Urban-rural inequalities in under-five child mortality in Pakistan: Evidence from the Pakistan Maternal Mortality Survey (PMMS).

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Abstract

Under-five child mortality remains a critical public health challenge in Pakistan, with persistent disparities between urban and rural populations. This study examines the magnitude and determinants of urban–rural inequalities in child mortality using data from the Pakistan Maternal Mortality Survey 2019. A quantitative cross-sectional design was employed, analyzing 89,155 live birth records through descriptive statistics, chi-square tests, and binary logistic regression. The findings reveal that rural children experience significantly higher mortality rates compared to urban children. However, multivariate analysis shows that this disparity is largely explained by socioeconomic and environmental factors rather than residence alone. Household wealth emerges as the strongest predictor, with higher wealth significantly reducing the risk of child mortality. Access to improved sanitation also demonstrates a protective effect, while the influence of rural residence becomes statistically insignificant after controlling these variables. Additionally, substantial regional variations in mortality patterns highlight the uneven distribution of health outcomes across provinces. The study concludes that socioeconomic inequality and inadequate household infrastructure are the primary drivers of child mortality disparities in Pakistan. Addressing these structural determinants through targeted policy interventions is essential for reducing mortality rates and achieving Sustainable Development Goal targets related to child health.

Keywords: *Under-five mortality, urban-rural disparity, socioeconomic factors, household wealth, sanitation, Pakistan, child health, PMMS 2019.*

Introduction

Child mortality remains one of the most pressing indicators of health equity and human development, serving as a sentinel marker of a nation's capacity to safeguard its most vulnerable citizens. The overall under-five mortality rate in the world has decreased by 59 per cent in 193 to 37 deaths per 1,000 live births, with under-five deaths in 2023 decreasing to 4.8 million (UN IGME, 2024). Although such improvements are being made, the load is still very unequal, and Pakistan is one of the most impacted countries. The number of deaths among children under five is the highest in Pakistan, which stands at 65.2 per 1,000 live births in 2020, compared to the global rate of 37 deaths per 1,000 live births (Tharwani et al., 2023). In Pakistan, these aggregate statistics hide a longstanding structural inequality: children born in rural families have a systematically higher risk of dying before their fifth birthday than children born in urban environments, a difference between rural and urban environments which is based on the disparity in access to healthcare, sanitation, economic resources, and social infrastructure. The nature, regional disparity, and socioeconomic factors of this urban-rural mortality gap are critical to developing specific interventions and help Pakistan to achieve Sustainable Development Goal 3.2, which requires the country to ensure under-five mortality is lower than 25 per 1,000 live births by 2030 (Soofi et al., 2023). This paper responds to that imperative by using the latest and most extensive mortality data on the country, the 2019 Pakistan Maternal Mortality Survey (PMMS), which is a nationally representative survey of 4,450,504 households and is the most recent, to rigorously measure and explain urban-rural inequalities in child mortality across the six administrative regions in the country.

Background

Child survival in Pakistan has improved over recent decades, yet the country remains critically off track to meet the SDG 3.2 targets. The targets set by the Sustainable Development Goals 2015 to reduce the mortality rates of neonatal to less than 12 deaths per 1,000 live births and under-five mortality to less than 25 deaths per 1,000 live births by 2030 (Soofi et al., 2023). The present under-five mortality trend in Pakistan is way below this. The infant mortality rate in Pakistan is significantly higher than the globally reported rate of 26.7 per 1,000 live births as of 2022, with a rate of 56.9 per 1,000 live births in Pakistan compared to only Afghanistan with 46 per 1,000 and Yemen with 42.2 per 1,000 among similar lower- The burden is not evenly spread among population and geography, wealth and type of residence turn out as potent factors in child survival.

The urban rural disparity in child health is not only recorded but also evident in Pakistan. The last survey, the Pakistan Maternal Mortality Survey 2019, organized by the National Institute of Population Studies, has demonstrated significant demographic disparities between rural and urban population, as the maternal mortality ratio is almost 26 times higher in rural regions than in urban ones, caused by a significant gap in the preferences of healthy care services provided to rural residents of remote areas (Ullah et al., 2022). These inequalities in structure direct to the mortality of children. Child mortality has been a challenge to the Government of Pakistan, with the number of deaths per 1,000 live births reaching 67.2 in 2019, and the country could not meet the targets of

the Millennium Development Goals but was striving to achieve the Sustainable Development Goals (Asif et al., 2022).

Socioeconomic variables add to the urban-rural disparity on several levels. Analysis of deaths at the district level in Pakistan indicates that the inequality ratio of the district mortality index indicates that higher decile districts have 16 times greater likelihood to face mortalities than the lower decile, and that districts in Balochistan reflect a greater level of spatial heterogeneity (Muhammad et al., 2024). A study of the application of spatial modelling also supports a significant spatial dependence in the child mortality rates between districts of 31% with clusters of high-high child mortality seen in districts of Punjab province (Khan and Sheikh, 2023). At the provincial level, large provincial and interprovincial inequalities in neonatal and child mortality have existed, and under-five mortality estimates continue to be significantly above SDG targets even in districts where intervention is targeted (Soofi et al., 2023). The PMMS 2019 dataset (which is nationally representative and accurately captures these disparities) made up of 91,489 birth records throughout all six regions of Pakistan offers a singularly potent platform to analyze these disparities with national representativeness and statistical accuracy not previously accessible in the published literature.

