

RESEARCH ARTICLE

Examining the heterogeneity in under-five mortality risk by household structure in Nepal 1970–2022

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ABSTRACT Despite significant progress in reducing child mortality, Nepal’s under-five mortality rate remains above the Sustainable Development Goal (SDG) target of 20 deaths per 1000 live births. This study examines the heterogeneity in under-five mortality by household generations and household structure using pooled data from six rounds of the Nepal Demographic and Health Survey (1996–2022). Multivariable logistic regression models reveal that children in one- or two-generation households face higher mortality risks compared to those in three- or more-generation households. Additionally, nuclear households exhibit slightly elevated mortality risks compared to extended households. A nonlinear multivariate decomposition analysis identifies birth cohort, household wealth and maternal education as key contributors to widening mortality disparities, while maternal age at birth and preceding birth interval help to narrow these gaps. The findings underscore the role of family structure in shaping child survival outcomes and highlight the need for targeted interventions to address persistent inequalities in under-five mortality in Nepal.

KEYWORDS Child mortality • Mortality inequality • Family structure • Pooled birth history • Demographic and Health Surveys • Nonlinear decomposition

Introduction

Child mortality is a crucial indicator of the Sustainable Development Goals (SDGs), reflecting the objective of good health and well-being (Abreha et al., 2024; Xie et al., 2024). Previously, the Millenium Development Goals (MDGs) had focused on reducing child mortality. These goals were later superseded by the Sustainable Development Goals (SDG), which stressed the importance of child mortality in terms of both local and global concerns targeting country-specific needs (Bryce et al., 2013; Campbell, 2017; Lomazzi et al., 2014; Nepal, 2018). In recent decades, recognising the significance of a child’s first five years, crucial strides have been made towards reducing preventable child deaths. The collective contributions of governments, organisations, communities, healthcare practitioners and families globally have yielded a remarkable 62% decline in under-five mortality from 1990 to 2022 (UNICEF et al., 2024). While laudable progress has been achieved,

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the sobering reality of nearly five million under-five deaths in 2022 underscores the persistent threat (UNICEF et al., 2024). The rate of under-five mortality improvement also fluctuates across time frames and geographical regions (UNICEF et al., 2024). For instance, the under-five mortality reduction during the initial phase of the SDG era (2015–2022) was slower than in the preceding MDG era (2000–2015). Sub-Saharan Africa and Southern Asia jointly accounted for almost 80% of under-five deaths in 2022, with Southern Asia contributing to 26% of the global total. Within the South Asian context, Nepal reported 27 under-five deaths per 1000 live births in 2022 (UNICEF et al., 2024). The recent Nepal Demographic and Health Survey (NPDHS) unveiled a notable 72% decrease in under-five mortality from 1996 to 2022 (Ministry of Health and Population and ICF, 2023). Nonetheless, Nepal remains distant from attaining the SDG benchmark of 20 deaths per 1000 live births (Khatiwada et al., 2024). Furthermore, these fatalities are profoundly tragic, given that the majority could have been averted. Although how to prevent child death remains a burning question in low- and middle-income countries, the progress made on this issue has been quite remarkable relative to its starting point (Bryce et al., 2013; Liu et al., 2012). It is evident that efforts and steps that have been taken to address the issue of under-five mortality have gradually resulted in a global decrease in the child mortality rate (Lozano et al., 2011; Wang et al., 2014). Child mortality is considered one of the best indicators of a country's economic development, and several studies have shown how child mortality and economic development are interconnected (O'Hare et al., 2013; Preston, 1975). Hence, there is a pressing need for further research in the field.

Family structure and under-five mortality

Under-five mortality, which refers to the likelihood of a child dying before reaching the age of five, remains a significant concern in Nepal. Under-five mortality in Nepal is still higher than the target of the Sustainable Development Goals, which is 20 per 1000 live births, owing to its diverse geographical landscape, ethnic diversity and socio-cultural customs (Basra et al., 2024; Ghimire et al., 2019; Goli et al., 2017; Pandey et al., 2013; Paudel et al., 2018). The country's terrain spans from the lofty Himalayas to the flat Terai plains, impacting the accessibility of healthcare services, dietary habits and exposure to environmental hazards (Bhattarai et al., 2020; Goli et al., 2017). Notably, Nepal's population comprises a tapestry of ethnic groups and castes with unique cultural traditions and differential access to resources (Pandey et al., 2013; Subba, 2020). Although under-five mortality has decreased over several decades, it remains a matter of concern due to ongoing socio-economic disparities.

Studies have reported various socio-economic gradients determining Nepal's under-five mortality rates. A time trend analysis from the NPDHS found a strong association between a mother's level of education, household wealth and under-five mortality, with disparities widening between 1996 and 2011 (Sreeramareddy et al., 2013). Various determinants such as maternal age, gender of the child, desired or undesired birth status, healthcare accessibility and environmental factors have been identified as contributors to under-five

mortality (Fledderjohann and Channon, 2022; Ghimire and Axinn, 2006; Naz et al., 2018; Pathak, 2017; Sohail and Neupane, 2019; Sreeramareddy et al., 2013). Extensive research highlights the impact of a household's socio-economic status on a child's survival, growth, and overall well-being in Nepal (Doocy et al., 2007; Kakchapati et al., 2023; Khadka et al., 2015; Miller et al., 2017). However, household structure, which significantly affects resource allocation and socio-economic status, is also crucial to a child's well-being (Adhikari and Podhisita, 2010; Akinyemi et al., 2016; Ekholuenetale et al., 2020; McLanahan and Percheski, 2008; Parache et al., 2024; Poulain et al., 2019). These relationships are often underexplored in South Asian countries like Nepal, where family dynamics play an essential role in the health of the household members.

Traditionally in Nepal, families have borne the primary responsibility for nurturing children, supporting ageing members and promoting the welfare of all family members (Yeung et al., 2018). Over the past half-century, the arrangement and composition of families, known as family structure, have undergone notable transformations, primarily influenced by shifts in fertility, mortality, marriage patterns and migration (Ghimire and Axinn, 2006; Yeung et al., 2018). In many developed nations, large, multi-generational households have been increasingly replaced by single-parent or single-person households (Furstenberg, 2019). However, many Asian countries have yet to undergo this transition, and the extended household, comprising multiple generations and members, continues to be the prevailing model in these countries (Das and Bardis, 2023; Yeung et al., 2018). In Nepal, the traditional household structure typically follows a patriarchal model, whereby the eldest male assumes the position of household head (Michaels, 2020; Speck and Müller-Böker, 2020). Historically, the joint family system was prevalent, fostering close bonds and collective support networks among multiple generations living under one roof. Nevertheless, with the advent of modernisation and urbanisation, there has been a gradual transition towards nuclear family setups, particularly in urban locales, where households typically comprise parents and their children (Silva and Indralal, 2003).

Households are the backbones of society, and are responsible for being the largest units of production and consumption. Household structure yields varied impacts on child well-being by providing children with economic, social and psychological security (Menashe-Oren et al., 2023). Population and health studies research mainly focuses on household composition and child health outcomes. The association of households based on generations and structure with under-five mortality is comparatively less explored in Nepal. In a nuclear household setup, parents wield considerable authority over decisions about their children's health, encompassing aspects such as proper care, nutritional intake and access to healthcare services (Griffiths et al., 2002; Kumar and Ram, 2013). This autonomy, which stems from the absence of the need to consult other adult household members when making such decisions, may result in lower child mortality risk in nuclear families. Conversely, extended households possess the potential to provide enhanced social support and are more inclined to offer financial and communal resources to family members, including children (Treleaven, 2023). Moreover, household structure can significantly influence the utilisation of healthcare services (Gage et al., 1997). Research from India suggests that women residing in non-nuclear

households exhibit lower rates of contraception usage and are less likely to access pre-natal and postnatal care compared to their counterparts in nuclear family arrangements (Saikia and Singh, 2009). In addition, studies have shown that child mortality is higher among children in multigenerational families with more vertical ties (Akinyemi et al., 2016; Rogers et al., 2020). However, it is noteworthy that non-nuclear households can also serve as robust sources of caregiving in specific scenarios (Griffiths et al., 2002).

Despite changes in household structure, reverence for elders and familial interconnectedness remain central tenets of Nepalese family life. Though there is evidence showing the association of generations in households and family structure with child well-being in developing countries, such associations have been sparsely studied in Nepal. This study aims to fill this critical gap by investigating the association of generations in households and household structure with under-five mortality in Nepal. The need for this study is multifaceted. First, despite the integral role of the family in individual well-being and development, studies exploring household structure in Nepal are limited. Second, utilising the complete birth histories of children from the NPDHS 1970–2022, this study will address the role of generations in households and household structure in under-five mortality in Nepal. This comprehensive analysis can provide significant evidence of the familial role in achieving SDG 3.2, which aims to end preventable deaths of newborns and children under five years of age. Third, by employing decomposition techniques, this study can identify the factors contributing to the heterogeneity of under-five mortality across household generations and household structures in Nepal. Understanding this heterogeneity is crucial for designing targeted interventions and policies that cater to the specific needs of vulnerable populations. The findings from this study will further provide valuable evidence to policymakers, healthcare providers and development organisations striving to reduce child mortality and improve child health outcomes in Nepal.

Methodology

Data source

For this study, we pooled data from six publicly available Nepal Demographic and Health Surveys (NPDHS) rounds conducted in 1996, 2001, 2006, 2011, 2016 and 2022, respectively. We chose the NPDHS because it provides information on a broad range of family health-related domains, including fertility levels, marriage, fertility preferences, awareness and use of family planning methods, child feeding practices, nutrition, adult and childhood mortality, awareness and attitudes regarding HIV/AIDS, women's empowerment and domestic violence. The NPDHS implemented a multistage cluster sampling design. Further details regarding the sample design, survey instruments, informed consent, training of interviewers and other fieldwork officers, data collection and processing and response rates are available in the final report of the respective surveys (Ministry of Health et al., 2002, 2017; Ministry of Health and Population et al., 2007, 2012; Ministry of Health and Population and ICF, 2023).

Study sample selection

To realise the study objectives, we pooled the raw birth histories of ever married women in the reproductive age group (15–49 years) across all the pre-specified rounds. We manually harmonised all required datasets so that our study variables had consistent categorisation and label codes across the surveys. Further, we reconstructed the unique survey identifiers and calculated the pooled survey weight following pre-documented procedures (Schmidt and Elkasabi, 2020). The information on birth histories was available for 164,761 children. The current study utilised Nepalese women's retrospective birth histories from 1970 to 2022 (until the interview date). Therefore, the analytical sample size of this study was 163,544 children born to 51,779 mothers.

Outcome variable

The under-five mortality status of the child was the outcome variable in this study. If a child passed away between their birth and their fifth birthday, they were classified as “dead” (coded as one). Otherwise, the child was labelled “alive” (coded as zero).

Main independent variables

The key independent variables of interest were the number of generations in the household and the household structure. Both variables were derived from the information on each household member's relationship with the household head. Household members were categorised into four generational groups: (i) parent, parent-in-law; (ii) household head, spouse, sibling, sibling-in-law; (iii) child, child-in-law; and (iv) grandchild. Further, the number of generations living in a household was constructed as a binary variable of 1–2 generations (coded as one) and 3+ (three or more) generations (coded as two).

