Assessing Individual- and Community-Level Variability in Predictors of Neonatal, Infant, and Under-Five Child Mortality in Ethiopia Using a Multilevel Modeling Approach

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Abstract: Background: In low-and middle-income countries, child mortality rates are basic indicators of a country’s socio-economic situation and quality of life. The Ethiopian government is currently working to reduce child mortality to accomplish its long-term development goals. Using data from the Ethiopian Mini Demographic and Health Survey, 2019, this study analyzed the determinants of child mortality in Ethiopia. Methods: A total of 4806 children were considered in the final analyses. Multivariate analysis was used to estimate the effects of the predictors simultaneously on each child mortality outcome. Results: The findings revealed that 31.6% of children died during the neonatal stage, 39.1% during the infant stage, and 48.5% during the under-five stage. Variation in child mortality was discovered between Ethiopian community clusters, with the result of heterogeneity between clusters on newborn mortality (χ² = 202.4, p-value < 0.0001), infant mortality (χ² = 777.35, p-value < 0.0001), and under-five mortality (χ² = 112.92, p-value < 0.0001). Children’s neonatal, infant, and under-five mortality intracluster correlation coefficient (ICC) were 0.35, 0.33, and 0.36, respectively, across communities. Conclusions: In Ethiopia, under-five mortality remains a serious public health issue, with wide variations and high rates among community clusters. Intervention measures focusing on lowering rates of household poverty, increasing education opportunities, and improving access to health care could assist in reducing child mortality in Ethiopia.

Keywords: child mortality; community; EMDHS; Ethiopia; multivariable multilevel
In 2015, 5.9 million children under the age of five died worldwide. The World Health Organization (WHO) African countries still have the highest mortality rate of children under five years (81 per 1000 live births), about seven times the rate in the WHO European region (11 per 1000 live births). Low-income countries reported 76 deaths per 1000 live births, about 11 times the average rate in high-income countries (7 deaths per 1000 live births) [3]. The region with the highest under-five child mortality rate in the world is sub-Saharan Africa [4].

Within sub-Saharan Africa, Ethiopia has one of the highest rates of child mortality and morbidity in the world, with over 704 children dying every day from preventable illnesses [5,6]. With current trends, more than 3,084,000 children are likely to die by 2030 if sustainable measures are not taken. Specifically, the child mortality rate stands at 20 deaths per 1000 children surviving to age 12 months. The under-five mortality rate stands at 67 deaths per 1000 live births, and the neonatal mortality rate is 29 deaths per 1000 live births [7]. Additionally, there are regional differences in child mortality across the country, with prevalence rates ranging from 39 per 1000 live births in Addis Ababa to 125 per 1000 live births in Afar [3–5,7,8]. Although the 2016 Ethiopian Demographic and Health Survey report shows that childhood mortality rates have declined over time, compared to the reported under-five mortality rate of 116 deaths per 1000 live births 10–14 years prior to the survey (2002–2006), the rate of 67 deaths per 1000 live births in the 0–4 years prior to the survey (2012–2016) remains high [9].

The infant mortality rate in the fifty years before the survey was 43 deaths per 1000 live births. Child mortality was 12 deaths per 1000 live births to 12 months, while the overall under-five mortality rate was 55 deaths per 1000 live births. The neonatal mortality rate was 30 per 1000 live births [10,11].

Ethiopia’s situation still calls for concerted efforts by stakeholders, including scholars, to continuously generate updated empirical data to help evaluate existing healthcare systems and also to design appropriate sustainable interventions. To provide effective evidence-based interventions such as minimizing undue delays in accessing obstetric and neonatal health care services (e.g., enhancing community knowledge of neonatal death risk factors, reinforcing appropriate referral systems toward birth and complication-readiness strategy, decreasing transportation barriers, facilitating health-promoting behaviors [12]), the key role of updated scholarly evidence cannot be underestimated. Therefore, methodologically sound and nationally representative empirical studies are warranted to provide updated information to guide public policy. Therefore, this study used the 2019 Ethiopian Mini Demographic and Health Survey (EMDHS) data to assess the determinants of child mortality in Ethiopia.

