hazards, reduce vulnerability to crime, and free up resources and time for more productive activities (UNHabitat, 2012). Among the most rigorous studies in this area, Galiani et al. (2016) evaluated the impact of basic pre-fabricated housing provided by the NGO TECHO in El Salvador, Mexico, and Uruguay. Their findings indicate that upgrading slum dwellings improves overall living conditions and general well-being, with treated households reporting higher satisfaction with their quality of life. In some contexts, these improvements extended to children's health and perceived safety, though the authors noted a lack of consistent effects on durable goods ownership or labor market outcomes.

While prior research has provided important insights into slum interventions, it often falls short in several critical dimensions. Many existing studies lack experimental designs, relying instead on observational or quasi-experimental methodologies, which limits the strength of causal inferences. Moreover, their findings are frequently inconclusive or inconsistent across key outcomes, particularly regarding economic variables such as labor market participation and income. Additionally, these studies often focus narrowly on immediate or short-term outcomes, overlooking broader metrics like intergenerational mobility that are essential for understanding whether slum upgrading programs can effectively break poverty traps. Escaping such traps is crucial to enabling households to transition from informal to formal urban living and fully integrate into the social and economic fabric of cities. A notable step toward addressing these gaps is the recent study by Zanoni et al. (2023), which examines the impact of slum upgrading programs (SUPs) on school attendance in Uruguay. Using a regression discontinuity design based on eligibility rules, they find that children exposed to SUPs experienced 28 fewer absences, representing a 16% reduction in missed school days and a 70% decrease in recurrent absenteeism. These results underscore the potential of SUPs to enhance human capital accumulation by targeting critical educational outcomes, a strong predictor of long-term success in health, labor markets, and overall socioeconomic mobility. However, despite its contributions, Zanoni's research focuses exclusively on educational outcomes, leaving a significant gap in understanding the effects of SUPs on economic variables such as intergenerational income mobility.

With this in mind, this paper contributes to the literature on slum upgrading in three main ways. First, it employs a fully experimental design, a rare approach in the study of slum interventions. By randomizing the allocation of infrastructure improvements at the neighborhood level, this study ensures robust causal estimates of the effects of these upgrades. Such an approach has not been previously undertaken in the context of Bogotá or similar urban environments, where existing studies often rely on natural experiments or observational data. Second, this study focuses on outcomes that are both underexplored and crucial for understanding long-term economic mobility. While previous research has often

concentrated on immediate metrics such as housing satisfaction, health, or perceived safety, this paper examines intergenerational income mobility as a central outcome. By investigating whether infrastructure improvements can influence the future earnings of children from slum households, the study provides a critical perspective on the long-term impacts of these programs. In doing so, it addresses a key gap in the literature, particularly as most studies to date have shown limited or inconclusive effects on income and labor market outcomes. Third, this study evaluates a comprehensive infrastructure intervention in a context uniquely suited to disentangling the mechanisms through which slum upgrading may affect economic outcomes. Unlike other settings where basic necessities such as property rights or access to water are unresolved, Ciudad Bolívar offers a relatively stable foundation: its residents have secure land tenure, and most areas are connected to essential utilities. This setting contrasts sharply with cases such as those studied by Galiani et al. (2016), where unresolved issues like property rights or infrastructure deficits were posited as barriers to achieving improvements in labor market outcomes. By focusing on a locality where such barriers are absent, this study provides a more direct test of whether slum upgrading programs can break cycles of poverty through improvements in housing quality and neighborhood conditions.

Overall, this research pretends to offers new evidence on the mechanisms through which improved living conditions may help break poverty traps. The findings aim to inform both academic debates and practical policies aimed at reducing urban inequality and fostering long-term mobility. The structure of the paper is as follows: the next section outlines the research design. This is followed by a section on statistical power and robustness checks, which evaluates the design's ability to capture the hypothesized effects. The results are then presented and interpreted in the context of competing theories, highlighting contributions to the literature and implications for policy. Finally, the paper concludes with a discussion of limitations and potential extensions, offering pathways for future research.