Additionally, NPDHS collected information about members who resided in the household the night before the interview (de facto residents) and those who were usual household residents (de jure residents). Based on this information, the household structure variable was constructed following pre-documented procedures (Pullum et al., 2020). The household structure variable was categorised as extended (coded as one) and nuclear (coded as two). A household was considered nuclear if it consisted only of individuals identified as head, spouse of head or child of head. If the household included individuals with any other relationship to the head, it was considered an extended household.

Other independent variables

We included child-, parent-, household- and community-level covariates of under-five mortality, in line with the Mosley–Chen framework of child survival and existing studies

(Mosley and Chen, 1984; Pathak, 2017; Paul et al., 2021a, 2022). The child-related variables were:

1. Birth interval preceding the birth of the index child in months (24 and more, 18–23, less than 18, first-order birth).
2. Birth cohort of the child (1970–1979, 1980–1989, 1990–1999, 2000–2009, 2010 and later).
3. Birth order of the child (1–2, three, four, five and higher).
4. Gender of the child (female, male).
5. Season during the birth of the index child (summer/pre-monsoon, monsoon, winter/post-monsoon).

The parent-related characteristics were:

1. Mother's age during the birth of the index child in years (less than 20, 20–24, 25–29, 30 and higher).
2. Mother's level of education (secondary or higher, up to primary, no formal schooling).
3. Father's level of education (secondary or higher, up to primary, no formal schooling).

The household-related variables were:

1. Religion of the household (Hinduism, Buddhism, other).
2. Native language of the household (Nepali, Maithili, Bhojpuri, other). The native language of the household was used as a proxy for linguistic ethnicity, cultural practices and socio-economic disparities that may influence child mortality. In Nepal, different linguistic groups exhibit variations in healthcare access, dietary habits and traditional health beliefs, which could impact under-five mortality risk. In our analysis, we harmonised and categorised the most commonly spoken languages in Nepal, i.e., Nepali, Maithili and Bhojpuri, while grouping all other languages under an “other” category. These languages were selected due to their large representation in the dataset (with more than 5% of the population speaking them across rounds), as seen in Table S1, and their distinct socio-cultural characteristics (Adhikari, 2024). This categorisation allowed us to assess whether linguistic differences contributed to variations in under-five mortality beyond conventional socio-economic factors.
3. Household wealth quintile (richest, richer, middle, poorer, poorest).

The community-related characteristics were:

1. Place of residence (urban, rural). Based on Nepal's census records, the DHS classified the primary sampling units (PSU) into census enumeration blocks in urban PSU and villages in rural PSU. In this study, the place of residence variable denoted whether a child belonged to a household from a rural or an urban PSU.
2. Ecological region (mountain, hill, Terai).

Statistical methods

Descriptive and bivariate analysis

To achieve the study objectives, we first conducted descriptive analyses to examine household and child distributions by household structure and generations across the six Nepal DHS rounds (Figures 1 and 2). We then explored the distribution of under-five mortality by birth cohorts and survey periods (Figure 3). Additionally, we examined the absolute and percentage distribution of births by background characteristics in the pooled dataset (Table S1) (supplementary material) and the distribution of children across nuclear, extended, one- or two-generation and three- or more-generation households by independent variables (Table 1).

Next, we performed bivariate analysis to assess the unadjusted relationship between under-five mortality and key household variables using the chi-square test for association (Table 1).

Multivariable regression analysis of the pooled dataset

To estimate the adjusted associations, we applied multivariable logistic regression models on the pooled dataset covering 1970–2022 (Table 3). Odds ratios (ORs) from the multivariable models indicated the relative likelihood of under-five mortality across different categories of each explanatory variable, adjusting for all other factors (Cameron and Trivedi, 2005).

Decomposition analysis of the pooled dataset

To further investigate mortality disparities, we employed the nonlinear multivariate decomposition technique to identify the contributions of the explanatory variables behind the observed gap in under-five mortality by household generations and structure among Nepali children in the pooled dataset (Powers et al., 2011; Yun, 2004).

We present both overall and detailed decomposition results. In the overall decomposition, the under-five mortality gap was decomposed into an explained (E) component and an unexplained (U) component (Powers et al., 2011). The detailed decomposition provided the contribution of each child-, parent-, household- and community-related independent characteristic to the explained component of the household generations and household structure-wise differential in under-five mortality. The decomposition models could provide different estimates for different reference categories of the categorical covariates. We provided normalised decomposition estimates to overcome this “identification problem” (Yun, 2008).

Sensitivity analysis by survey rounds

To account for potential changes in under-five mortality determinants over time, we extended the analysis by estimating separate regression models for each survey round (1996, 2001, 2006, 2011, 2016 and 2022) (Figures 4 and 5). The complete survey round-specific

regression results are provided in the supplementary material (Tables S.2–S.5). These round-wise analyses offered insights into temporal variations in how household generations, household structure and other factors influenced under-five mortality.

The decomposition analysis was conducted separately for each survey round to assess how the factors contributing to mortality disparities evolved over time. The results from the decomposition models are visualised in Figures 5 to 8, which illustrate the temporal changes in the factors contributing to under-five mortality across survey rounds. The complete decomposition estimates are available in Tables S.6–S.17 (supplementary material).

Sensitivity analysis for all births vs births in the last five years from each survey

Although the distribution of household generations and structure was measured at the time of the survey, it may have fluctuated over the birth history of mothers. Therefore, we recalculated the multivariable and decomposition analysis estimates for the recent sample of children born within five years of the survey date. The comparison of the full sample estimates with the recent sample allowed us to check the sensitivity towards differences in household composition across the birth history of mothers.

The results of the comparison of household generations and structure estimates across the full and the recent samples are shown in Figures 10 and 11. The complete regression results are provided in the supplementary material (Tables S.18 and S.19). Similarly, the decomposition estimates for the recent sample of children born within five years of the survey are visualised in Figures 12 and 13. The complete decomposition estimates are available in Tables S.20 and S.21 (supplementary material).

Survey design and statistical software

To account for the complex survey design, we applied appropriate sampling weights (Schmidt and Elkasabi, 2020). We also verified that none of the multivariable models violated the multicollinearity assumption (Cameron and Trivedi, 2005). The analyses used R 4.4.0 (R Core Team, 2023) and its user-written packages (Firke et al., 2024; Gohel et al., 2024a, b; Sjoberg et al., 2025; Wickham et al., 2019, 2023) and STATA 17 (StataCorp, 2021) software.

Results

Descriptive findings

Trends in household generations and structure

Figures 1 and 2 illustrate the household composition patterns in Nepal from 1996 to 2022. Throughout this period, one- or two-generation households remained more prevalent than three- or more-generation households. However, the share of one- or two-generation households went from 68.3% in 1996 to 69.8% in 2022, reflecting relative stability in the

Figure 1 Proportional bar chart of weighted distribution of Nepalese households by structure and generations across survey years

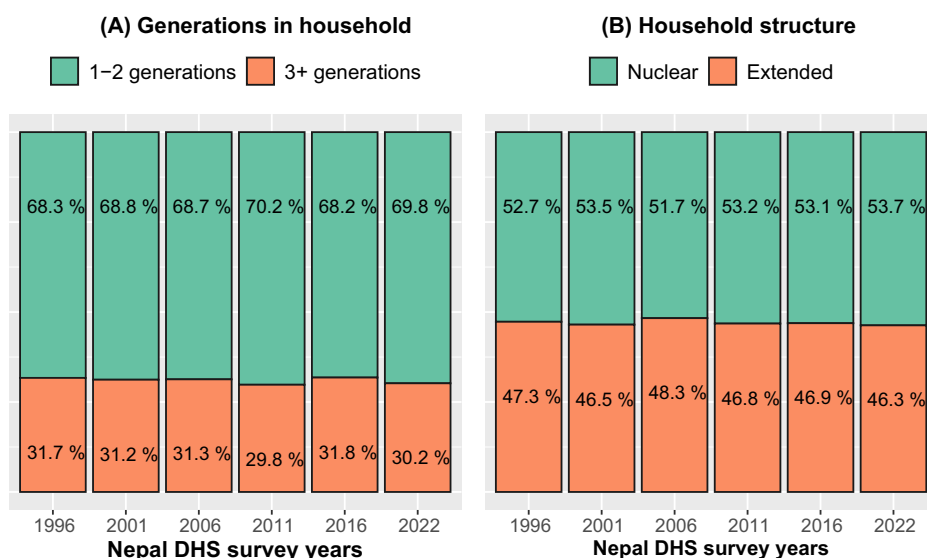
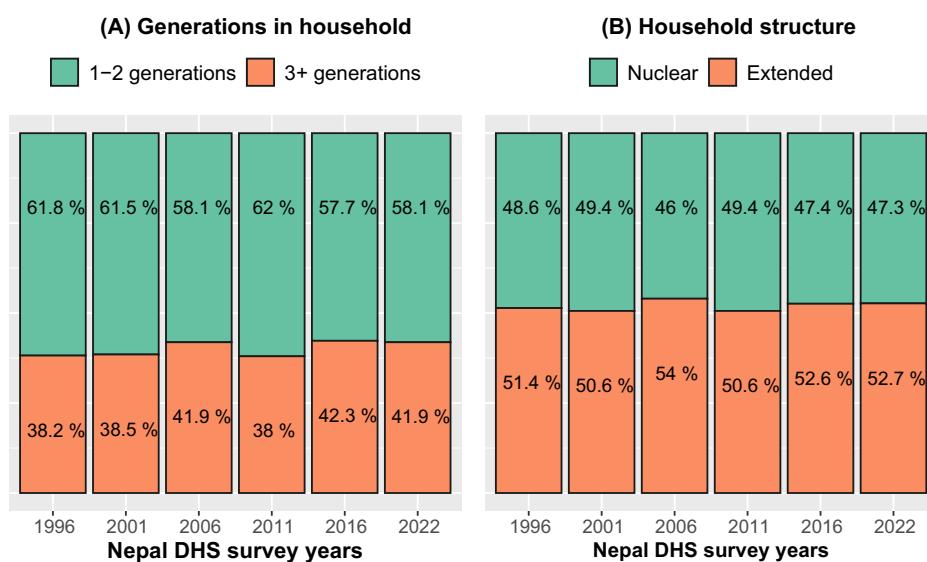


Figure 2 Proportional bar chart of weighted distribution of Nepalese children by structure and generations across survey years



household structure over the years. Similarly, the proportion of multiple-generation households went from 31.7% to 30.2%. A similar pattern was observed in family structure, with nuclear families remaining dominant. The proportion of nuclear households went from 52.7% in 1996 to 53.7% in 2022, while the proportion of extended families changed from 47.3% to 46.3%, signalling stability in the proportions over the survey rounds.

The distribution of children across different household types also remained stable over time, as shown in Figure 2. The proportion of children living in one- or two-generation households went from 61.8% in 1996 to 58.1% in 2022, while the proportion of those living in multiple-generation households changed marginally from 38.2% to 41.9%. A similar trend was observed among nuclear families, with the proportion of children living in these families going from 48.6% in 1996 to 47.3% in 2022. In contrast, the proportion of children living in extended families went from 51.4% to 52.7% over the same period. Both patterns suggest that the proportions of children living in different household types were stable across the years.