2. Methodology

2.1. Data Source

The study used cross-sectional secondary data, which were obtained from the 2019 EMDHS. The survey drew a representative sample of children from the EDHS database at https://dhsprogram.com/data/available-datasets.cfm (accessed on 30 March 2022). The survey was conducted from 21 March 2019 to 28 June 2019 [10]. A total of 4806 children were considered in the final analyses.

2.2. Study Variables

2.2.1. Outcome Variable

The outcome variable for this study was neonatal mortality (death in the first month of birth), infant mortality (death between birth and the first birthday), and under-five Mortality (death between birth and the fifth birthday), as mortality can occur because of age-specific reasons. Each of the three outcome variables were categorized into binary variables, which are split into “No death” or “Death”.
2.2.2. Explanatory Variables

Individual-Level Factors

Individual level factors included size of a child at birth (very large, larger than average, average, smaller than average, very small); sex of child (male, female); mother’s educational level (no education, primary, secondary, higher); age of mother (15–24, 25–34, 35–44, 45 and above); father’s educational level (no education, primary, secondary, higher); mother’s occupational status (no, yes); household wealth index of (poorest, poorer, middle, richer, richest); sex of household head (male, female); current marital status (never in a union, married/living with partner, separated); breastfeeding duration (never breast fed, still breastfeeding, and ever breast fed); preceding birth interval (in months) (<24, ≥24); and birth order number (first, 2–4, >4). These explanatory variables were chosen based on previous literature, which found them to be associated with neonatal, infant, and under-five child mortality, and the report of 2019, EMDHS [6,7,11–13].

Community-Level Factors

Community-level factors included region (Tigray, Afar, Amhara, Oromia, Somalia, Benishangul-gumuz, SNNPR, Gambela, Harari, Dire Dawa, Addis Ababa) and place of residence (urban, rural).

2.3. Data Analysis Procedure

First, descriptive and bivariate analyses were performed. Using bivariate analysis, we selected candidate variables with p-values less than 0.25 for a multivariate multilevel logistic regression analysis [14,15].

2.3.1. Multivariable Multilevel Logistic Analysis

Multivariable response multilevel models may possibly be necessary when one is interested in two or more outcomes measured on an individual’s within-group factors [16]. This study evaluated the effect of the predictors on the three outcomes of infant mortality and a single test of the combined effect of predictors.

2.3.2. Multilevel Logistic Regression

Two Level Multilevel Analysis

Two-level multilevel logistic regression analysis was applied to assess the effects of individual and community level factors, for which individual factors were the first level (level 1), and community was the second level (level 2). The two-level logistic regression models were written as:

\[ \log \left( \frac{\pi}{1-\pi} \right) = \beta_0 + \beta_1 X_p + U_{oj} \]

where \(\pi\) stands for the probability that the \(i\)th individual level factors in the \(j\)th community; \(\beta_0, \beta_1, \beta_2, \ldots, \beta_p\) were the regression parameter of the variables associated with child mortality; \(X_1, X_2, \ldots, X_p\) were independent variables related with each outcome variable and \(U_{oj}\) (random effect at level 2).

Equivalently, we split model (1) into two: one for level 1 and the other for level 2.

\[ \log \left( \frac{\pi}{1-\pi} \right) = \beta_{oj} + \beta_1 X_p \quad \text{Model : Level One} \]

\[ \beta_{oj} = \beta_0 + U_{oj} \quad \text{Model : Level Two} \]
Multilevel Logistic Regression Empty Model

Multilevel empty model is a model that contains no explanatory variables at all that serves as a point of reference with which other models are compared. The two-level empty multilevel logistic regression model is expressed as follows:

$$\log \it{it}(\pi) = \beta_0 + U_{oj}$$

where $\pi$ is the probability (average proportion of successes) in group $j$; $\beta_0$ is the population average of the transformed probabilities; and $U_{oj}$ is the random deviation from this average for group $j$, and $U_{oj} \sim N(0, \sigma_u^2)$.