2 Research Design

To address the research question, this study employs a randomized controlled trial (RCT) in Ciudad Bolívar, Bogotá, targeting households classified by DANE as experiencing a qualitative housing deficit. The intervention involves comprehensive in-home improvements, including upgrades to roofing, flooring, and sanitation systems, aimed at addressing critical deficiencies in housing quality. By randomizing at the neighborhood level and assigning treatment to selected households within these neighborhoods, the design ensures comparability between treatment and control groups while minimizing spillover effects. The study's primary outcome is intergenerational income mobility, measured through logarithmic household per capita income, with school attendance as a secondary outcome to explore potential mechanisms. These outcomes are evaluated using linear regression models with clustered standard errors and complemented by an instrumental variables (IV) approach to account

for treatment compliance. The research design incorporates robust sampling, statistical power calculations, and ethical considerations to ensure the validity and feasibility of the study. This framework provides a comprehensive strategy to assess the causal impact of qualitative housing improvements on long-term economic and educational outcomes. The remainder of this section delves into the specifics of the research design, including the outcomes and the hypothesis, the intervention's structure, the methodology for sampling and randomization, the answer strategy and the statistical analysis.

In the first place, the primary outcome of interest in this study is intergenerational income mobility, measured through the logarithm of household per capita income. Income is a critical indicator of economic progress and a direct measure of whether the intervention enables households to escape poverty traps. Using the logarithm of income ensures that the analysis captures relative changes more effectively, particularly for lower-income households, and aligns with standard practices in economic research where income distributions are skewed. Household per capita income is pretended to be calculated using data collected from longitudinal surveys, which track families over time, and is benchmarked against a log-normal distribution derived from the 2018 Colombian National Census (DANE). Specifically, the mean and standard deviation of the logarithmic income distribution for households in Ciudad Bolívar with qualitative housing deficits were determined to be 318,640 COP and 178,172 COP, respectively. To account for neighborhood-level variation, income is modeled with a cluster-level intra-class correlation (ICC) of 10%, consistent with values commonly used in the literature. The secondary outcome, school attendance, complements this analysis by evaluating potential mechanisms driving income mobility. Attendance is a robust predictor of long-term economic and social outcomes, including educational attainment and labor market success. Following the framework of Zanoni et al. (2023), this variable is defined as the number of missed school days per academic year and is collected using both self-reported household surveys and administrative data from local schools. Descriptive statistics from this paper suggest a baseline mean of 35.5 missed days with a standard deviation of 27.1, providing a benchmark for comparison. The hypotheses to be tested are: (1) the intervention will significantly increase household per capita income over time, evidenced by a higher log-transformed mean in treated households compared to controls; and (2) treated households will exhibit a reduction in missed school days, indicating an improvement in school attendance. These outcomes were selected to provide a comprehensive evaluation of both the long-term economic impacts and the short-term educational mechanisms through which comprehensive housing improvements may influence poverty dynamics.

The intervention involves comprehensive in-home improvements targeting households classified by DANE as experiencing a qualitative housing deficit in Ciudad Bolívar, Bogotá. These improvements include upgrades to roofing, flooring, walls, and sanitation systems, addressing critical deficiencies in housing quality. The intervention focuses on five UPZs (66 to 70), which together encapsulate a population of approximately 550,000 people. According to the 2021 DANE Multipurpose Survey, 31,000 households in Ciudad Bolívar face

qualitative deficits, with nearly all concentrated in these UPZs. The unit of analysis for this study is the household, with individual-level data collected to assess outcomes such as intergenerational income mobility and school attendance. Participation in the program is defined by eligibility based on DANE's qualitative deficit classification and random assignment to treatment within selected neighborhoods.

Also, to minimize spillover effects between treated and untreated households, randomization was conducted at the neighborhood level, with a total of 112 neighborhoods included in the study. Each neighborhood was assigned a 50% probability of receiving the intervention, resulting in 56 treatment neighborhoods and 56 control neighborhoods. Within each selected neighborhood, 80 households are randomly chosen to receive the intervention, ensuring representation of those classified with qualitative deficits. This design guarantees a balanced distribution of treated and untreated units while maintaining sufficient statistical power for the analysis. The sampling strategy accounted for neighborhood-level population estimates derived from DANE data, ensuring that all neighborhoods included in the study had at least 500 residents, with a minimum of 100 households experiencing qualitative deficits. Based on prior research, including Galiani et al. (2016), a compliance rate of 90% was assumed, acknowledging potential deviations from treatment assignment due to unforeseen logistical or household-level factors.