Figure 3 highlights the temporal under-five mortality shifts across different birth cohorts and survey periods. The results indicated a steady decline in under-five mortality over time, with higher mortality rates in earlier birth cohorts (1970–1979), which gradually decreased in subsequent cohorts. The most recent cohorts (2010 and later) exhibited the lowest mortality rates, reflecting improvements in child survival over the decades.

Sample characteristics

Table 1 presents the distribution of Nepalese children across different household types based on key background characteristics. The findings revealed notable demographic and socio-economic differences between household types. Birth order patterns showed that a majority of children in both one- or two-generation and three- or more-generation households were first- or second-order births, with the proportion being slightly higher in the former. Similarly, nuclear and extended families exhibited a comparable distribution, with most children being first- or second-born. Across all household types, the 1990–1999 birth cohort accounted for the largest proportion of children, reflecting higher birth rates during this period.

Regional differences were evident, with the Terai region having the highest concentration of children across all household structures, and the mountain region having the lowest. With respect to religion, Hinduism remained the predominant faith, with slight variation between household types.

The educational disparities were striking. A substantial proportion of mothers and fathers in all household structures had no formal schooling, although the share was slightly higher in multiple-generation and extended households. Economic differences were also apparent, with extended and multiple-generation families being poorer and nuclear and one- or two-generation households being wealthier on average.

Geographic distribution patterns showed that a majority of children in all household types resided in rural areas. However, the proportion was slightly higher in extended and multiple-generation households than in nuclear and one- or two-generation households.

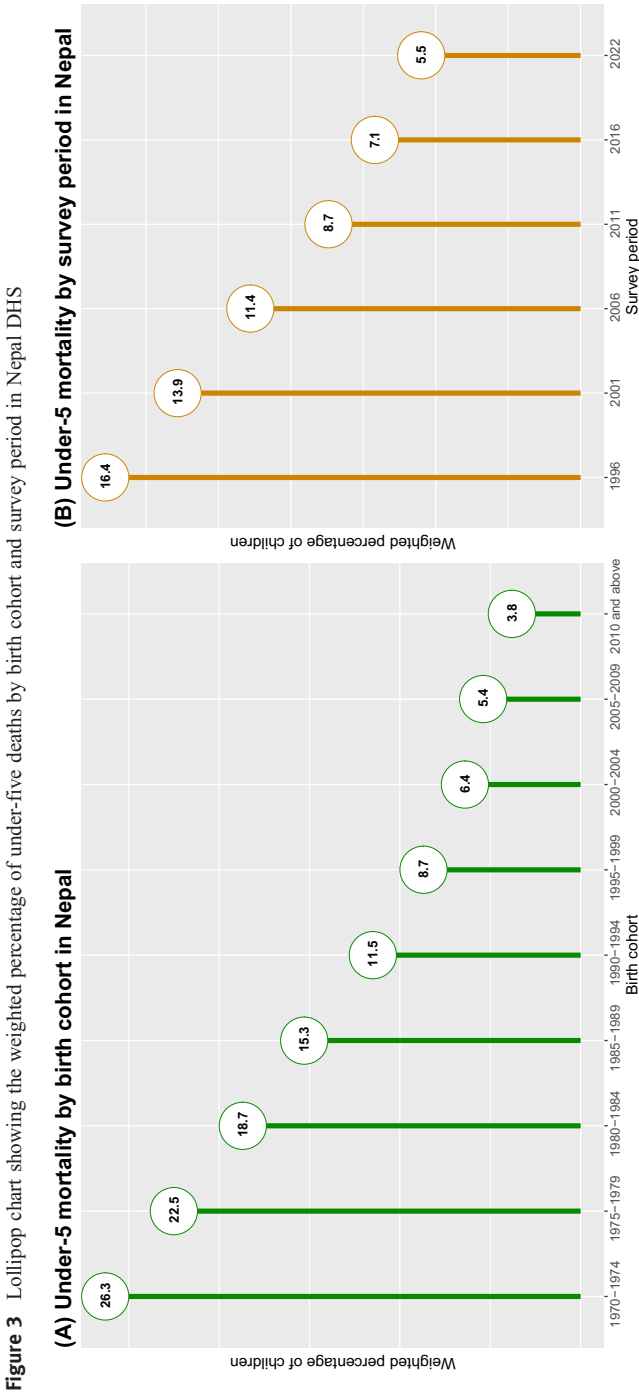


Table 1 Distribution of Nepalese children among various household types by background characteristics from 1970–2022

Characteristic	Generations in household		Household structure	
	1–2 generations N = 118,169,189	3+ generations N = 78,631,826	Nuclear N = 94,675,559	Extended N = 102,125,456
Preceding birth interval (in months)				
24 and more months	59,841,326 (51%)	36,557,344 (46%)	48,309,716 (51%)	48,088,955 (47%)
18–23 months	14,035,498 (12%)	9,119,030 (12%)	11,312,802 (12%)	11,841,726 (12%)
Less than 18 months	9,826,337 (8.3%)	5,890,666 (7.5%)	7,784,282 (8.2%)	7,932,721 (7.8%)
First-order births	34,466,028 (29%)	27,064,786 (34%)	27,268,759 (29%)	34,262,055 (34%)
Birth cohort of index child				
2010 and above	10,648,602 (9.0%)	11,292,643 (14%)	8,769,561 (9.3%)	13,171,684 (13%)
2000–2009	27,169,561 (23%)	18,348,067 (23%)	22,741,304 (24%)	22,776,324 (22%)
1990–1999	43,315,935 (37%)	26,463,589 (34%)	35,296,771 (37%)	34,482,753 (34%)
1980–1989	28,693,080 (24%)	15,941,318 (20%)	22,079,643 (23%)	22,554,755 (22%)
1970–1979	8,342,011 (7.1%)	6,586,209 (8.4%)	5,788,281 (6.1%)	9,139,940 (8.9%)
Birth order				
1–2	64,272,824 (54%)	46,779,673 (59%)	51,245,330 (54%)	59,807,167 (59%)
3	21,117,661 (18%)	12,870,551 (16%)	17,074,823 (18%)	16,913,388 (17%)
4	13,700,329 (12%)	8,004,487 (10%)	11,170,628 (12%)	10,534,188 (10%)
5 and more	19,078,376 (16%)	10,977,116 (14%)	15,184,779 (16%)	14,870,713 (15%)
Sex of child				
Female	57,725,282 (49%)	38,259,618 (49%)	46,760,367 (49%)	49,224,533 (48%)
Male	60,443,907 (51%)	40,372,208 (51%)	47,915,192 (51%)	52,900,923 (52%)

(table continues)

Table 1 (continued)

Characteristic	Generations in household		Household structure	
	1-2 generations N = 118,169,189	3+ generations N = 78,631,826	Nuclear N = 94,675,559	Extended N = 102,125,456
Season during birth				
Summer/pre-monsoon	41,487,003 (35%)	27,420,719 (35%)	33,365,111 (35%)	35,542,612 (35%)
Monsoon	29,879,054 (25%)	20,600,832 (26%)	23,743,574 (25%)	26,736,312 (26%)
Winter/post-monsoon	46,803,132 (40%)	30,610,275 (39%)	37,566,875 (40%)	39,846,532 (39%)
Mother's age at childbirth (in years)				
Above 29 years	19,281,165 (16%)	9,599,939 (12%)	15,541,653 (16%)	13,339,451 (13%)
25-29 years	28,634,958 (24%)	16,897,290 (21%)	23,159,148 (24%)	22,373,100 (22%)
20-24 years	44,259,321 (37%)	31,236,690 (40%)	35,377,090 (37%)	40,118,921 (39%)
Below 20 years	25,993,745 (22%)	20,897,907 (27%)	20,597,669 (22%)	26,293,984 (26%)
Mother's education				
Secondary or higher	14,676,954 (12%)	12,575,048 (16%)	11,227,718 (12%)	16,024,284 (16%)
Up to primary	18,167,083 (15%)	12,315,777 (16%)	14,449,112 (15%)	16,033,748 (16%)
No formal schooling	85,325,152 (72%)	53,741,001 (68%)	68,998,729 (73%)	70,067,424 (69%)
Father's education				
Secondary or higher	38,417,621 (33%)	32,582,472 (41%)	29,875,084 (32%)	41,125,009 (40%)
Up to primary	33,925,087 (29%)	21,054,132 (27%)	27,771,316 (29%)	27,207,904 (27%)
No formal schooling	45,826,482 (39%)	24,995,222 (32%)	37,029,160 (39%)	33,792,544 (33%)
Religion of the household				
Hinduism	99,224,009 (84%)	67,646,196 (86%)	79,615,846 (84%)	87,254,359 (85%)
Buddhism	9,289,188 (7.9%)	4,035,801 (5.1%)	7,284,420 (7.7%)	6,040,568 (5.9%)
Others	9,655,992 (8.2%)	6,949,830 (8.8%)	7,775,294 (8.2%)	8,830,528 (8.6%)

(table continues)

Table 1 (continued)

Characteristic	Generations in household		Household structure	
	1-2 generations N = 118,169,189	3+ generations N = 78,631,826	Nuclear N = 94,675,559	Extended N = 102,125,456
Native language of the household				
Nepali	60,339,407 (51%)	31,202,089 (40%)	48,089,577 (51%)	43,451,919 (43%)
Maithili	15,245,391 (13%)	14,897,530 (19%)	12,590,741 (13%)	17,552,179 (17%)
Bhojpuri	8,070,558 (6.8%)	8,146,827 (10%)	6,486,524 (6.9%)	9,730,862 (9.5%)
Others	34,513,834 (29%)	24,385,380 (31%)	27,508,717 (29%)	31,390,497 (31%)
Wealth index quintile				
Richest	18,904,365 (16%)	12,752,087 (16%)	13,811,713 (15%)	17,844,738 (17%)
Richer	20,655,799 (17%)	16,814,855 (21%)	15,721,141 (17%)	21,749,513 (21%)
Middle	21,894,809 (19%)	18,921,279 (24%)	17,517,541 (19%)	23,298,546 (23%)
Poorer	25,047,772 (21%)	15,993,237 (20%)	20,638,419 (22%)	20,402,589 (20%)
Poorest	31,666,444 (27%)	14,150,370 (18%)	26,986,744 (29%)	18,830,070 (18%)
Place of residence				
Urban	28,993,285 (25%)	18,790,827 (24%)	22,849,097 (24%)	24,935,015 (24%)
Rural	89,175,904 (75%)	59,841,000 (76%)	71,826,463 (76%)	77,190,441 (76%)
Ecological region				
Mountain region	9,827,858 (8.3%)	4,529,648 (5.8%)	8,125,139 (8.6%)	6,232,368 (6.1%)
Hill region	52,039,176 (44%)	26,723,789 (34%)	42,061,917 (44%)	36,701,049 (36%)
Terai region	56,302,154 (48%)	47,378,389 (60%)	44,488,504 (47%)	59,192,039 (58%)

Notes: N = Absolute distribution; % = Column percentage; Adjusted for sampling weights.

Under-five mortality patterns in Nepal

Mortality distribution by household type

Table 2 presents the distribution of under-five mortality across household structures, showing that mortality was slightly higher in one- or two-generation households (12%) than in three- or more-generation households (10%) with statistical significance (p -value < 0.05). However, in terms of family structure, mortality was similar in nuclear families (11%) and in extended families (11%).