Random Intercept Multilevel Logistic Regression Model

With the random intercept model, the intercept is the only random effect, meaning that the groups differ in relation to the average value of child mortality, but the relationship between related factors and response variables cannot differ between them. The random intercept model expresses the log-odds, i.e., the logit of $\pi$ as a sum of a linear function of the explanatory variables. That is,

$$\log \left( \frac{\pi}{1 - \pi} \right) = \beta_{0j} + \beta_1 X_{i1} + \beta_2 X_{i2} + \ldots, \beta_p X_{ip}$$

where $\pi$ is the probability of child mortality, and the intercept term $\beta_0$ is assumed to vary randomly and is given by the sum of intercept $\beta_0$ and group-dependent deviations $U_{uj}$. That is, $\beta_{0j} = \beta_0 + U_{uj}$.

Multi-Level Random Coefficient Logistic Regression Model

In this model, the coefficients of the explanatory variables are considered as random.

$$\log \left( \frac{\pi}{1 - \pi} \right) = \beta_o \sum_{h=1}^{k} \beta_h X_{hij} + U_{oj} + \sum_{h=1}^{k} U_{hij} x_{hij}$$

$\beta_0 \sum_{h=1}^{k} \beta_h x_{hij}$ is the fixed part of the model; $U_{oj} + \sum_{h=1}^{k} U_{hij} x_{hij}$ is the random part of the model where $\pi$ is the probability of child mortality, and the intercept term $\beta_0$ is assumed to vary randomly and is given by the sum of intercept $\beta_0$ and group-dependent deviations $U_{uj}$. That is, $\beta_{0j} = \beta_0 + U_{oj}$.

Multilevel Logistic Regression Parameter Estimation

The most common methods of estimating multilevel models used in this study are based on the likelihood approximations. Among the methods, marginal quasi-likelihood and penalized quasi-likelihood are the two prevailing approximation procedures. After applying these quasi-likelihood methods, the model is then estimated using iterative generalized least squares or reweighted iterative least squares consisting of Laplacian approximation, which is a full maximum likelihood estimation procedure in estimating random intercept and fixed effect [17].

Intra-class correlation coefficient (ICC): The authors purposively used ICC to measure the reliability of ratings for the clusters. Level one residuals distributed using the default logistic distribution $e_{ij}$ imply a variance of $\frac{\pi^2}{3} = 3.29$. Thus, the variation of child mortality
across community was determined. The ICC for the two-level binary data can be defined for each level separately:

$$ICC(\text{Community}) = \frac{\delta^2_{\text{Community}}}{\delta^2_{\text{Community}} + \pi^2_3}$$

where \(\pi^2_3\) denotes the variation of a lower-level unit (individual); \(\delta^2_{\text{Community}}\) indicates the differences between the communities.

2.4. Model Selection Criteria

Akaike Information Criteria (AIC)

Before fitting the model, checking the adequacy or goodness of fit of the model is needed. To select the best model, AIC (Akaike information criterion) was used. The model with a small value of AIC is the optimal model, which means the model is close to the actual one, and the model has few parameters to be estimated [17].

AIC are defined as:

$$AIC = -2\ln(\text{likelihood}) + 2k$$

where \(k\) indicates the degrees of freedom calculated from a variance-covariance matrix of the parameters, and \(N\) indicates the number of observations used in the estimation or, more precisely, the number of independent terms in the likelihood.

3. Results

3.1. Summary of Child Mortality Statistics in Ethiopia (Neonatal Mortality, Infant Mortality, and Under-Five Mortality)

Table 1 presents the descriptive results obtained from EDHS 2019 based on child mortality factors in Ethiopia, such as neonatal mortality, infant mortality, and under-five mortality.