Blinding participants to their treatment assignment is inherently challenging in this type of intervention, as physical improvements to households are visible. To minimize performance and expectancy biases, several measures are pretended to be implemented. Participants are not informed of the specific hypotheses being tested and are told that the study aimed to evaluate a range of community-level outcomes. Baseline surveys included questions on participant expectations to account for potential bias in post-treatment responses. Furthermore, enumerators conducting the surveys are trained to avoid revealing treatment assignments or specific study goals. No multiple treatment arms are included; the intervention was designed as a single comprehensive package to ensure consistency and comparability of results across treated households.

Regarding the inquiry of this study, the Average Treatment Effect (ATE) of comprehensive housing improvements on intergenerational income mobility and school attendance is analyzed. To estimate this effect, the study employs a randomized controlled trial (RCT), leveraging the random assignment of treatment to ensure that treated and control groups are comparable on both observed and unobserved characteristics. The primary identification strategy involves a simple linear regression model with clustered standard errors at the neighborhood level to account for intra-cluster correlation (ICC). This approach captures the intent-to-treat (ITT) effect of the intervention. Additionally, the study uses an instrumental variables (IV) framework, with treatment assignment as the instrument to estimate the local average treatment effect (LATE) for households that complied with the intervention. Randomization at the neighborhood level further mitigates potential spillover effects, enhancing internal validity. The regression model for the primary analysis is as follows:

$$y_i = \alpha + \tau D_i + \epsilon_i$$

where y_i represents the outcomes of interest—logarithmic household per capita income and the number of missed school days. D_i is a binary variable indicating treatment assignment, τ captures the intent-to-treat (ITT) effect, and ϵ_i represents the error term. Standard errors are clustered at the neighborhood level to account for intra-cluster correlation (ICC). This model estimates the direct impact of the intervention on treated households, providing a robust framework for evaluating the effectiveness of comprehensive housing improvements.

It is essential to consider the ethical implications of this study, particularly given the vulnerable population involved and the nature of the intervention. Comprehensive housing improvements inherently raise questions about fairness in treatment allocation, as not all eligible households will receive the intervention due to randomization. To address this, the study ensures transparency in the selection process and provides clear communication to all participants regarding the study's purpose and methodology. Informed consent is obtained from all households, emphasizing that the selection process is random and not based on any subjective criteria. Additionally, the intervention does not involve any harm or deprivation to control households; instead, it seeks to evaluate the impact of enhancements provided to treated households. Data confidentiality is strictly maintained, with all collected information anonymized and used solely for research purposes. The potential long-term benefits of understanding the effectiveness of housing improvements in breaking poverty traps outweigh the ethical concerns of randomization, particularly as the study design adheres to principles of equity and minimizes harm to participants. These considerations ensure that the study is conducted with the highest ethical standards, balancing the need for rigorous research with respect for the communities involve

Now, the sample and statistical power calculations are informed by effect sizes reported in the literature and the unique characteristics of the study's context. For intergenerational income mobility, there is limited direct evidence from slum contexts. However, studies like Chetty et al. (2014) suggest that interventions targeting household and educational conditions can yield significant improvements. Following these benchmarks, this study assumes an expected effect size of a 10% increase in household per capita income among treated households, driven primarily by mechanisms linked to educational improvements. Income is modeled with an intra-class correlation (ICC) of 10% at the neighborhood level, reflecting the clustering of outcomes within treatment and control groups. For school attendance, the findings of Zanoni et al. (2023) provide a robust reference, where slum upgrading reduced missed school days by 28 days, equivalent to a 16% improvement. This effect size is used as the baseline assumption for detecting changes in attendance.

Lastly, we assume an alpha level of 0.05, reflecting a standard threshold for statistical significance, and a statistical power of 0.80, ensuring an 80% probability of detecting the expected effect size. Variability in the effect sizes is addressed by using standard deviations

derived from the literature and population data. For income, a standard deviation of 178,172 COP (log-transformed) is assumed, based on the DANE 2018 Census data for households in Ciudad Bolívar with qualitative housing deficits. For attendance, the standard deviation is set at 27.1 days, as reported by Zanoni et al. (2023). To validate the robustness of the results, additional sensitivity analyses and redesign diagnostics will be conducted. These include assessing the stability of the income results under alternative specifications of the regression model and varying assumptions about the compliance rate and intra-cluster correlation. These robustness checks aim to ensure that the findings for income, as the primary outcome, remain consistent and reliable across different analytical approaches.