Mortality trends by parental, household and community-level characteristics

Under-five mortality varied significantly across birth intervals, birth cohorts and parental characteristics (Table 2). Mortality was highest among children born within 18 months of a previous birth, with 22% experiencing under-five mortality. In contrast, children born after a preceding birth interval of 24 months or more had the lowest mortality rate of 8%. Birth order also influenced survival chances, with 11% of first-order births experiencing mortality, while the mortality rates of higher-order births were slightly lower.

Maternal age at childbirth was a key determinant, with the highest under-five mortality (14%) observed among children born to mothers under 20 years old. Mortality decreased with increasing maternal age, with the rates being lowest among children whose mothers were aged 25–29 years (9.7%). Parental education also played a crucial role, as children born to parents with no formal schooling had significantly higher mortality rates than those born to parents who had completed secondary or higher education.

Regional disparities were notable, with under-five mortality being highest in the mountain region (16%), followed by in the Terai (11%) and the hill regions (10%). Rural-urban differences were also stark, with urban areas recording a significantly lower mortality rate (6%) compared to rural areas (12%).

Multivariable analysis of under-five mortality in the pooled dataset

Table 3 presents the results of the logistic regression analysis, showing key factors associated with under-five mortality. Children in one- or two-generation households had 1.12 times higher odds of experiencing under-five mortality compared to children in three- or more-generation households. Short birth intervals, particularly those under 18 months, were associated with a significantly higher risk, with mortality odds being 2.68 times higher for these births than for births with a preceding interval of 24 months or longer. A clear declining trend in mortality risk was observed across birth cohorts. Compared to children born in 2010 or later, children born in 1970–1979 had 5.29 times higher odds of experiencing under-five mortality. Similarly, the odds for children born in 1980–1989 and 1990–1999 were 3.58 and 2.14 times higher, respectively.

Maternal age at childbirth remained a strong predictor, with children born to mothers under age 20 facing 1.65 times higher mortality odds than those of children born to mothers

Table 2 Distribution of under-five deaths by background characteristics among Nepalese children 1970–2022

Characteristic	Under-five mortality (0–59 months)		
	Overall N = 196,801,015	Dead N = 21,588,549	p-value ¹
Generations in household			<0.001
3+ generations	78,631,826	7,908,142 (10%)	
1–2 generations	118,169,189	13,680,407 (12%)	
Household structure			0.011
Extended	102,125,456	10,932,388 (11%)	
Nuclear	94,675,559	10,656,161 (11%)	
Preceding birth interval (in months)			<0.001
24 and more months	96,398,671	7,963,502 (8.3%)	
18–23 months	23,154,528	3,335,321 (14%)	
Less than 18 months	15,717,003	3,401,757 (22%)	
First-order births	61,530,814	6,887,970 (11%)	
Birth cohort of index child			<0.001
2010 and above	21,941,245	829,715 (3.8%)	
2000–2009	45,517,628	2,714,384 (6.0%)	
1990–1999	69,779,524	7,059,751 (10%)	
1980–1989	44,634,398	7,448,909 (17%)	
1970–1979	14,928,220	3,535,790 (24%)	
Birth order			<0.001
1–2	111,052,497	11,645,496 (10%)	
3	33,988,211	3,507,662 (10%)	
4	21,704,815	2,440,210 (11%)	
5 and more	30,055,492	3,995,182 (13%)	
Sex of child			0.019
Female	95,984,900	10,324,136 (11%)	
Male	100,816,115	11,264,413 (11%)	
Season during birth			0.048
Summer/pre-monsoon	68,907,723	7,445,614 (11%)	
Monsoon	50,479,886	5,437,512 (11%)	
Winter/post-monsoon	77,413,407	8,705,423 (11%)	
Mother's age at childbirth (in years)			<0.001
Above 29 years	28,881,104	2,912,147 (10%)	
25–29 years	45,532,248	4,420,210 (9.7%)	
20–24 years	75,496,011	7,698,245 (10%)	
Below 20 years	46,891,652	6,557,947 (14%)	

(table continues)

Table 2 (continued)

Characteristic	Under-five mortality (0–59 months)		
	Overall N = 196,801,015	Dead N = 21,588,549	p-value ¹
Mother's education			<0.001
Secondary or higher	27,252,002	1,029,982 (3.8%)	
Up to primary	30,482,860	2,048,815 (6.7%)	
No formal schooling	139,066,154	18,509,752 (13%)	
Father's education			<0.001
Secondary or higher	71,000,093	5,192,065 (7.3%)	
Up to primary	54,979,219	5,767,448 (10%)	
No formal schooling	70,821,703	10,629,036 (15%)	
Religion of the household			0.4
Hinduism	166,870,205	18,407,534 (11%)	
Buddhism	13,324,988	1,468,883 (11%)	
Others	16,605,822	1,712,133 (10%)	
Native language of the household			<0.001
Nepali	91,541,496	9,275,669 (10%)	
Maithili	30,142,920	3,392,972 (11%)	
Bhojpuri	16,217,386	1,970,046 (12%)	
Others	58,899,214	6,949,863 (12%)	
Wealth index quintile			<0.001
Richest	31,656,452	2,130,580 (6.7%)	
Richer	37,470,654	3,612,942 (9.6%)	
Middle	40,816,087	4,585,841 (11%)	
Poorer	41,041,009	4,997,932 (12%)	
Poorest	45,816,814	6,261,254 (14%)	
Place of residence			<0.001
Urban	47,784,112	3,011,575 (6.3%)	
Rural	149,016,904	18,576,974 (12%)	
Ecological region			<0.001
Mountain region	14,357,507	2,264,364 (16%)	
Hill region	78,762,966	7,882,540 (10%)	
Terai region	103,680,543	11,441,645 (11%)	

Notes: N = Absolute distribution; % = Row percentage; Adjusted for sampling weights.

¹Pearson's χ^2 : Rao & Scott adjustment.

Table 3 Multivariable association of under-five mortality and the independent variables among children in Nepal 1970–2022

Characteristic	Model-1			Model-2		
	OR	95% CI	p-value	GVIF	OR	95% CI
Generations in household				1.2		
3+ generations	—	—				
1–2 generations	1.12	1.07, 1.16	<0.001			
Household structure						
Extended					—	—
Nuclear					1.04	1.00, 1.09
						0.058
Preceding birth interval (in months)				2.7		
24 and more months	—	—			—	—
18–23 months	1.71	1.62, 1.82	<0.001		1.71	1.62, 1.81
Less than 18 months	2.68	2.51, 2.87	<0.001		2.68	2.51, 2.87
First-order births	1.44	1.36, 1.53	<0.001		1.44	1.36, 1.53
						<0.001
Birth cohort of index child				2.0		
2010 and above	—	—			—	—
2000–2009	1.34	1.21, 1.48	<0.001		1.35	1.22, 1.49
1990–1999	2.14	1.94, 2.35	<0.001		2.16	1.96, 2.38
1980–1989	3.58	3.24, 3.96	<0.001		3.63	3.28, 4.01
1970–1979	5.29	4.73, 5.93	<0.001		5.34	4.77, 5.98
						<0.001
Birth order				3.6		
1–2	—	—			—	—
3	1.11	1.04, 1.18	<0.001		1.11	1.04, 1.18
4	1.22	1.13, 1.31	<0.001		1.21	1.13, 1.31
5 and more	1.45	1.34, 1.58	<0.001		1.45	1.34, 1.57
						<0.001

(table continues)

Table 3 (continued)

Characteristic	Model-1				Model-2			
	OR	95% CI	p-value	GVIF	OR	95% CI	p-value	GVIF
Sex of child				1.1				1.1
Female	—	—			—	—		
Male	1.05	1.01, 1.09	0.010		1.05	1.01, 1.09	0.009	
Season during birth				1.2				1.2
Summer/pre-monsoon	—	—			—	—		
Monsoon	1.03	0.98, 1.08	0.3		1.03	0.98, 1.08	0.3	
Winter/post-monsoon	1.00	0.96, 1.05	0.8		1.00	0.96, 1.05	0.8	
Mother's age at childbirth (in years)				3.8				3.8
Above 29 years	—	—			—	—		
25–29 years	1.07	0.99, 1.15	0.074		1.06	0.99, 1.14	0.091	
20–24 years	1.21	1.12, 1.32	<0.001		1.21	1.11, 1.31	<0.001	
Below 20 years	1.65	1.50, 1.82	<0.001		1.64	1.48, 1.80	<0.001	
Mother's education				1.6				1.6
Secondary or higher	—	—			—	—		
Up to primary	1.28	1.15, 1.43	<0.001		1.28	1.16, 1.43	<0.001	
No formal schooling	1.66	1.51, 1.82	<0.001		1.65	1.50, 1.82	<0.001	
Father's education				1.4				1.4
Secondary or higher	—	—			—	—		
Up to primary	1.12	1.06, 1.19	<0.001		1.13	1.06, 1.20	<0.001	
No formal schooling	1.30	1.22, 1.37	<0.001		1.31	1.23, 1.38	<0.001	

(table continues)

Table 3 (continued)

Characteristic	Model-1			Model-2		
	OR	95% CI	p-value	OR	95% CI	p-value
Religion of the household						
Hinduism	—	—		—	—	
Buddhism	0.87	0.78, 0.96	0.007	0.87	0.79, 0.97	0.011
Others	0.88	0.80, 0.96	0.005	0.88	0.81, 0.96	0.006
Native language of the household						
Nepali	—	—		—	—	
Maithili	1.14	1.06, 1.23	<0.001	1.13	1.05, 1.22	0.002
Bhojpuri	1.26	1.14, 1.40	<0.001	1.25	1.13, 1.39	<0.001
Others	1.19	1.12, 1.26	<0.001	1.18	1.12, 1.25	<0.001
Wealth index quintile						
Richest	—	—		—	—	
Richer	1.24	1.14, 1.35	<0.001	1.24	1.13, 1.35	<0.001
Middle	1.39	1.28, 1.52	<0.001	1.39	1.27, 1.52	<0.001
Poorer	1.53	1.40, 1.67	<0.001	1.53	1.41, 1.67	<0.001
Poorest	1.69	1.54, 1.85	<0.001	1.70	1.55, 1.86	<0.001
Place of residence						
Urban	—	—		—	—	
Rural	1.13	1.06, 1.21	<0.001	1.13	1.06, 1.20	<0.001

(table continues)

Table 3 (continued)

Characteristic	Model-1				Model-2			
	OR	95% CI	p-value	GVIF	OR	95% CI	p-value	GVIF
Ecological region				1.8				1.8
Mountain region	—	—			—	—		
Hill region	0.65	0.60, 0.70	<0.001		0.65	0.60, 0.70	<0.001	
Terai region	0.70	0.64, 0.75	<0.001		0.69	0.64, 0.75	<0.001	
No. Obs.	163,544				163,544			
AIC	103,835				103,871			
BIC	104,136				104,171			

Notes: OR = Odds Ratio, CI = Confidence Interval, GVIF = Generalised Variance Inflation Factor.