### Table 1. Results of descriptive statistics and bivariate analysis.

| Variables                          | Categories | Neonatal Mortality | Infant Mortality | Under-Five Mortality |
|------------------------------------|------------|--------------------|-----------------|----------------------|
|                                    |            | Death Alive \(\chi^2\) | Death Alive \(\chi^2\) | Death Alive \(\chi^2\) |
| Place of residence                 | Urban      | 189 675            | 46.327 *         | 377 487              | 9.279 *         | 361 503 | 19.04 *         |
|                                    | Rural      | 1331 2611          | 1500 2442        | 1970 1972            |                |
| Mothers’ educational level         | No education | 1022 1984          | 1131 1875        | 1544 1462            |                |
|                                    | Primary    | 394 859            | 530 723          | 583 670              | 39.37 *         |
|                                    | Secondary  | 79 281             | 134 226          | 133 227              |                |
|                                    | Higher     | 25 162             | 82 105           | 71 116               |                |
| Sex of household head              | Male       | 1253 2594          | 1536 2311        | 1866 1981            | 12.5 *          |
|                                    | Female     | 267 692            | 341 618          | 465 494              |                |
| Wealth index of mothers            | Poorest    | 1574 1135          | 637 1072         | 847 862              |                |
|                                    | Poorer     | 259 531            | 306 484          | 454 336              |                |
|                                    | Middle     | 242 432            | 268 406          | 355 319              | 67.305 *        |
|                                    | Richer     | 231 423            | 244 410          | 287 367              |                |
|                                    | Richest    | 214 765            | 422 557          | 388 591              |                |
| Age of mothers                     | 15-24      | 781 1584           | 925 1440         | 1181 1184            |                |
|                                    | 25-34      | 676 1495           | 828 1343         | 1012 1159            | 5.790 *         |
|                                    | 35-44      | 59 186             | 115 130          | 125 120              |                |
|                                    | 45 and above | 4 21               | 9 16             | 13 12               |                |
Of the total 1520 children who died in the first month of birth, 189 resided in urban areas, and 1331 resided in rural areas. Out of the 1877 infant deaths, 377 occurred in urban areas, and 1500 in rural areas. Out of the 2337 under-five deaths, 361 occurred in urban areas, and 1970 in rural areas. Likewise, regarding deaths in the first month after birth, 770 children who died were males, and 750 females, respectively. From between birth and the first day, 938 males and 939 females died, respectively. For under-five deaths, 1195 were among males and 1136 females.