Problem Statement

Despite a general downward trend in child mortality over recent decades, Pakistan continues to grapple with a profound and persistent urban-rural disparity that threatens the equitable achievement of its child survival goals. While national-level statistics suggest incremental progress, these aggregates mask stark inequalities in child survival outcomes between urban and rural populations. Analysis of the PMMS 2019 data reveals a child mortality rate of 48.3 per 1,000 live births in urban settings compared to 62.9 per 1,000 in rural settings, representing a 30% excess mortality burden borne by rural children, with an odds ratio of 1.32 (95% CI: 1.25–1.40). The disparity widens further when examined at the provincial level, with Sindh recording a rural-urban mortality gap of 23.8 per 1,000 live births — over seven times the gap observed in Azad Jammu and Kashmir — pointing to deeply uneven provincial health system performance.

Despite the scale of this problem, critical research gaps remain. Existing Pakistani studies have largely relied on older Demographic and Health Survey data predating the PMMS 2019 or have focused on specific provinces rather than the full national picture (Asif et al., 2022; Niazi et al., 2022). No published study has conducted a comprehensive, nationally representative urban-rural decomposition of child mortality using the PMMS 2019, which remains Pakistan's most recent and methodologically rigorous mortality survey. Furthermore, most prior studies have not simultaneously examined regional heterogeneity in the urban-rural mortality gap alongside household-level socioeconomic factors, leaving policymakers without the granular, actionable evidence needed to design geographically targeted interventions. Pakistan is also among the countries with the highest numbers of direct child deaths attributable to preventable causes, including severe acute malnutrition (UNICEF, 2024), making the need for subnational evidence on survival inequalities all the more urgent. This study directly addresses these evidence gaps by

providing a multi-region, socioeconomically stratified analysis of urban-rural child mortality differentials using the most current nationally representative data available.

Research Questions

1. What is the magnitude of the urban-rural disparity in child mortality across Pakistan's six administrative regions, and how does this disparity vary by province, according to the 2019 Pakistan Maternal Mortality Survey?
2. To what extent do household-level socioeconomic factors — including wealth quintile, housing quality, sanitation access, and cooking fuel type — explain the observed urban-rural differential in child mortality in Pakistan?

Research Objectives

1. To estimate and compare child mortality rates between urban and rural populations across all six regions of Pakistan using PMMS 2019 data.
2. To identify the provincial regions exhibiting the largest and smallest urban-rural disparities in child mortality and to characterize the geographic pattern of that inequality.
3. To examine the association between household-level socioeconomic determinants — including wealth quintile, sanitation infrastructure, and housing material — and child mortality outcomes, stratified by urban and rural residence.
4. To determine the adjusted odds of child mortality for rural versus urban children after controlling for wealth, sex of child, and regional fixed effects using binary logistic regression.

Significance of Study

This study makes an original and timely contribution to the evidence base on child health inequalities in Pakistan. By leveraging the PMMS 2019 the country's first and most recent nationally representative stand-alone mortality survey. it provides the most current, statistically robust examination of urban-rural child mortality disparities available in the published literature. Pakistan is among the countries with the highest burden of preventable child deaths globally (UNICEF, 2024), making rigorous subnational evidence on survival inequalities critically urgent for both national and international stakeholders. The findings will directly inform the post-18th Amendment provincial health planning process, enabling evidence-based prioritization of rural child health investments in the provinces with the largest disparities, particularly Sindh and Punjab. The study further contributes to global SDG monitoring by documenting how far Pakistan remains from SDG 3.2 targets at the subnational level, providing a baseline against which future programmatic progress can be measured (WHO, 2024). For the research community, the study establishes a methodological template for secondary analysis of PMMS 2019 data that can be extended to maternal mortality, stillbirths, and neonatal outcomes in subsequent investigations.

Literature Review

Under-five child mortality remains a critical indicator of health inequality and socioeconomic development, particularly in low- and middle-income countries. Although global progress has been substantial in reducing child mortality, disparities persist across and within countries. Pakistan continues to experience disproportionately high under-five mortality rates, with pronounced inequalities between urban and rural populations. Recent literature suggests that these disparities are not merely geographic but are deeply rooted in socioeconomic inequalities, access to healthcare, and environmental conditions. This chapter critically reviews recent empirical studies on urban-rural disparities in child mortality, compares key findings, and develops a theoretical framework and hypotheses for the current study.

Trends in Under-Five Child Mortality

Recent global estimates indicate a continued decline in under-five mortality; however, progress remains uneven across regions. Studies show that while South Asia has experienced improvements, Pakistan lags behind comparable countries in achieving reductions in child mortality (You et al., 2023). Similarly, a study by Perin et al. (2022) highlights that countries with weak health systems and persistent inequalities show slower progress despite global advancements.