Table 4 Multivariate decomposition of difference in under-five mortality among children by household generations in Nepal 1970–2022

Characteristics	Difference in under-five mortality by household generations			
	Coefficient	95% CI	p-value	Percent
Preceding birth interval (in months)	−0.00234	(−0.00258, 0.00210)	<0.001	−14.9
Birth cohort of index child	0.00446	(0.00423, 0.00469)	<0.001	28.4
Birth order	0.00212	(0.00189, 0.00236)	<0.001	13.5
Sex of child	−0.00003	(−0.00004, 0.00002)	<0.001	−0.2
Season during birth	0.00000	(0.00000, 0.00001)	0.413	0.0
Mother's age at childbirth (in years)	−0.00261	(−0.00299, 0.00224)	<0.001	−16.6
Mother's education	0.00178	(0.00149, 0.00208)	<0.001	11.3
Father's education	0.00191	(0.00156, 0.00227)	<0.001	12.2
Religion of the household	−0.00011	(−0.00016, 0.00005)	<0.001	−0.7
Native language of the household	−0.00068	(−0.00088, 0.00047)	<0.001	−4.3
Wealth index quintile	0.00221	(0.00188, 0.00255)	<0.001	14.1
Place of residence	−0.00006	(−0.00008, 0.00004)	<0.001	−0.4
Ecological region	0.00100	(0.00062, 0.00139)	<0.001	6.4
Explained difference (E)	0.00767	(0.00697, 0.00838)	<0.001	48.8
Unexplained difference (U)	0.00805	(0.00507, 0.01104)	<0.001	51.2
Total difference (T)	0.01572	(0.01275, 0.01870)	<0.001	100.0

Note: CI = Confidence Interval.

aged 29 and above. Similarly, paternal education was a significant determinant, as children of fathers without formal schooling were 1.30 times more likely to die before age five compared to children of fathers who had completed secondary or higher education. Regional disparities persisted, with lower mortality risks observed in the hill and Terai regions than in the mountain region.

Decomposition analysis of mortality gaps in the pooled dataset

Table 4 presents the decomposition analysis examining differences in under-five mortality between household generations. The explained component accounted for 48.8% of the mortality gap, while the unexplained component contributed 51.2%. The birth cohort of the child was the most significant contributor to widening the mortality gap (28.4%), followed by household wealth (14.1%) and birth order (13.5%). In contrast, maternal age (−16.6%) and preceding birth interval (−14.9%) played key roles in narrowing the gap.

Table 5 explores mortality differences between nuclear and extended households, showing that 52.2% of the gap was explained by observed factors, while 47.8% remained

Table 5 Multivariate decomposition of difference in under-five mortality among children by household structure in Nepal 1970–2022

Characteristics	Difference in under-five mortality by household structure			
	Coefficient	95% CI	p-value	Percent
Preceding birth interval (in months)	−0.00124	(−0.00147, 0.00101)	<0.001	−21.4
Birth cohort of index child	0.00027	(0.00024, 0.00031)	<0.001	4.7
Birth order	0.00107	(0.00090, 0.00125)	<0.001	18.5
Sex of child	−0.00009	(−0.00012, 0.00006)	<0.001	−1.5
Season during birth	0.00000	(0.00000, 0.00000)	0.432	−0.0
Mother's age at childbirth (in years)	−0.00143	(−0.00169, 0.00117)	<0.001	−24.6
Mother's education	0.00124	(0.00098, 0.00150)	<0.001	21.4
Father's education	0.00098	(0.00071, 0.00125)	<0.001	16.9
Religion of the household	−0.00006	(−0.00009, 0.00003)	<0.001	−1.1
Native language of the household	−0.00037	(−0.00048, 0.00025)	<0.001	−6.3
Wealth index quintile	0.00207	(0.00158, 0.00257)	<0.001	35.7
Place of residence	0.00005	(0.00002, 0.00007)	<0.001	0.8
Ecological region	0.00052	(0.00025, 0.00080)	<0.001	9.0
Explained difference (E)	0.00303	(0.00228, 0.00377)	<0.001	52.2
Unexplained difference (U)	0.00277	(−0.00022, 0.00577)	0.069	47.8
Total difference (T)	0.00580	(0.00286, 0.00875)	<0.001	100.0

Note: CI = Confidence Interval.

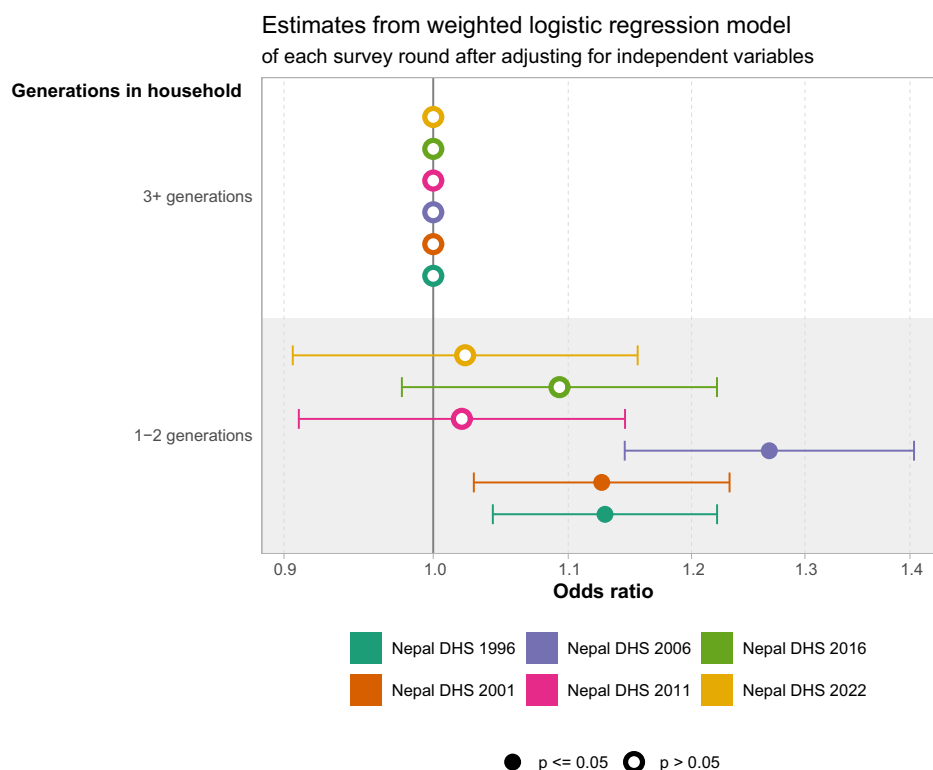
unexplained. Household wealth (35.7%), maternal education (21.4%) and birth order (18.5%) contributed the most to widening disparities, whereas maternal age at birth (−24.6%) and preceding birth interval (−21.4%) were key factors in reducing the mortality gap.

Sensitivity analysis by survey rounds

Multivariable analysis

Figures 4 and 5 illustrate trends in the association between the two household types and under-five mortality across survey years. The elevated mortality risk for children living in one- or two-generation households compared to children living in multi-generational households was more pronounced in earlier survey rounds but weakened in later years (OR: 1.13 in 1996 to OR: 1.02 in 2022). Similarly, nuclear households exhibited a higher mortality risk in earlier survey years, particularly in 1996 (OR: 1.08) and 2006 (OR: 1.16), though this pattern was not consistently significant. Overall, the findings suggested a diminishing association between household structure and under-five mortality over time, although it was never statistically significant (p -value > 0.05).

Figure 4 The odds ratios of under-five mortality by household generations from logistic regression models for Nepal DHS 1996, 2001, 2006, 2011, 2016 and 2022

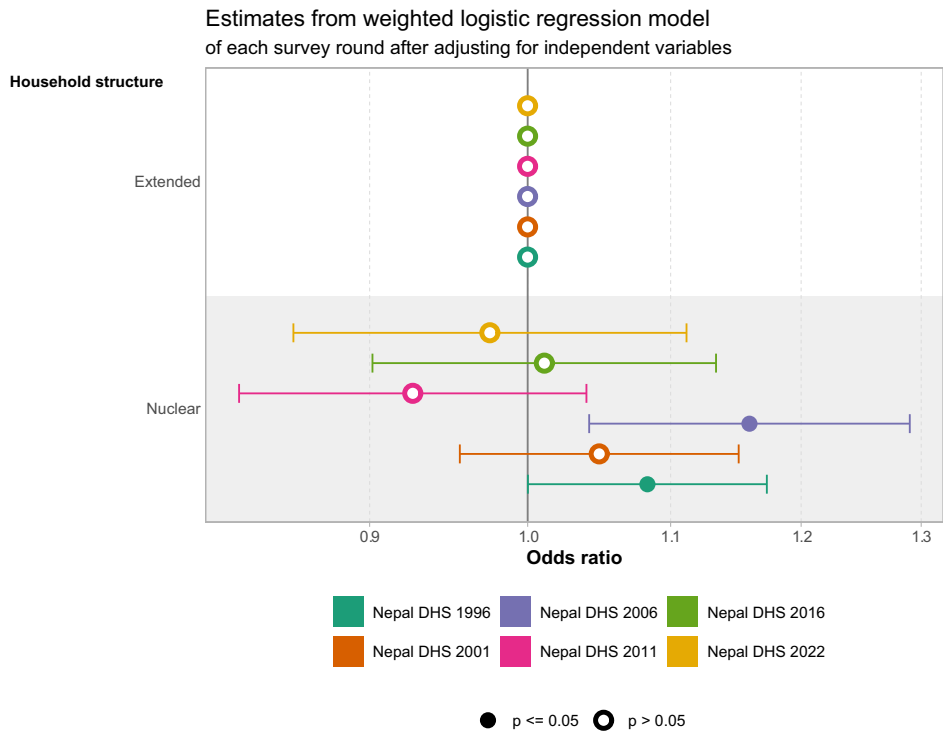


Note: The odds ratios are from separate regression models for each DHS round; full regression tables are given in Tables S4 and S5.

Decomposition analysis

Figures 6 and 7 present the decomposition of under-five mortality gaps by household generations across different survey years, highlighting variations in the contributions of key determinants over time. Across survey rounds, the birth cohort of the child consistently emerged as a primary driver of mortality disparities. Its largest contribution to widening the gap was observed in 2016 (41%), followed by in 2011 (25.9%) and 2022 (23.9%). Additionally, birth order played a significant role in early survey years, contributing 16.3% in 1996 and 23.1% in 2001 to widening the mortality gap. Household wealth remained a key widening factor across all years, with notable contributions in 1996 (18.8%), 2001 (17.4%), 2011 (12%), 2016 (16.8%) and 2022 (15.6%). Similarly, father's education contributed substantially to widening the mortality gap, with the highest shares recorded in 1996 (22.2%) and 2001 (25.2%).