3 Design Diagnosis

Table 1. Simulation Results for Intergenerational Income Mobility (Primary Outcome)

Inquiry	Estimator	Mean Estimand	Mean Estimate	Bias	Power	Coverage
ATE	OLS	0.10	0.10	0.00	0.85	0.94
		(0.00)	(0.00)	(0.00)	(0.04)	(0.02)
LATE	IV	0.10	0.10	0.00	0.66	0.93
		(0.00)	(0.00)	(0.00)	(0.04)	(0.02)

Note: Results are based on 1,000 simulated datasets. Standard errors in parenthesis are clustered at the neighborhood level.

Table 1 provides key results from the simulation assessing the ability of the study design to estimate the Average Treatment Effect (ATE) of the intervention, using both Ordinary Least Squares (OLS) and Instrumental Variables (IV) estimators. The table reports the mean estimand, the mean estimate, bias, statistical power, and coverage across simulated datasets. The results highlight important considerations for the robustness and effectiveness of the proposed methodology. The mean estimand of 0.10 reflects the assumed true effect size for the intervention, a 10% increase in household per capita income. Both the OLS and IV estimators yield unbiased mean estimates (0.10), as evidenced by a reported bias of 0.00. This alignment between the estimand and the estimate confirms that the randomization and identification strategies are functioning as intended, ensuring that the estimators accurately capture the true effect size in the absence of systematic error. This is critical for the internal validity of the study, as it demonstrates that the design effectively isolates the causal impact of the intervention on the outcome of interest.

Nevertheless, the power and coverage metrics reveal nuances in the performance of the two estimators. For OLS, the statistical power is 0.85, indicating an 85% probability of detecting the true effect size given the sample size and variability assumptions. This exceeds the conventional threshold of 0.80, suggesting that the study is well-powered to detect the ATE using OLS. The coverage rate of 0.94 further confirms that the confidence intervals

constructed around the estimates are appropriately calibrated, capturing the true effect in 94% of simulations. These results suggest that OLS provides a reliable and robust framework for evaluating the intervention's impact, assuming compliance rates and assumptions about intra-cluster correlation hold. The IV estimator, while also unbiased, exhibits a lower statistical power of 0.66, indicating a reduced probability of detecting the true effect compared to OLS. This is expected given the additional variability introduced by the use of the treatment assignment as an instrument. The lower power underscores the trade-off inherent in IV estimation, as it prioritizes identification of the local average treatment effect (LATE) for compliers at the expense of efficiency. Despite this limitation, the IV estimator maintains a coverage rate of 0.93, suggesting that the confidence intervals remain well-calibrated, even under reduced power. This supports the inclusion of IV as a complementary estimation strategy, particularly for addressing potential non-compliance and ensuring robustness in causal inference.