In the Pakistani context, recent research indicates that structural challenges such as poverty, limited healthcare access, and governance issues hinder progress in reducing child mortality (Bhutta et al., 2023). In contrast, localized intervention-based studies suggest that targeted health programs have improved outcomes in certain regions but have not significantly reduced national-level disparities (Khan et al., 2024).

These findings present a contrast between macro-level and micro-level perspectives. While global and national studies emphasize systemic barriers, localized studies highlight the potential of targeted interventions. However, both perspectives converge on the conclusion that inequality remains the primary barrier to achieving sustained reductions in child mortality.

Urban-Rural Disparities in Child Mortality

Urban-rural disparities in child mortality are widely documented in recent literature. Studies consistently show that children in rural areas face significantly higher mortality risks compared to their urban counterparts. A recent analysis by Ahmed et al. (2023) demonstrates that rural residence is associated with higher child mortality due to limited healthcare infrastructure, poor transportation networks, and reduced access to skilled healthcare providers.

Similarly, research by Khan et al. (2024) finds that rural populations experience higher mortality rates due to structural disadvantages, including poverty and inadequate public health services. However, other studies challenge the direct effect of residence. For instance, Nisar et al. (2022) argue that when socioeconomic variables such as wealth and maternal education are controlled, the effect of rural residence becomes statistically insignificant.

This divergence in findings reflects two competing perspectives. One perspective views rural residence as a direct determinant of child mortality, while the other considers it an indirect factor mediated by socioeconomic conditions. The latter perspective is increasingly supported by recent empirical evidence, suggesting that geographic disparities are largely explained by underlying structural inequalities rather than location alone.

Socioeconomic Determinants of Child Mortality

Household Wealth

Household wealth is consistently identified as one of the strongest predictors of child survival. Recent studies show that children from poorer households face significantly higher risks of mortality compared to those from wealthier households (Aheto, Keegan, & Taylor, 2023). In Pakistan, research by Iqbal et al. (2023) confirms a strong wealth gradient, with mortality rates significantly higher among lower-income households.

At a broader level, spatial analyses indicate that poverty contributes to geographic clustering of high mortality rates. For example, a study by Ali et al. (2024) finds that economically deprived districts exhibit significantly higher child mortality rates compared to wealthier regions.

While some studies emphasize the direct effect of household wealth, others highlight its interaction with other factors such as education and access to healthcare. Despite these differences, there is strong consensus that poverty is the most significant determinant of child mortality across contexts.

Maternal Education and Awareness

Maternal education is another critical determinant of child survival. Educated mothers are more likely to utilize healthcare services, adopt preventive health behaviors, and ensure proper nutrition for their children (Yaya et al., 2022). However, recent studies suggest that the effect of education is partially mediated by household wealth and access to resources.

For example, research by Bado et al. (2023) shows that while maternal education significantly reduces child mortality, its impact diminishes when controlling for socioeconomic status. This suggests that education and wealth operate through overlapping pathways, both contributing to improved child health outcomes.

Gender of the Child

The relationship between child gender and mortality remains inconclusive in recent literature. Some studies report higher mortality among male children due to biological vulnerability (Perin et al., 2022), while others highlight sociocultural factors that disadvantage female children in certain contexts (Yaya et al., 2022).

In Pakistan, recent evidence suggests that gender differences in child mortality are less pronounced compared to socioeconomic determinants (Iqbal et al., 2023). This indicates that while gender may influence mortality, its effect is relatively weaker and context-dependent.

Environmental and Infrastructure Factors

Environmental conditions and household infrastructure play a significant role in determining child survival outcomes. Access to improved sanitation, clean water, and safe cooking fuel has been consistently associated with lower child mortality rates.

A recent study by Prüss-Ustün et al. (2023) highlights that inadequate sanitation and unsafe water contribute significantly to child mortality through increased exposure to infectious diseases. Similarly, research by Rana et al. (2022) finds that children living in households with poor sanitation facilities are at a significantly higher risk of mortality.

Indoor air pollution from solid fuel use is another critical risk factor. While some studies report strong associations between clean cooking fuel and reduced child mortality (Naz et al., 2023), others find that this relationship weakens after controlling for wealth (Aheto et al., 2023). This suggests that clean fuel access may serve as a proxy for broader socioeconomic conditions rather than an independent determinant.

Overall, the literature indicates that environmental factors are important but often operate through their association with household wealth and living standards.

Theoretical Framework

This study is grounded in the Social Determinants of Health (SDH) framework, which posits that health outcomes are shaped by broader social, economic, and environmental conditions rather than individual factors alone. According to this framework, structural determinants such as income, education, and geographic location influence intermediate factors such as living conditions, access to healthcare, and environmental exposure, which in turn affect health outcomes (World Health Organization, 2022). Applying this framework to child mortality, rural residence is considered a structural determinant that influences child survival indirectly through socioeconomic conditions and infrastructure deficits. Household wealth, sanitation, and access to services function as intermediate determinants that directly impact child health outcomes.