Figure 5 The odds ratios of under-five mortality by household structure from logistic regression models across Nepal DHS 1996, 2001, 2006, 2011, 2016 and 2022



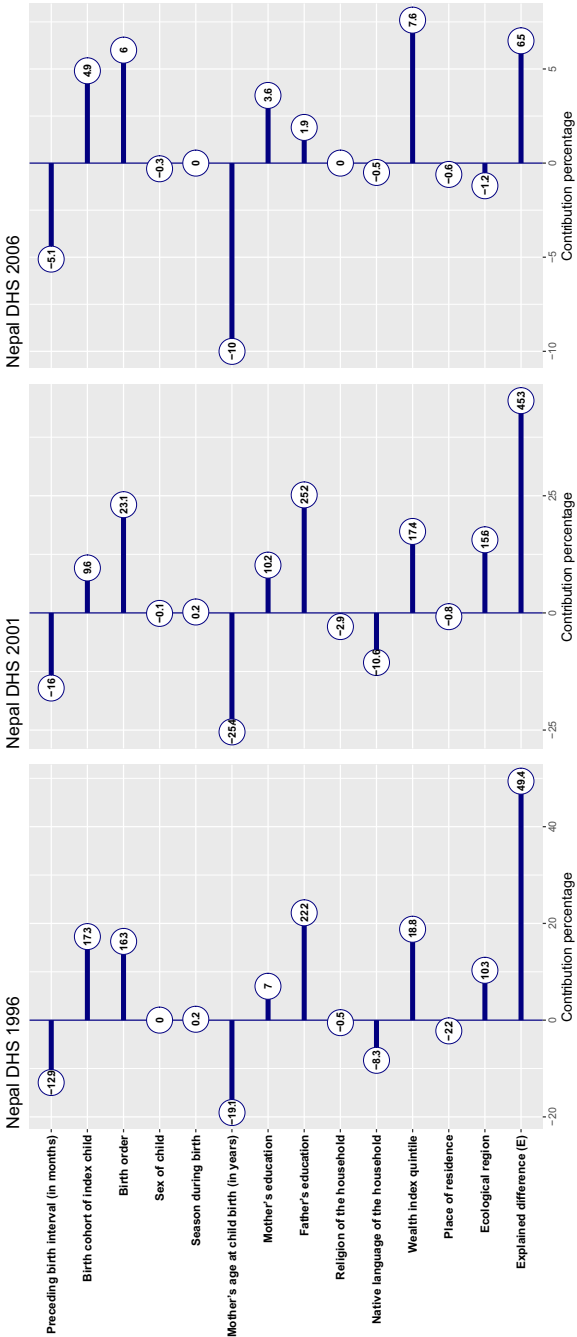
Note: The odds ratios are from separate regression models for each DHS round; full regression tables are given in Tables S2 and S3.

Conversely, maternal age at birth and preceding birth interval played crucial roles in narrowing the mortality gap across all survey rounds. The largest contribution of maternal age at birth in reducing disparities was observed in 2001 (−25.4%), followed by in 1996 (−19.1), 2016 (−18.4%) and 2011 (−15.6%). Similarly, the preceding birth interval had a substantial gap-narrowing effect, contributing −12.9% in 1996, −16% in 2001, −14% in 2011, −21% in 2016 and −28.8% in 2022.

Figures 8 and 9 show the decomposition of under-five mortality gaps by household structure. Household wealth was the most significant factor in widening the mortality gap in several survey years, contributing 30.2% in 1996, 74.1% in 2011, 44.5% in 2016 and 80.6% in 2022. Father’s and mother’s education also played critical roles in widening the gap in 1996, 2011, 2016 and 2022.

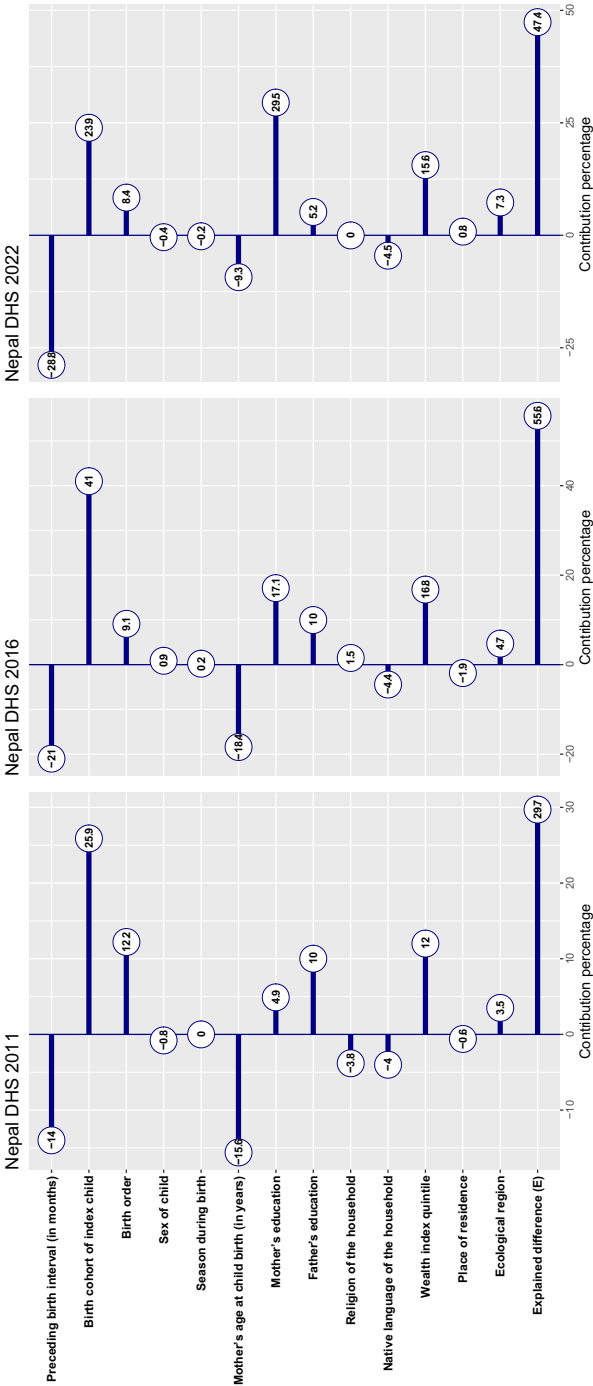
In contrast, maternal age at birth had a strong gap-narrowing effect, particularly in 1996 (−19.2%), 2011 (−29.6%), 2016 (−33.2%) and 2022 (−33%). Similarly, preceding birth intervals played a crucial role in reducing mortality disparities, with the largest contribution observed in 2022 (−74.4%), followed by in 2016 (−32%) and 2011 (−27.8%). In 2022,

Figure 6 Explained contribution percentage of multivariate decomposition of under-five mortality gap by household generations in Nepal DHS 1996, 2001 and 2006



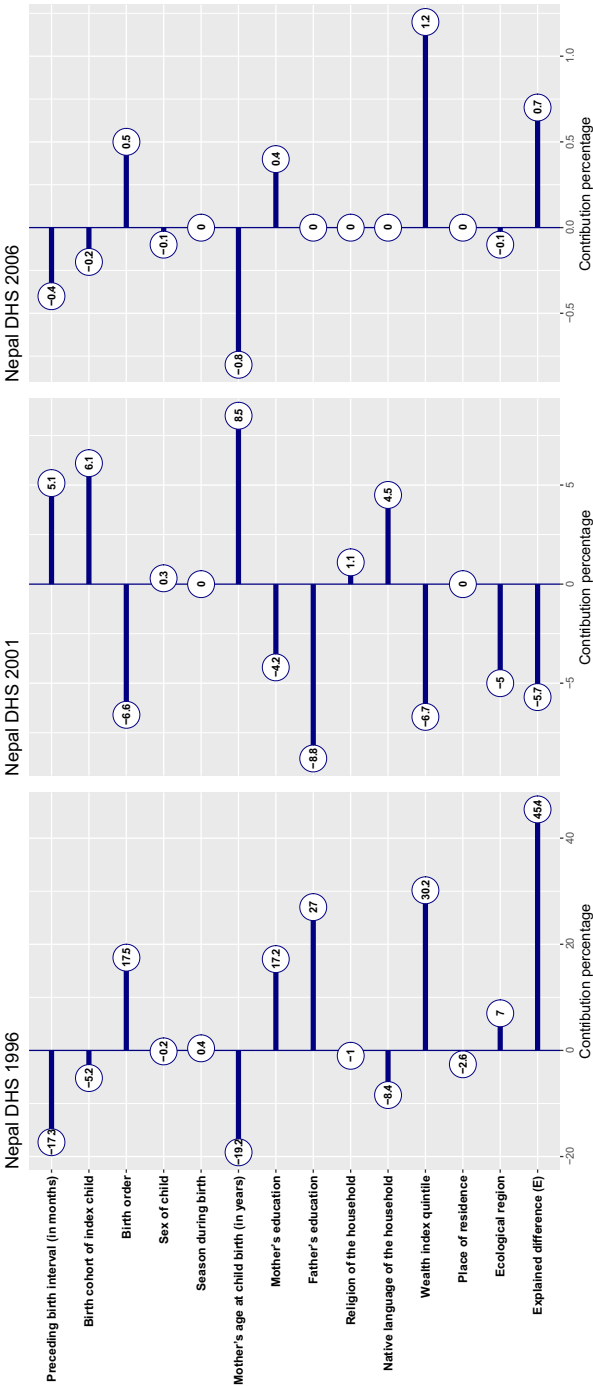
Note: The full table of multivariate decomposition estimates corresponding to the figure are given in Tables S6, S7 and S8.

Figure 7 Explained contribution percentage of multivariate decomposition of under-five mortality gap by household generations in Nepal DHS 2011, 2016 and 2022



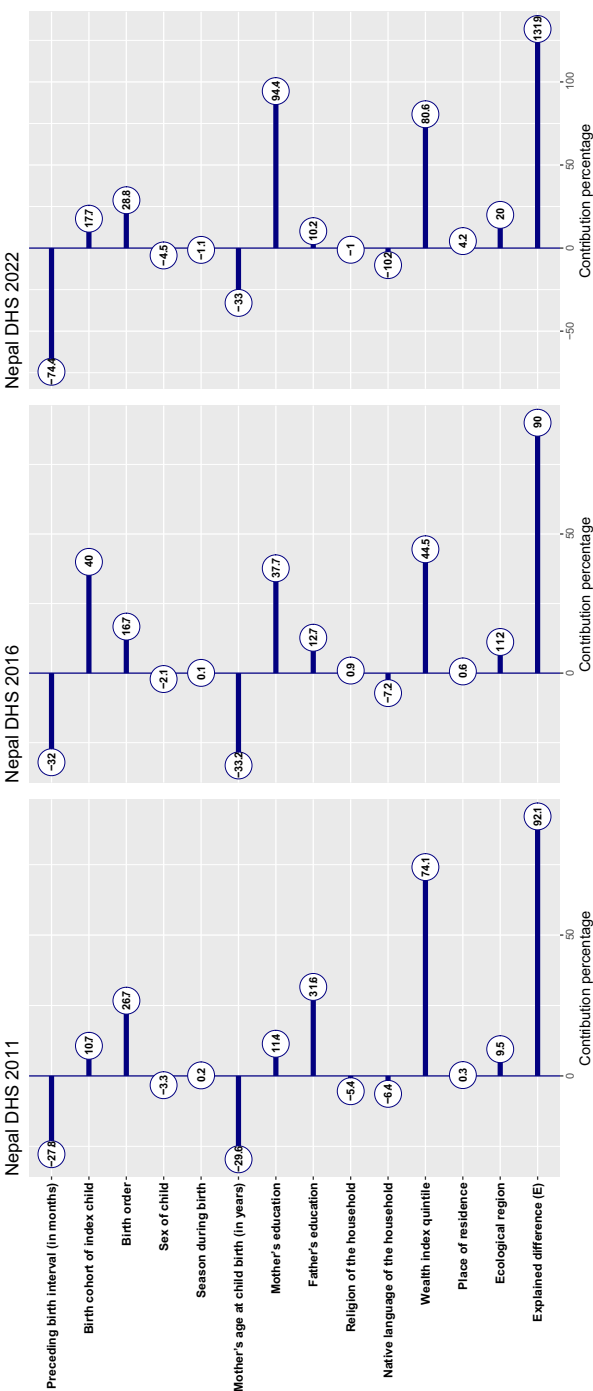
Note: The full table of multivariate decomposition estimates corresponding to the figure are given in Tables S9, S10 and S11.