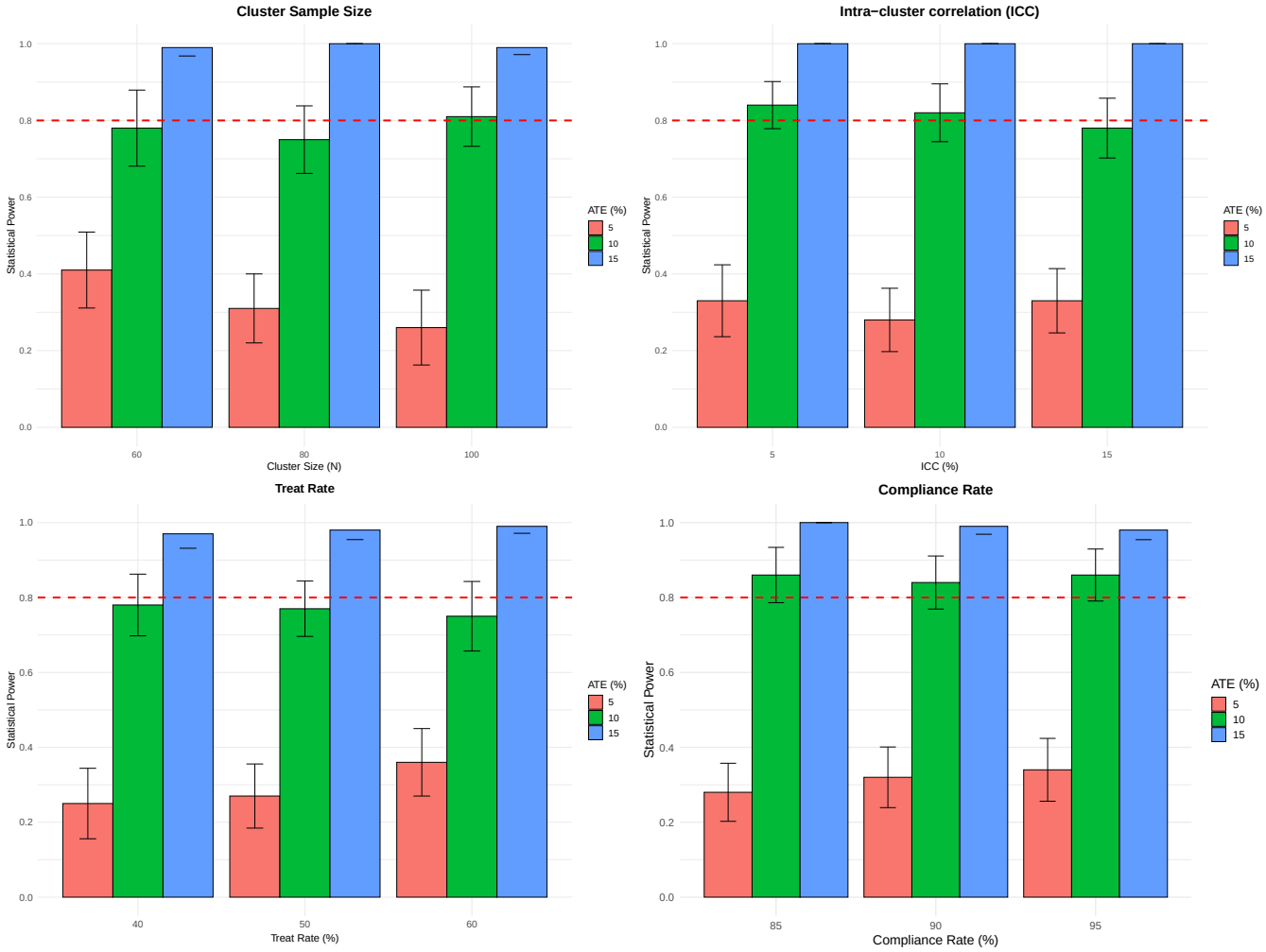
The results also highlight the practical implications for the study's design and analysis. The strong performance of OLS suggests that the study's sample size and clustering strategy are sufficient for detecting the hypothesized effect under the given assumptions. However, the lower power for IV emphasizes the importance of ensuring high compliance rates and minimizing measurement error in treatment assignment. Furthermore, these results underscore the need for sensitivity analyses, particularly around the assumptions of compliance and intra-cluster correlation, to validate the robustness of the findings across alternative scenarios.

Concerning the redesign exercise, it focuses on statistical power as the primary diagnosand, given that bias remained negligible in the original simulations. By systematically varying critical design parameters—cluster sample size, intra-cluster correlation (ICC), treatment rate, and compliance rate—this exercise explores their impact on statistical power and evaluates the robustness of the study's design. The redesign specifically considers three potential effect sizes (5%, 10%, and 15%) for the Average Treatment Effect (ATE) to test the sensitivity of the results under different assumptions. These parameters were chosen because they directly influence statistical power and are subject to practical constraints, such as logistical feasibility and resource availability. The results, presented in *Figure 2*, provide important insights into the trade-offs inherent in the study design and reaffirm the appropriateness of the chosen parameters.