Recent studies support this framework by demonstrating that the effect of rural residence on child mortality diminishes after controlling socioeconomic variables (Nisar et al., 2022; Iqbal et al., 2023). This suggests that structural inequalities, rather than geographic location alone, are the primary drivers of disparities in child mortality. The framework also incorporates elements of the Health Production Function theory, which conceptualizes health as an outcome of inputs such as income, education, and environmental conditions. This perspective reinforces the idea that improving socioeconomic conditions can significantly enhance child survival outcomes.

Hypothesis

H1: Rural residence is positively associated with under-five child mortality in Pakistan, such that children living in rural areas have higher mortality risk compared to those in urban areas.

H2: Household wealth is negatively associated with under-five child mortality in Pakistan, such that higher wealth levels significantly reduce the risk of child mortality.

H3: Access to improved sanitation is negatively associated with under-five child mortality in Pakistan, such that households with improved sanitation facilities experience lower child mortality rates.

Research Methodology

Research Design

This study adopts a quantitative research design to examine urban–rural inequalities in under-five child mortality in Pakistan. A cross-sectional analytical approach is employed using secondary data from a nationally representative survey. Quantitative methods are appropriate for this study as they allow for statistical examination of relationships between child mortality and socioeconomic as well as environmental determinants. The design enables both descriptive and inferential analysis to address the research objectives and test the proposed hypotheses.

Data Source

The study utilizes data from the Pakistan Maternal Mortality Survey (PMMS) 2019, conducted by the National Institute of Population Studies in collaboration with international partners. The PMMS 2019 is the most recent and comprehensive nationally representative dataset on maternal and child health in Pakistan. It includes detailed information on birth histories, household characteristics, and health indicators across all provinces and administrative regions.

The dataset provides extensive coverage of demographic, socioeconomic, and environmental variables, making it highly suitable for analyzing disparities in child mortality. Its large sample size ensures statistical reliability and generalizability of findings at the national and regional levels.

Study Population and Sample

The study population consists of all live births recorded in the PMMS 2019 dataset. After data cleaning and exclusion of missing or incomplete observations, the final analytic sample includes 89,155 live birth records. For regression analysis involving wealth-related variables, a subsample with complete socioeconomic data is used.

The sample includes both urban and rural households across six administrative regions: Punjab, Sindh, Khyber Pakhtunkhwa, Balochistan, Gilgit-Baltistan, and Azad Jammu and Kashmir. This wide geographic coverage enables comprehensive analysis of regional and residential disparities in child mortality.

Variables and Measurement

The dependent variable in this study is under-five child mortality, measured as a binary outcome indicating whether a child died before reaching five years of age. This variable is coded as 1 for death and 0 for survival.

The key independent variable is place of residence, categorized as urban or rural. This variable captures the primary focus of the study on geographic disparities.

Several control variables are included to examine socioeconomic and environmental determinants. Household wealth is measured using wealth quintiles, representing relative economic status. Environmental variables include access to improved sanitation and use of clean cooking fuel, both coded as binary indicators. Additionally, the sex of the child and regional location are included as control variables to account for demographic and geographic variation.

Data Analysis

Data analysis is conducted using statistical software. The analysis proceeds in three stages.

First, descriptive statistics are used to summarize the characteristics of the study sample and to calculate child mortality rates across different categories of variables. This includes comparison of mortality rates between urban and rural populations and across regions. Second, bivariate analysis is performed using chi-square tests to examine associations between child mortality and independent variables. This step helps identify statistically significant relationships and patterns in the data. Third, multivariate analysis is conducted using binary logistic regression to estimate the adjusted effects of independent variables on child mortality. Logistic regression is appropriate due to the binary nature of the dependent variable. The model includes residence, wealth quintile, sanitation, cooking fuel, sex of the child, and regional fixed effects. Odds ratios and confidence intervals are reported to interpret the strength and direction of associations. Additionally, correlation analysis is conducted to assess the relationships between key variables and to identify potential multicollinearity.

Ethical Considerations

This study is based on secondary data obtained from a publicly available dataset. The PMMS 2019 survey adhered to strict ethical standards, including informed consent from participants and confidentiality of personal information. Since the dataset is anonymized, there is no risk of identifying individual respondents. Therefore, no additional ethical approval was required for this study.

Results and Discussion

This chapter presents the findings of the analysis conducted on 89,155 live birth records drawn from the Pakistan Maternal Mortality Survey (PMMS) 2019. The results are organized in alignment with the four study objectives: first, child mortality rates are described and compared by urban and rural residence across all six administrative regions; second, the geographic pattern of the urban-rural disparity is characterized at provincial level; third, the association between household-level socioeconomic determinants and child mortality is examined; and fourth, adjusted odds ratios from binary logistic regression are reported alongside correlation analysis to quantify independent predictors. Each section is followed by an interpretive discussion linking findings to the research questions.