Figure 8 Explained contribution percentage of multivariate decomposition of under-five mortality gap by household structure in Nepal DHS 1996, 2001 and 2006



Note: The full table of multivariate decomposition estimates corresponding to the figure are given in Tables S12, S13 and S14.

Figure 9 Explained contribution percentage of multivariate decomposition of under-five mortality gap by household structure in Nepal DHS 2011, 2016 and 2022



Note: The full table of multivariate decomposition estimates corresponding to the figure are given in Tables S15, S16 and S17.

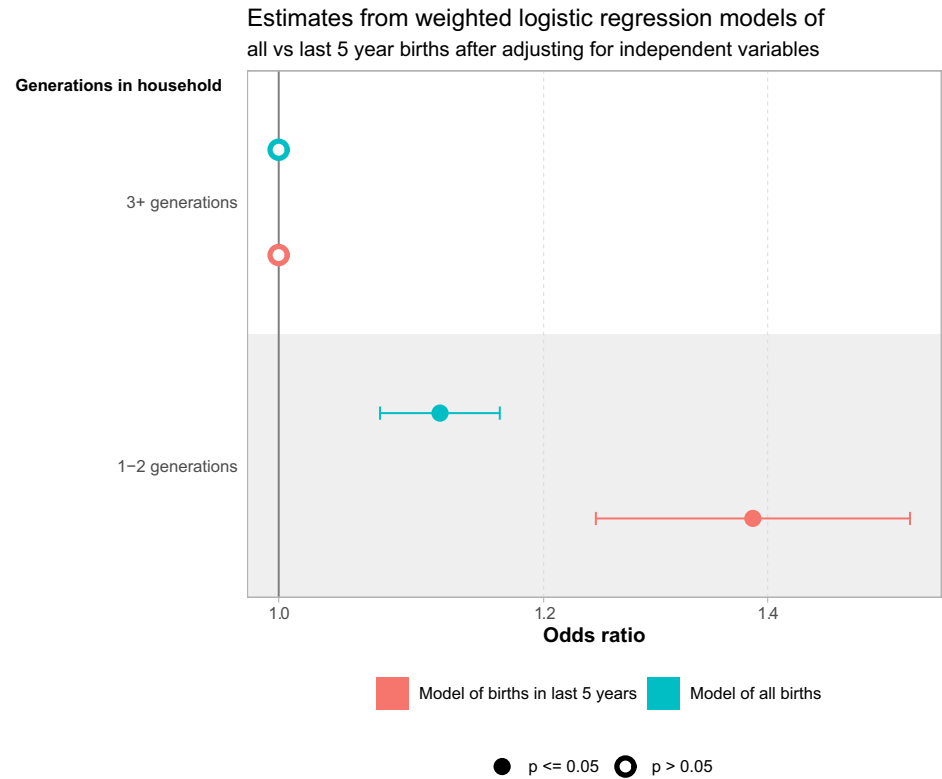
maternal education (94.4%) and household wealth (80.6%) were the most substantial factors in widening the mortality gap, whereas preceding birth interval (−74.4%) and maternal age at birth (−33%) were the key determinants in reducing mortality disparities among nuclear and extended households.

Sensitivity analysis for all births vs births in the last five years of each survey round

Multivariable analysis

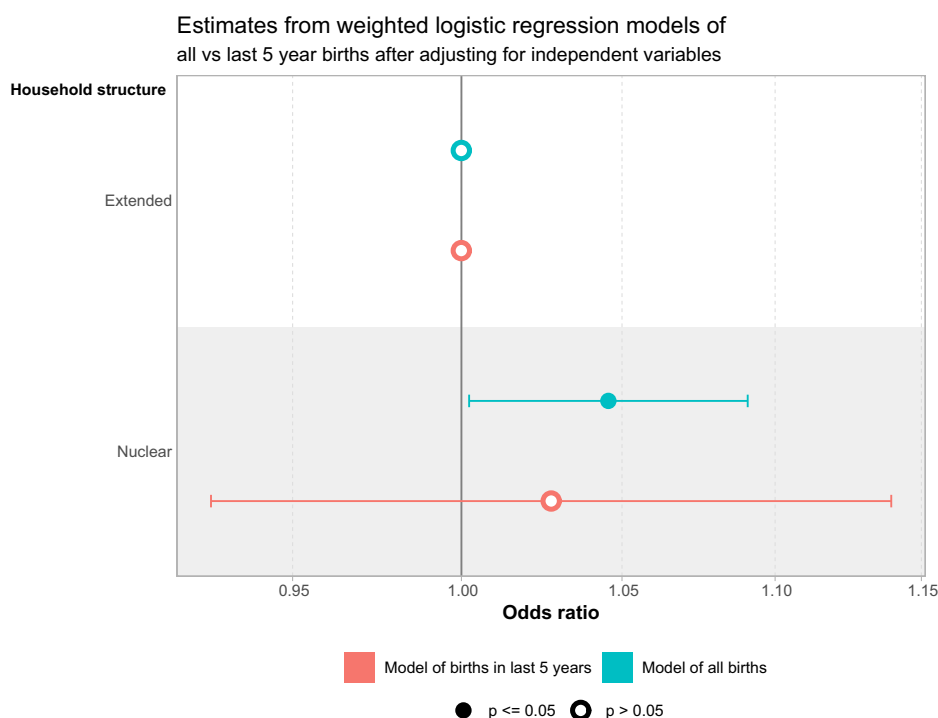
Figures 10 and 11 show the association between the two household types and under-five mortality for the full sample and for children born within five years of the survey. Among

Figure 10 The odds ratios of under-five mortality by household generations from logistic regression models for all births and births in the last five years in Nepal 1970–2022



Note: The odds ratios are from separate regression models for each sample; full regression tables are given in Table S18.

Figure 11 The odds ratios of under-five mortality by household structure from logistic regression models for all births and births in the last five years in Nepal 1970–2022



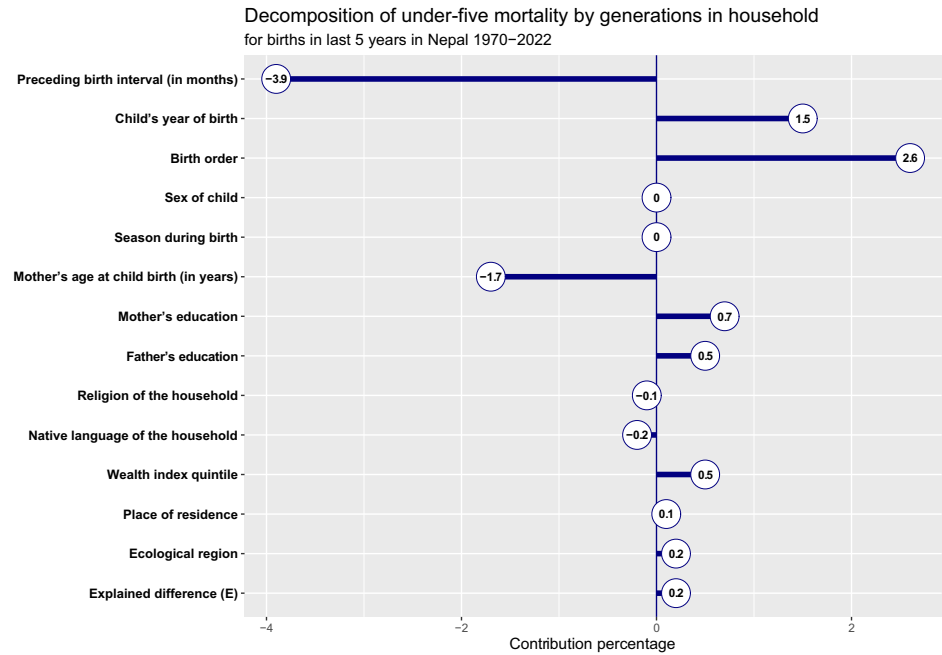
Note: The odds ratios are from separate regression models for each sample; full regression tables are given in Table S19.

children born within five years of the survey, those living in one- or two-generation households had an elevated risk of under-five mortality (OR: 1.39, CI: 1.24, 1.54) compared to those living in multi-generational households. Moreover, in the recent sample, children living in nuclear households had 1.03 higher odds of experiencing under-five mortality compared to children living in extended families. Overall, the multivariable regression findings from the recent sample were similar to those from the all-children sample.

Decomposition analysis

Figures 12 and 13 present the decomposition of under-five mortality gaps by household generations and structure among the recent sample of children born within five years of the survey. For the under-five mortality gaps by household generations (see Figure 12), the birth order of the child emerged as the most significant contributor to the widening of the mortality gap, followed by the child's year of birth and the mother's education. In contrast, preceding birth interval and maternal age narrowed the gap.

Figure 12 Explained contribution percentage of multivariate decomposition of the under-five mortality gap by household generations among births in the last five years in Nepal 1970–2022



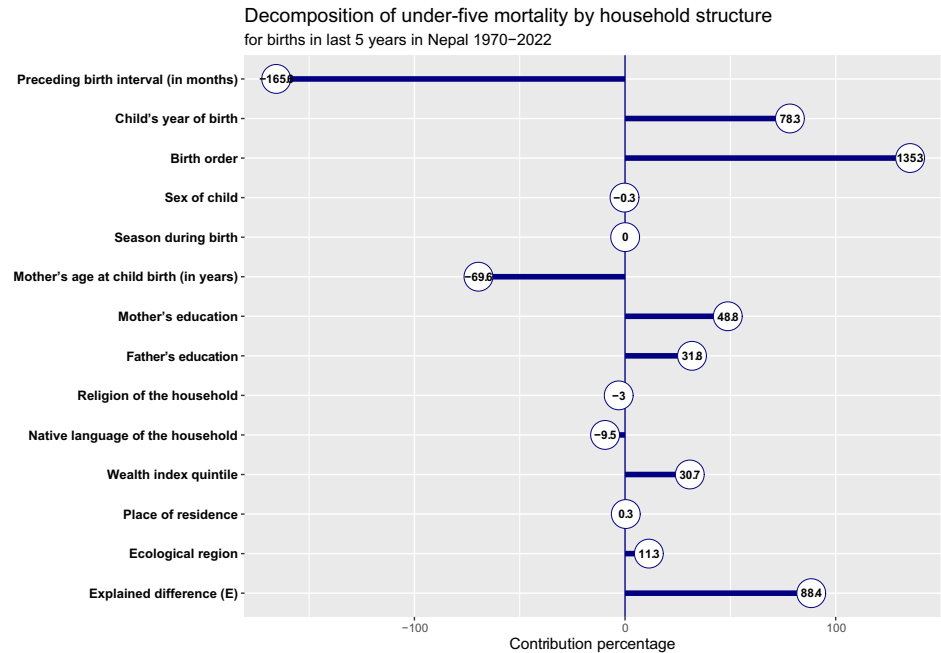
Note: The full table of multivariate decomposition estimates corresponding to the figure are given in Table S20.