### Table 1. Cont.

| Variables                  | Categories                        | Neonatal Mortality | Infant Mortality | Under-Five Mortality |
|----------------------------|-----------------------------------|--------------------|------------------|----------------------|
|                            |                                   | Death Alive | χ²  | Death Alive | χ²  | Death Alive | χ²  |
| Current marital status     | Never in Union                   | 2          | 6     | 0.640       | 3    | 5          | 0.064       | 5    | 3          | 0.712 |
|                            | Married                           | 1470       | 3183  |             | 1816 | 2837       |             | 2254 | 2399       |          |
|                            | Separated                         | 48         |       |             | 58   | 87         |             | 72   | 73         |          |
| Fathers' educational level | No education                      | 792        | 1497  | 41.640 *    | 848  | 1441       | 10.177 *    | 1206 | 1083       | 50.709 * |
|                            | Primary                           | 505        | 1060  |             | 652  | 913        |             | 750  | 815        |          |
|                            | Secondary                         | 130        | 378   |             | 211  | 297        |             | 213  | 295        |          |
|                            | Higher                            | 93         | 351   |             | 166  | 278        |             | 162  | 282        |          |
| Region                     | Tigray                            | 171        | 326   | 62.496 *    | 213  | 284        |             | 251  | 246        |          |
|                            | Afar                              | 159        | 322   |             | 164  | 317        |             | 238  | 243        |          |
|                            | Amhara                            | 170        | 311   |             | 181  | 300        |             | 266  | 215        |          |
|                            | Oromia                            | 187        | 377   |             | 225  | 339        |             | 273  | 291        |          |
|                            | Somalia                           | 231        | 469   |             | 275  | 425        |             | 341  | 359        |          |
|                            | Benishangul-gumuz                 | 106        | 294   |             | 139  | 261        |             | 214  | 186        | 41.387 * |
|                            | SNNPR                             | 266        | 446   |             | 297  | 415        |             | 348  | 364        |          |
|                            | Gambela                           | 84         | 232   |             | 121  | 195        |             | 113  | 203        |          |
|                            | Harari                            | 58         | 157   |             | 101  | 114        |             | 89   | 126        |          |
|                            | Addis Ababa                       | 34         | 200   |             | 81   | 153        |             | 102  | 132        |          |
|                            | Dire Dawa                         | 54         | 152   |             | 80   | 126        |             | 96   | 110        |          |
| Mothers' working status    | Not working                       | 1136       | 2313  | 9.693 *     | 1328 | 2313       | 11.561 *    | 1167 | 1772       | 12.72 *  |
|                            | Working                           | 384        | 973   |             | 549  | 973        |             | 654  | 703        |          |
| Birth order number         | 1(First)                         | 242        | 642   |             | 347  | 642        |             | 412  | 472        |          |
|                            | >4                                | 585        | 1117  |             | 649  | 1117       |             | 865  | 837        |          |
| Sex of child               | Male                              | 770        | 1647  | 0.120       | 938  | 1479       | 0.125       | 1195 | 1222       | 1.719    |
|                            | Female                            | 750        | 1639  |             | 939  | 1450       |             | 1136 | 1253       |          |
| Preceding birth interval (months) | <24   | 378        | 857   | 8.799 *     | 471  | 764        | 9.588 *     | 648  | 587        | 10.476 * |
|                            | ≥24                               | 1142       | 2429  |             | 1406 | 2165       |             | 1683 | 1888       |          |
| Duration of breastfeeding   | Ever breastfed, not currently breastfeeding | 785 | 1732  | 13.148 *    | 988  | 1529       | 12.097 *    | 1322 | 1195       | 41.733 * |
|                            | Never breastfed                   | 48         | 132   |             | 61   | 119        |             | 97   | 83         |          |
|                            | Still breastfeeding               | 687        | 1422  |             | 828  | 1281       |             | 912  | 1197       |          |
| Size of child at birth     | Very large                        | 253        | 543   | 8.401 *     | 332  | 464        |             | 358  | 438        | 11.22 *  |
|                            | Larger than average               | 226        | 460   |             | 277  | 409        |             | 334  | 352        |          |
|                            | Average                           | 638        | 1409  |             | 781  | 1266       | 9.587 *     | 974  | 1073       |          |
|                            | Smaller than average              | 139        | 334   |             | 174  | 299        |             | 245  | 228        |          |
|                            | Very small                        | 264        | 540   |             | 313  | 491        |             | 420  | 384        |          |

* Chi-square was significant at \((p < 0.25)\).
3.2. Inferential Statistical Analysis
3.2.1. Bivariate Analysis

Before performing the multivariable multilevel analysis, a bivariate analysis was performed for all independent variables separately. Then, those variables showing association with child mortality at \( p \)-value < 0.25 were selected and entered into the multivariable multilevel analysis. Bivariate analysis in Table 1 shows that place of residence, mother’s educational level, sex of household head, wealth index of mothers, age of mothers, father’s educational level, region, birth order number, preceding birth interval (in months), mother’s occupational status, breastfeeding duration, and size of child at birth are significant factors for child mortality. However, current marital status was significant only with infant mortality but not neonatal and under-five mortality.

3.2.2. Multivariable Multilevel Logistic Analysis

Multilevel Analysis using Empty Model

Before performing the multilevel analysis, there was a test of heterogeneity performed on each child mortality outcome separately. The parametric version of assessing the heterogeneity of child mortality was utilized.