Demographic Characteristics of the Study Sample

Table 1 presents the sociodemographic profile of the analytic sample. Of the 89,155 live birth records included, 57.4% were from rural households and 42.6% from urban households. Punjab contributed the largest regional share (26.2%), followed by KP (21.6%), Sindh (18.4%), Balochistan (14.7%), AJK (9.9%), and GB (9.3%). Male children slightly outnumbered female children (51.5% vs 48.5%). A notable feature of the sample is the very low prevalence of improved household amenities: only 7.3% of households had improved sanitation, 3.9% used clean cooking fuel, and 8.2% accessed improved water underscoring the pervasive material deprivation characterizing the study population, particularly in rural areas. The overall child mortality rate was 56.7 per 1,000 live births, with 5,054 deaths recorded among the 89,155 live births.

Table 1
Sociodemographic Characteristics of the Analytic Sample (PMMS 2019, n = 89,155 live births)

Characteristic	Category	n	% (of 89,155)
Residence	Urban	38,009	42.6%
	Rural	51,146	57.4%
Region	Punjab	23,344	26.2%
	Sindh	16,412	18.4%
	KP	19,262	21.6%
	Balochistan	13,072	14.7%
	GB	8,261	9.3%
	AJK	8,804	9.9%
Sex of child	Male	45,954	51.5%
	Female	43,201	48.5%
Wealth quintile	Lowest	2,226	2.5%
	Second	2,105	2.4%
	Middle	1,980	2.2%
	Fourth	1,645	1.8%
	Highest	1,520	1.7%
Improved sanitation	Yes	6,495	7.3%
	No	82,660	92.7%
Clean cooking fuel	Yes	3,464	3.9%
	No	85,691	96.1%
Child mortality	Survived	84,101	94.3%
	Died	5,054	5.7%

Note. CMR = child mortality rate per 1,000 live births. Wealth quintile percentages reflect the subsample with non-missing wealth data (n = 9,476). PMMS = Pakistan Maternal Mortality Survey.

Descriptive Statistics: Child Mortality by Residence and Region

Overall Urban-Rural Disparity (RQ1, Objective 1)

Table 2 presents child mortality rates per 1,000 live births stratified by urban and rural residence, disaggregated across all six regions. The overall child mortality rate was 48.3 per 1,000 live births in urban areas compared to 62.9 per 1,000 in rural areas — a 14.6-point absolute gap. The chi-

square test confirmed this difference was highly statistically significant ($Chi^2 = 86.26$, $p < 0.001$), and the unadjusted odds ratio indicated that rural children faced 1.32 times greater odds of dying than urban children (OR = 1.32, 95% CI: 1.25–1.40). This finding directly answers Research Question 1: the urban-rural disparity in child mortality is substantial, nationally significant, and consistent in direction across all regions of Pakistan.

Table 2.
Child Mortality Rate (per 1,000 live births) by Place of Residence and Region (PMMS 2019)

Region	Urban CMR	Rural CMR	Gap	Chi² (p)	OR (95% CI)
Overall	48.3	62.9	+14.6	86.26 (<0.001)	1.32 (1.25–1.40)
Punjab	51.4	70.4	+18.9	35.34 (<0.001)	1.40 (1.25–1.56)
Sindh	55.3	79.1	+23.8	34.36 (<0.001)	1.47 (1.29–1.67)
KP	46.7	55.9	+9.2	7.99 (0.005)	1.21 (1.06–1.38)
Balochistan	43.8	49.5	+5.7	2.23 (0.135)	1.14 (0.97–1.34)
GB	43.8	62.6	+18.8	9.74 (0.002)	1.46 (1.15–1.84)
AJK	41.8	45.0	+3.3	0.48 (0.491)	1.08 (0.88–1.33)

*Note. CMR = child mortality rate per 1,000 live births. OR = odds ratio for rural vs urban. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$. Balochistan and AJK differences not statistically significant at $p < 0.05$.*

Provincial Variation in the Urban-Rural Gap (RQ1, Objective 2)

The magnitude of the urban-rural disparity varied markedly across provinces, providing a direct answer to the geographic dimension of Research Question 1. Sindh recorded the largest urban-rural gap (23.8 per 1,000; OR = 1.47, 95% CI: 1.29–1.67; $p < 0.001$), followed by Punjab (18.9 per 1,000; OR = 1.40, 95% CI: 1.25–1.56; $p < 0.001$) and GB (18.8 per 1,000; OR = 1.46, 95% CI: 1.15–1.84; $p = 0.002$). KP showed a moderate but statistically significant gap (9.2 per 1,000; OR = 1.21, 95% CI: 1.06–1.38; $p = 0.005$). By contrast, Balochistan (gap = 5.7; $p = 0.135$) and AJK (gap = 3.3; $p = 0.491$) showed non-significant urban-rural differences at the $p < 0.05$ threshold, suggesting that in these regions other factors may dominate child mortality risk beyond residence type alone. Sindh's disparity — 7.2 times larger than AJK's — points to stark provincial heterogeneity in health system performance and rural service coverage.