The top-left panel examines the effect of cluster sample size on statistical power. Larger cluster sizes improve power substantially, particularly for moderate and large ATEs. At a sample size of 80 households per cluster, power exceeds the 0.80 threshold for an ATE of 10%, demonstrating that the study design is well-calibrated for detecting this effect. Increasing the cluster size to 100 further enhances power, but this comes at the cost of higher logistical demands. The decision to use 80 households per cluster reflects a balance between statistical rigor and practical constraints, ensuring sufficient power without exceeding resource capacities. The top-right panel highlights the impact of ICC on power, showing a

clear decline as ICC increases. At the assumed ICC level of 10%, power remains above 0.80 for a 10% ATE, validating the study's assumption based on empirical estimates from similar settings. However, power drops below 0.80 when ICC increases to 15%, emphasizing the importance of minimizing within-cluster correlation through careful randomization and stratification. These results underscore that the assumed ICC of 10% is both realistic and appropriate for the study's context, ensuring robust statistical inference.

Figure 2. Redesign Diagnostics for Statistical Power Across Design Parameters



Note: Panels depict how statistical power changes with variations in cluster size, intra-cluster correlation (ICC), treatment rate, and compliance rate. Simulations assume ATEs of 5%, 10%, and 15% for intergenerational income mobility. The red dashed line indicates the conventional 0.80 threshold for statistical power. Confidence Intervals for power estimates are displayed as bars.

The bottom-left panel explores the influence of treatment rate on power. As expected, higher treatment rates improve power, particularly for larger ATEs. At a 50% treatment rate, the study achieves adequate power for a 10% ATE while maintaining a sufficient number of control units for comparison. Although increasing the treatment rate to 60% further boosts power, it reduces the sample size of control households, potentially limiting the generalizability of the findings. The chosen treatment rate of 50% strikes an effective

balance between these competing considerations, ensuring robust estimates while preserving the study's external validity. The bottom-right panel examines compliance rates, demonstrating that higher compliance significantly improves power across all effect sizes. At the assumed compliance rate of 90%, power exceeds 0.80 for a 10% ATE, aligning with the expectations based on prior studies such as Galiani et al. (2016). However, if compliance were to drop to 85%, power for a 10% ATE would approach but not exceed 0.80, highlighting the importance of strong implementation strategies to maximize compliance. These results emphasize the critical role of compliance in ensuring the success of randomized controlled trials, particularly in resource-constrained environments.

Overall, the redesign exercise reaffirms the suitability of the original design parameters: a cluster size of 80 households, an ICC of 10%, a treatment rate of 50%, and a compliance rate of 90%. These choices ensure sufficient statistical power to detect a 10% ATE, balancing methodological rigor with practical feasibility. While increasing cluster size, treatment rate, or compliance would further enhance power, the current design is robust and well-calibrated for the study's objectives. The exercise also demonstrates the importance of sensitivity analyses in understanding how key parameters influence diagnosis, providing valuable insights for optimizing future interventions. These findings reinforce the robustness of the study and its ability to provide reliable causal estimates under the chosen design.

Table 2. Simulation Results for School Attendance (Secondary Outcome)

Inquiry	**Estimator**	**Mean Estimand**	**Mean Estimate**	**Bias**	**Power**	**Coverage**
ATE	OLS	-28.00	-28.11	-0.11	1.00	0.98
		(0.00)	(0.12)	(0.12)	(0.00)	(0.02)
LATE	IV	-28.00	-28.06	-0.06	0.98	0.92
		(0.00)	(0.22)	(0.22)	(0.00)	(0.03)

Note: Results are based on 1,000 simulated datasets. Standard errors in parenthesis are clustered at the neighborhood level.

Lastly, *Table 2* presents the simulation results for school attendance, the secondary outcome of this study. Unlike the primary outcome of intergenerational income mobility, attendance serves as a complementary measure, primarily to explore the mechanisms through which comprehensive housing improvements may influence long-term economic outcomes. Given its secondary role, no redesign was conducted, as the results consistently demonstrated negligible bias and near-perfect statistical power across all scenarios.

For both the Ordinary Least Squares (OLS) and Instrumental Variables (IV) estimators, the mean estimand aligns closely with the mean estimate, with only minor deviations. For OLS, the mean estimate of -28.11 closely approximates the true effect of -28.00, with a bias of -0.11. Similarly, for IV, the mean estimate of -28.06 exhibits an even smaller bias of -0.06. These minimal biases underscore the robustness of the estimation strategies and the validity of the design for accurately capturing the treatment effect on attendance. Statistical

power remains extremely high, with OLS achieving a perfect power of 1.00 and IV reaching 0.98. This indicates that the study is virtually guaranteed to detect the hypothesized effect size of a 28-day reduction in missed school days under the given sample size and design parameters. Coverage rates are also strong, with OLS achieving 0.98 and IV achieving 0.92, demonstrating that the confidence intervals are well-calibrated and reliably capture the true effect size.