For the under-five mortality gap by household structure, child's year of birth, birth order, maternal and paternal education and household wealth were found to contribute the most to widening disparities. At the same time, preceding birth interval and maternal age at birth were key factors in the reduction of the mortality gap. Altogether, the direction of the contribution of the independent variables to under-five mortality gaps was similar across the recent and the full sample of children.

Discussion

Despite substantial evidence of the familial role in reducing under-five mortality, this aspect is often overlooked in Nepal. With household dynamics changing in recent years, it has become increasingly important to understand how a household can impact a child's well-being (Kayastha and Shreshtha, 2003). The present study examined the heterogeneity in the under-five mortality risk in Nepal, focusing on the influence of household generations and household structure from 1970 to 2022. Interestingly, our research findings revealed that the nuclear family structure remained stable in Nepal over the study period. This observation contrasts with the results of other region-based studies done in Nepal, which showed an

Figure 13 Explained contribution percentage of multivariate decomposition of the under-five mortality gap by household structure among births in the last five years in Nepal 1970–2022



Note: The full table of multivariate decomposition estimates corresponding to the figure are given in Table S21.

increase in nuclear families (Ghimire and Axinn, 2006; Rai, 2023). The findings uncovered significant disparities in under-five mortality risk based on household dynamics, highlighting the critical impact of household characteristics on child health outcomes. Additionally, factors contributing to the mortality risk heterogeneity across different generations of households and household structures were explored. The results of this study are summarised as follows:

The study's findings revealed that the risk of under-five mortality was higher in one- or two-generation households. There is ample evidence showing that extended households can provide substantial caregiving and support for children, positively affecting their well-being (Kumar and Ram, 2013; Menashe-Oren et al., 2023; Zewudie et al., 2020). Extended families can offer care not only while a child is growing (through immunisation, daily care, etc.), but also during pregnancy and delivery (Kumar and Ram, 2013). Such social support is often lacking in nuclear households. Additionally, households with more members can contribute financially, helping families with income deficits to provide better resources and proper nutrition for children (Griffiths et al., 2002; Kumar and Ram, 2013; Treleaven, 2023). However, these scenarios may change over time. Living with dependent extended family members can sometimes burden the household, and parental authority over child health decisions may be hindered (Kumar and Ram, 2013). Moreover, some studies have

found that living in extended households increases the risk of child mortality (Akinyemi et al., 2016). There is also evidence that women living in nuclear households have greater autonomy than women living in extended households, where resource allocation seems to be constraining (Matsumura and Gubhaju, 2001).

The contributions of mother's education and mother's age at childbirth to under-five mortality in Nepal were found to be significant. Our results showed that with decreasing levels of mother's education and age at birth, the incidence of under-five mortality increased. These findings are in line with several other studies (Ghimire et al., 2019; Pandey et al., 2013; Pandey et al., 2017; Sarkodie, 2021; Singh and Tripathi, 2013; Sohail and Neupane, 2019). Having more education can increase mothers' awareness of better pregnancy practices, knowledge and access to available healthcare facilities. Our findings were similar to the results to several other studies showing that children born to mothers and fathers with no education or primary-level education are at greater risk of under-five mortality (Akter et al., 2015; Ghimire et al., 2019; Khadka et al., 2015). Similarly, we found that father's education significantly influenced under-five mortality, consistent with other studies (Dendup et al., 2018; Goli et al., 2017; Khadka et al., 2015; Sohail and Neupane, 2019). The decomposition analysis showed that mother's age at birth narrowed the gap in under-five mortality. In recent decades, there have been several socio-economic transformations leading to improvements in women's education and empowerment, which have, in turn, significantly affected women's age at marriage. Parents are not only the primary caregivers of children, but are also the main providers of economic, social and emotional support to them. Hence, the age, education and income of parents are important factors in children's growth and development.

The study found that shorter birth intervals were associated with higher mortality risk. This finding is consistent with other studies showing a significant association between birth interval and infant mortality (Dadi, 2015; Houle et al., 2013; Kozuki and Walker, 2013; Rutstein, 2005). There is ample evidence indicating that a short birth interval might hamper a mother's physical and psychological recovery due to a lack of proper nutrition and sleep, and due to several underlying conditions, which can arise when a woman gives birth again before fully recovering from the previous birth. Moreover, if two children are spaced closely, issues regarding the distribution food, healthcare and time in the family may arise, leading to adverse child health outcomes. Additionally, socio-economic background and physical health are crucial factors in the risk of under-five mortality. The multivariate decomposition analyses revealed that the preceding birth interval narrowed the gap in under-five mortality in both cases. It is reasonable to assume that long birth intervals significantly reduce the chances of child mortality. Similarly, multiple childbirths might be associated with short birth intervals, leading to increased child mortality. The results clearly showed that the third-, fourth- and last-born children were more prone to under-five mortality, which is in line with previous findings (Mishra et al., 2018; Modin, 2002; Paul et al., 2021b; Srivastava et al., 2021). However, some studies have found that first-born children are more likely to experience under-five mortality, as younger mothers may lack parenting experience and knowledge (Siervo et al., 2010).

Our study found that the birth cohort of the child was significantly associated with under-five mortality in Nepal, with older birth cohorts facing a greater risk of under-five mortality.

This finding is in line with several other studies showing improvements in child mortality in Nepal over the decades (Pradhan et al., 2012; Sreeramareddy et al., 2013; Thapa, 2008). A potential explanation for this observation is that in recent decades, efforts to expand female education, increase awareness, ensure access to healthcare and skilled obstetric services, improve healthcare sectors and increase political commitments to ensuring newborn survival in Nepal have reduced the risk of child mortality (Bishai et al., 2016; Pradhan et al., 2012).

The household wealth quintile was found to be significant in determining under-five mortality in Nepal. The results of the decomposition analysis showed that the household wealth quintile played a role in widening the under-five mortality gap between the groups varying by generations and household structure. These results are consistent with other studies showing that child mortality is much higher among the poorest quintile households (Boettiger et al., 2021; Chao et al., 2018; Fagbamigbe et al., 2022). Wealth is considered one of the most vital determinants of good health (Semyonov et al., 2013). The household wealth quintile has several aspects. Generally, parents from poor households have less financial security, education and awareness than their rich counterparts. Hence, children born into wealthier households have better access to food, sanitation, healthcare facilities, etc., than their poor counterparts, which decreases their chances of experiencing child mortality. In short, poor households find it difficult to afford basic needs, resulting in health shocks among children (Boyle et al., 2006; Lartey et al., 2016).

The present study showed that mortality among children under age five was lower in Nepal's hill and Terai regions than in the mountain region. This finding is also in line with several other studies showing that child mortality in Nepal is significantly higher in the mountain areas (Ghimire et al., 2019; Goli et al., 2017; Pandey et al., 2013; Sreeramareddy et al., 2013). The decomposition analysis showed the role of the ecological region in widening the gap in under-five mortality by generations in households and household structure. One potential explanation for this gap is that mountain areas have higher concentrations of poor populations, increasing the chances of that the residents lack access to proper transportation and healthcare centres, which could, in turn, lead to elevated infant mortality (National Planning Commission, 2016). The people living in mountain regions are less willing to pay for advanced medical care because most of them are disadvantaged ethnic populations (Nawal and Goli, 2013). However, recent improvements in communication and transportation infrastructure in these regions have helped to narrow the gap in under-five mortality. This study also found that under-five deaths were higher in rural areas than in urban areas. This finding is also in line with some previous studies on child mortality (Goli et al., 2017; Khadka et al., 2015; Mishra et al., 2018; Sreeramareddy et al., 2013). Compared to rural areas, urban areas tend to have better healthcare facilities, better communication and transportation infrastructure, greater awareness, and, most importantly, more healthcare centres, which may, in turn, lead to lower child mortality.

A major share of Nepal's population is comprised of migrants from Tibet or of Indo-Aryan heritage (Basra et al., 2024), and almost 124 languages and dialects are spoken in Nepal (Regmi, 2024), making it a socio-culturally diverse and multi-lingual country. Our study revealed that under-five mortality was higher among populations that spoke

Maithili, Bhojpuri or other languages than among the Nepali-speaking population. This finding is in line with a recent report on maternal services showing that Maithili- and Bhojpuri-speaking women have a lower rate of institutional delivery (Khatri et al., 2024). One plausible explanation for this gap is that people speaking any language other than the native Nepali language face language barriers in accessing healthcare facilities. Moreover, cultural upbringing plays a vital role in care-seeking attitudes.

This study has a few limitations. First, the household structure may change over the birth history of mothers, and the DHS datasets provide information on household type at the time of the survey, and not during each child's birth. It is possible that the household composition may have changed after the death of a child or before the time of the survey. To address this issue, we performed sensitivity analysis by comparing model estimates for the recent sample of children born within five years of the survey date with model estimates for the full sample. The findings revealed that the model estimates were similar across the full and recent samples, thereby documenting the robustness of our findings. However, this is a standard limitation in demographic studies, and future research using datasets with longitudinal household data could address this issue. This issue has been mentioned in a similar study that examined the association of household structure with under-five mortality, suggesting that longitudinal data might be used to consider the de facto household structure at the time of death rather than at the time of the survey, which would be a more accurate way to study this association (Menashe-Oren et al., 2023). Second, the study could not account for factors such as the absence of household members due to migration, as this information was unavailable in the dataset. Finally, child mortality is shaped by complex socio-economic interactions, and an intersectional approach could further enrich our understanding of these dynamics in future research.

Conclusion

The present study aimed to show the gap in under-five mortality by generations in the household and household structure. The study found that the wealth quintile of the household, mother's age at birth, mother's educational level, the preceding birth interval and the ecological region were significantly associated with Nepal's under-five mortality, and considered their role in widening the under-five mortality gap between the groups. Several studies have shown how crucial a mother's education is to a child's overall development. One study found that almost 26% of married women of reproductive age in Nepal have an unmet family planning need, making this a pressing concern for the country (Ghimire et al., 2019). Laws must be enacted that consider both men's and women's minimum age at marriage and women's education. Women's education is an essential issue to focus on because it will benefit both mothers and their children by increasing awareness, knowledge and practices regarding pregnancy. Similarly, a household's wealth plays an important role in child development as it affects access to education, healthcare and other rudimentary requirements. Moreover, healthcare facilities must be improved in rural areas of Nepal at the grassroots level. Finally, there is a need for more exploration of why under-five mortality varies by ecological region.

Supplementary material

Available online at <https://doi.org/10.1553/p-d6a3-acn8>

Supplementary file 1. Tables S.1–S.21



Ethical approval

The Nepal DHS datasets used for the present analysis were publicly available, and no information about the respondents' identities was disclosed. Thus, there was no need for prior ethical approval to use the datasets. Nepal DHS collected informed consent from all participants before data collection.

Availability of data and materials

The datasets used for this study are publicly available from the Demographic and Health Survey website upon fulfilling the data-sharing agreement.

Link to DHS repository: <https://dhsprogram.com/data/available-datasets.cfm>.

Author's contribution

Conceived and designed the research paper: R. P., R. R. and S. N.; Analysed the data: R. P.; Wrote the manuscript: R. P., R. R. and S. N.; Refined the manuscript: R. R., and S. N. All authors read and approved the final manuscript to be submitted.

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