Socioeconomic Determinants of Child Mortality (RQ2, Objectives 3 & 4)

Child Mortality by Wealth Quintile

Table 3 presents child mortality rates stratified by wealth quintile and residence. A pronounced and statistically significant wealth gradient was observed ($Chi^2 = 52.36$, $p < 0.001$). Children in the lowest wealth quintile experienced a mortality rate of 88.5 per 1,000 live births, compared to 44.7 per 1,000 in the highest quintile — a near-twofold difference. Within rural areas, children in the lowest quintile had a mortality rate of 89.1 per 1,000, while rural children in the highest quintile

recorded 44.7 per 1,000. Notably, the wealth gradient was steeper in rural than in urban areas, with rural poor children particularly disadvantaged. The convergence in mortality rates at higher wealth quintiles between urban and rural children suggests that economic resources partially offset the residential disadvantage.

Table 3
Child Mortality Rate (per 1,000 live births) by Wealth Quintile and Residence (PMMS 2019)

Wealth Quintile	n	Overall CMR	Urban CMR	Rural CMR	Chi² p-value
Lowest	2,226	88.5	83.7	89.1	
Second	2,105	67.0	72.9	65.0	
Middle	1,980	47.5	49.6	45.5	
Fourth	1,645	44.4	51.5	34.1	
Highest	1,520	44.7	44.7	44.7	Chi²=52.36, p<0.001

Note. CMR = child mortality rate per 1,000 live births. Chi-square significance is for overall quintile x mortality cross-tabulation. Wealth data available for n = 9,476 records with non-missing quintile values.

Household Environment and Child Mortality

Table 4 displays child mortality rates by household environmental factors. Children in households with improved sanitation had a significantly lower mortality rate (50.2 vs 57.2 per 1,000; Chi² = 5.40, p = 0.020; OR = 0.87, 95% CI: 0.78–0.98), indicating that access to adequate sanitation was associated with a 13% reduction in the odds of child death. Similarly, households using clean cooking fuel showed a lower mortality rate (48.5 vs 57.0; Chi² = 4.36, p = 0.037; OR = 0.84, 95% CI: 0.72–0.99). A statistically significant sex difference was also observed, with male children recording higher mortality (59.0 per 1,000) than female children (54.2 per 1,000; Chi² = 9.52, p = 0.002).

Table 4
Child Mortality Rate (per 1,000 live births) by Household Environmental Factors and Sex (PMMS 2019)

Variable	CMR (Yes)	CMR (No)	Chi²	p-value	OR (95% CI)
Improved sanitation	50.2	57.2	5.40	0.020	0.87 (0.78–0.98)
Clean cooking fuel	48.5	57.0	4.36	0.037	0.84 (0.72–0.99)
Male child	59.0	—	9.52	0.002	—
Female child	54.2	—	—	—	—

Note. CMR = child mortality rate per 1,000 live births. OR = crude odds ratio for mortality (Yes vs No).

**** p < 0.001, ** p < 0.01, * p < 0.05.*

Binary Logistic Regression: Adjusted Predictors of Child Mortality (Objective 4)

To determine the independent effect of rural residence and socioeconomic factors on child mortality while controlling for potential confounders, a binary logistic regression model was estimated. The model included rural residence, wealth quintile, sex of child, improved sanitation,

clean cooking fuel, and regional fixed effects (Punjab as reference category). Results are presented in Table 5.

The overall model was statistically significant (LR $Chi^2[10] = 86.52$, $p < 0.001$), confirming that the predictors jointly explained variation in child mortality beyond chance. The model's Pseudo R^2 (McFadden) of 0.020 is typical for population-level mortality models where unmeasured biological and care-quality factors account for substantial variance.

Wealth quintile emerged as the strongest and most consistent predictor: each unit increase in the wealth quintile was associated with a 18% reduction in the odds of child mortality (B = -0.198, SE = 0.048, OR = 0.820, 95% CI: 0.746–0.902, z = -4.107, $p < 0.001$). This finding confirms the socioeconomic gradient observed in the descriptive analysis and directly answers Research Question 2 — household wealth is the primary socioeconomic driver of child mortality differentials in Pakistan.

Improved sanitation remained a significant predictor after adjustment (B = -0.292, SE = 0.104, OR = 0.747, 95% CI: 0.609–0.916, z = -2.801, p = 0.005), indicating that access to adequate sanitation reduced the adjusted odds of child death by 25.3%. Notably, rural residence as an isolated predictor was not statistically significant in the adjusted model (B = -0.126, SE = 0.108, OR = 0.882, z = -1.163, p = 0.245), suggesting that the crude urban-rural disparity observed in Table 2 is substantially mediated by the socioeconomic conditions — particularly wealth and sanitation — that systematically differ between urban and rural settings.

Among regional predictors, Balochistan (OR = 0.717, z = -2.156, p = 0.031) and GB (OR = 0.649, z = -2.324, p = 0.020) showed significantly lower adjusted odds of child mortality relative to Punjab after controlling for individual-level factors, indicating that Punjab's high absolute child mortality rate reflects its population composition more than its health system performance relative to these territories.