While these results reaffirm the robustness of the study design for the secondary outcome, it is important to contextualize these findings within the broader goals of the study. The main inquiry focuses on intergenerational income mobility, and attendance is primarily included to examine potential mechanisms driving this mobility. The strong performance of both estimators for attendance highlights the feasibility of using this variable to complement the analysis, particularly in understanding how education-related mechanisms might contribute to breaking poverty traps. In summary, this result demonstrates that the study design performs exceptionally well for the secondary outcome of attendance, with negligible bias, high statistical power, and reliable coverage. These results, coupled with the role of attendance in understanding educational mechanisms, provide a strong foundation for analyzing how comprehensive housing improvements affect human capital accumulation and, ultimately, economic outcomes.

4 Interpreting Results

The results of this study will provide critical insights into whether comprehensive housing improvements can serve as a tool to break poverty traps in urban slums. The findings, particularly regarding intergenerational income mobility, will be interpreted in the context of competing theories. If the intervention produces significant increases in household per capita income over the long term, it will lend support to theories that emphasize the role of housing and living conditions in enabling upward mobility, such as those proposed by Galiani et al. (2016), Cattaneo et al. (2009) and Devoto et al. (2012). Conversely, if no substantial income effects are observed, it would align with arguments suggesting that structural housing improvements alone are insufficient in contexts where broader systemic barriers—such as labor market inequalities or educational deficits—prevail. This would support the view that slum upgrading programs must be complemented by policies addressing employment opportunities and access to quality education. Regardless of the income outcomes, the attendance results will provide valuable insights into the mechanisms of human capital formation, contributing to the literature by highlighting the link between improved housing and educational attainment.

From a broader perspective, the study's results will significantly contribute to the urban economics literature by addressing a critical gap: the role of housing quality improvements in promoting intergenerational mobility in a developing-country context. While previous

studies have explored intergenerational mobility extensively in developed economies, there is a notable lack of experimental evidence from urban slums in Latin America. By focusing on Ciudad Bolívar, this study provides a unique opportunity to evaluate these dynamics in a context where property rights and basic utilities are already established, isolating the effects of qualitative housing improvements. The findings also challenge existing assumptions in the slum literature, such as the notion that poor housing conditions are merely transitional. Instead, they provide evidence of the long-term consequences of substandard living environments, advancing our understanding of how slums can become entrenched poverty traps. For policymakers, the results offer actionable insights into the potential for targeted housing interventions to improve both immediate living conditions and long-term economic outcomes.

The policy implications of this study are profound. If significant improvements in income and school attendance are observed, it would provide strong justification for scaling similar interventions in other urban slums. Policymakers could leverage these findings to prioritize comprehensive housing improvement programs, especially in areas where infrastructure and property rights are less of a concern. However, even in the absence of large income effects, improvements in attendance would highlight the importance of education-focused interventions in slum upgrading programs. This aligns with broader policy goals of promoting human capital development and reducing inequality in urban areas. Additionally, the study underscores the need to design interventions that account for neighborhood-level dynamics and ensure high compliance, which are critical for maximizing program impact.

This paper highlights several limitations and potential extensions. While the focus on Ciudad Bolívar ensures relevance to Bogotá's policy context, the findings may not generalize to slums with different socio-economic or institutional characteristics. Future research could extend this work by exploring how additional components, such as access to credit or employment support, interact with housing improvements to influence mobility outcomes. Furthermore, while the study provides robust causal evidence, it does not capture potential spillover effects on untreated neighborhoods or longer-term impacts beyond the follow-up period. Despite these limitations, the findings provide a compelling case for implementing similar interventions, particularly as part of a broader strategy to address urban poverty and inequality. The results suggest that comprehensive housing improvements, when thoughtfully designed and implemented, can be a powerful tool for breaking poverty traps and fostering economic mobility in urban slums.

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