Table 5
Binary Logistic Regression: Predictors of Child Mortality (PMMS 2019, n = 9,476)

Predictor	**B**	**SE**	**OR**	**95% CI**	**z-statistic**	**p-value**
Rural residence (ref=Urban)	-0.126	0.108	0.882	0.71–1.09	-1.163	0.245
Wealth quintile	-0.198	0.048	0.820	0.75–0.90	-4.107	< 0.001 ***
Female child (ref=Male)	-0.117	0.087	0.890	0.75–1.06	-1.346	0.178
Improved sanitation (ref=No)	-0.292	0.104	0.747	0.61–0.92	-2.801	0.005 **
Clean cooking fuel (ref=No)	0.061	0.135	1.063	0.82–1.39	0.452	0.652
Sindh (ref=Punjab)	0.228	0.128	1.256	0.98–1.61	1.785	0.074
KP (ref=Punjab)	-0.243	0.137	0.785	0.60–1.03	-1.770	0.077
Balochistan (ref=Punjab)	-0.333	0.154	0.717	0.53–0.97	-2.156	0.031 *

GB (ref=Punjab)	-0.433	0.186	0.649	0.45–0.93	-2.324	0.020 *
AJK (ref=Punjab)	-0.172	0.180	0.842	0.59–1.20	-0.958	0.338

Model fit: N = 9,476 | Pseudo R² (McFadden) = 0.020 | LR chi²(10) = 86.52, p < 0.001 | AIC = 4,261.4

*Note. B = unstandardized logistic coefficient. SE = standard error. OR = odds ratio. CI = confidence interval. z = Wald z-statistic (equivalent to t-statistic for large samples). *** p < 0.001, ** p < 0.01, * p < 0.05. Reference categories: Urban (residence), Male (sex), No (sanitation/fuel), Punjab (region). Model: LR Chi²(10) = 86.52, p < 0.001; Pseudo R² = 0.020.*

Correlation Analysis

Table 6 presents Spearman rank-order correlations between key study variables, used to assess the direction and strength of bivariate associations. Spearman correlation was selected due to the ordinal and binary nature of the variables. Rural residence showed a small but statistically significant positive correlation with child mortality (r = 0.022, p = 0.031), consistent with the crude odds ratio finding. Wealth quintile showed the strongest negative correlation with child mortality (r = -0.069, p < 0.001), reinforcing the regression finding that poverty is the primary driver of excess mortality. Improved sanitation (r = -0.064, p < 0.001) and clean cooking fuel (r = -0.038, p < 0.001) also correlated negatively with child mortality at high significance. Female child sex showed no statistically significant correlation with mortality (r = -0.014, p = 0.182).

Critically, the correlation between wealth quintile and rural residence was strongly negative (r = -0.461, p < 0.001), confirming that rural households are systematically poorer — which explains why controlling for wealth attenuates the rural coefficient in the regression. Similarly, clean cooking fuel and sanitation were both strongly negatively correlated with rural residence (r = -0.463 and r = -0.238, p < 0.001 respectively), demonstrating that the infrastructure deficit in rural areas — not residence per se — is the proximate driver of the urban-rural mortality gap. The correlation between clean fuel and wealth was particularly strong (r = 0.648, p < 0.001), indicating high collinearity between material living standards and access to cleaner domestic energy.

Table 6
Rank Correlation Coefficients Between Study Variables (PMMS 2019)

Variable pair	**Variable 1**	**Variable 2**	**r (Spearman)**	**p-value**	**Sig.**
Primary associations	Rural residence	Child mortality	0.022	0.031	*
	Wealth quintile	Child mortality	-0.069	< 0.001	***
	Improved sanitation	Child mortality	-0.064	< 0.001	***
	Clean cooking fuel	Child mortality	-0.038	< 0.001	***
	Female child	Child mortality	-0.014	0.182	ns

SES mediators	Wealth quintile	Rural residence	-0.461	< 0.001	***
	Improved sanitation	Rural residence	-0.238	< 0.001	***
	Clean cooking fuel	Rural residence	-0.463	< 0.001	***
Infrastructure correlates	Sanitation	Wealth quintile	0.463	< 0.001	***
	Clean fuel	Wealth quintile	0.648	< 0.001	***

*Note. r = Spearman correlation coefficient. *** p < 0.001, ** p < 0.01, * p < 0.05, ns = not significant. All correlations computed on the analytic subsample with complete data (n = 9,476 for wealth-stratified analyses; n = 89,155 for residence and environmental variables).*

Discussion and Conclusion

Discussion

Urban-Rural Child Mortality Disparity

The finding that rural children face a 30% higher risk of dying before age five compared to their urban counterparts (CMR 62.9 vs 48.3 per 1,000; OR = 1.32) is consistent with the broader literature on residential inequalities in child survival across low- and middle-income countries. This disparity reflects the cumulative disadvantage of rural residence: lower access to skilled healthcare, poorer sanitation infrastructure, greater distance to health facilities, and lower household income. The magnitude of the gap — 14.6 per 1,000 live births nationally — translates to hundreds of preventable deaths annually that are attributable to the structural conditions of rural life rather than to any fixed biological risk.

The provincial heterogeneity is a particularly important finding. Sindh's rural-urban gap (23.8 per 1,000) being seven times larger than AJK's (3.3 per 1,000) suggests that the urban-rural divide is not an immutable feature of Pakistani society but rather a product of provincial health system capacity and investment patterns. Provinces such as KP, Balochistan, and AJK, despite overall lower wealth levels, appear to have achieved more equitable rural-urban child survival outcomes than the more economically developed Punjab and Sindh — a counterintuitive finding that merits further investigation into the role of community health worker programmes, provincial governance, and targeted rural health investment.

Wealth as the Primary Driver

The most consequential finding of the regression analysis is that after adjustment for wealth, sanitation, sex, and region, rural residence per se is no longer a statistically significant predictor of child mortality (z = -1.163, p = 0.245). This indicates that the observed urban-rural disparity in crude rates is largely mediated through the socioeconomic conditions that disproportionately characterize rural households, particularly poverty (r = -0.461 between wealth and rural residence). The strong, independent effect of wealth quintile (OR = 0.820 per quintile unit, p < 0.001) confirms

that poverty — not geography — is the fundamental driver of child mortality inequality in Pakistan. This has direct policy implications: interventions targeting rural poverty reduction and social protection are likely to yield greater reductions in child mortality than residence-based targeting alone.

Role of Household Infrastructure

Access to improved sanitation was a statistically significant independent predictor of reduced child mortality (OR = 0.747, p = 0.005), even after adjustment for wealth and region. The strong negative correlation between rural residence and both sanitation (r = -0.238) and clean fuel access (r = -0.463) confirms that the infrastructure deficit in rural areas is a key pathway through which rurality translates into excess child mortality. The finding that the clean fuel coefficient did not remain significant in the adjusted model (p = 0.652) likely reflects suppression from its high collinearity with wealth (r = 0.648) — both capturing the same underlying material standard of living. Nevertheless, the bivariate association (OR = 0.84, p = 0.037) suggests that fuel-related indoor air pollution reduction may still offer an independent protective pathway worth targeting in programme design.

Implications for SDG 3.2

Pakistan's current child mortality rate of 56.7 per 1,000 live births from this analysis (consistent with national estimates of 65–67 per 1,000) remains more than twice the SDG 3.2 target of 25 per 1,000 live births by 2030. The findings of this study suggest that achieving this target will require not merely aggregate service expansion, but a deliberate focus on reducing the structural inequalities — poverty, sanitation infrastructure deficit, and provincial health system performance — that sustain the urban-rural mortality gap. Sindh and Punjab, as the most populous and most unequal provinces, represent the highest-priority targets for subnational intervention. Closing the rural-urban gap in these two provinces alone would prevent thousands of child deaths annually.

Summary of Key Findings

1. Rural children face a 30% higher odds of child death than urban children (OR = 1.32, 95% CI: 1.25–1.40; $Chi^2 = 86.26$, $p < 0.001$), confirming a significant national urban-rural disparity (RQ1 / Objective 1).
2. Provincial variation in the urban-rural gap ranges from 23.8 per 1,000 (Sindh) to 3.3 per 1,000 (AJK), with Sindh, Punjab, and GB showing the largest and most significant disparities (RQ1 / Objective 2).
3. A strong wealth gradient exists: child mortality falls from 88.5 per 1,000 in the lowest quintile to 44.7 per 1,000 in the highest ($Chi^2 = 52.36$, $p < 0.001$), and wealth is the strongest adjusted predictor (OR = 0.820, z = -4.107, $p < 0.001$) (RQ2 / Objective 3).
4. After adjustment for wealth and sanitation, rural residence loses statistical significance (z = -1.163, p = 0.245), indicating the crude urban-rural gap is mediated through socioeconomic conditions (RQ2 / Objective 4).

5. Improved sanitation independently reduces child mortality odds by 25.3% (OR = 0.747, p = 0.005), and is strongly correlated with both wealth (r = 0.463) and rural residence (r = -0.238) — confirming infrastructure access as a key pathway.

Conclusion

This study examined urban–rural inequalities in under-five child mortality in Pakistan using nationally representative data from the PMMS 2019. The findings reveal a significant disparity, with children in rural areas facing a higher risk of mortality compared to their urban counterparts. However, the analysis demonstrates that this disparity is largely driven by underlying socioeconomic and environmental factors rather than residence alone. Household wealth emerged as the most influential determinant, with children from poorer households experiencing substantially higher mortality rates. Access to improved sanitation also showed a significant protective effect, highlighting the importance of basic infrastructure in improving child survival outcomes. Importantly, the results indicate that once socioeconomic variables are controlled, the effect of rural residence becomes statistically insignificant, suggesting that poverty and deprivation are the primary drivers of inequality. Regional variations further emphasize the need for targeted, province-specific interventions.

Overall, the study underscores that reducing child mortality in Pakistan requires addressing structural inequalities, particularly poverty and inadequate living conditions, rather than focusing solely on geographic disparities. Policy efforts aimed at improving household socioeconomic status and expanding access to essential services will be critical for achieving sustainable reductions in under-five mortality and meeting global development targets.

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