From Table 2, the variances of neonatal, infant, and under-five mortality were estimated as \( \sigma_{\text{ou}}^2 = 2.283 \), \( \sigma_{\text{ou}}^2 = 2.905 \), and \( \sigma_{\text{ou}}^2 = 0.186 \), respectively, which were significant at 5% level of significance and indicate that there were variations of child mortality across the community of Ethiopia. Accordingly, the intra-cluster correlation coefficients (ICCs) from the empty model were 0.409, 0.468, and 0.053 for neonatal, infant, and under-five mortality across the community, respectively. This shows that about 40.9%, 46.8%, and 5.3% of the variation in neonatal, infant, and under-five mortality can be attributed to community-level variations, respectively.

Table 2. Results of multivariate multilevel logistic regression of empty model.

| Response Variable | Indicators                  | Estimate | S.E  | Z-Value | \( p \)-Value | 95% CI          |
|-------------------|-----------------------------|----------|------|---------|---------------|-----------------|
|                   | \( \beta_0 = \) Intercept  | 5.418    | 2.488| 3.68    | 0.000         | 2.202–13.327    |
| Neonatal Mortality| Community Estimate          |          |      |         |               |                 |
|                   | Var(\( U_{ij} \)) = \delta_0^2 | 2.283    | 0.997|         |               | 0.970–5.374     |
|                   | ICC for Community           | 0.409    | 0.105|         |               | 0.227–0.620     |
|                   | Deviance-based chi-square (\( X^2 \)) = 927.50; \( p \)-value < 0.0001 |
|                   | \( \beta_0 = \) Intercept  | 24.093   | 12.65| 6.06    | 0.000         | 8.604–67.464    |
| Infant Mortality  | Community Estimate          |          |      |         |               |                 |
|                   | Var(\( U_{ij} \)) = \delta_0^2 | 2.905    | 1.294|         |               | 1.213–6.957     |
|                   | ICC for Community           | 0.468    | 0.110|         |               | 0.269–0.678     |
|                   | Deviance-based chi-square (\( X^2 \)) = 777.35; \( p \)-value < 0.0001 |
|                   | \( \beta_0 = \) Intercept  | 0.499    | 0.067| −5.15   | 0.000         | 0.383–0.650     |
| Under-five Mortality| Community Estimate         |          |      |         |               |                 |
|                   | Var(\( U_{ij} \)) = \delta_0^2 | 0.186    | 0.087|         |               | 0.073–0.469     |
|                   | ICC for Community           | 0.053    | 0.023|         |               | 0.021–0.124     |
|                   | Deviance-based chi-square (\( X^2 \)) = 112.92; \( p \)-value < 0.0001 |

3.3. Model Comparison

Once the set of candidate models were chosen, the statistical analysis selected the best fit of these models. A good model selection technique was to balance goodness of fit with
simplicity. Therefore, choosing a relevant multilevel model is an important step, and it should be based on the necessity of parsimony in the model.

Table 3 shows that AIC for neonatal, infant, and under-five mortality was small for model III (individual- and community-level factors). This shows that model III (individual- and community-level factors) best-fitted the data. Therefore, model III (individual- and community-level factors) was used for further analysis and interpretation.

Table 3. Model comparison between the models on child mortality.

| Response             | Model Comparison Criteria | Null Model (Model I) | Individual-Level Factors (Model II) | Individual-and Community-Level Factors (Model III) |
|----------------------|---------------------------|----------------------|-------------------------------------|-----------------------------------------------|
| Neonatal mortality   | AIC                       | 3552.244             | 2912.324                           | 2633.845                                     |
| Infant mortality     | AIC                       | 1605.123             | 1574.248                           | 1359.224                                     |
| Under-five mortality | AIC                       | 6114.218             | 5999.25                            | 5963.110                                     |

Mother’s educational level, wealth index of mothers, father’s educational level, preceding birth interval, duration of breastfeeding, region, place of residence, and sex of household head has a significant impact on child mortality at a 5% level of significance. The intra-cluster correlation (ICC) of neonatal mortality, infant mortality, and under-five mortality across the community was 0.35, 0.33, and 0.36, respectively (Table 4). These observed correlations indicate that about 35% of the variation in neonatal mortality is due to the variation across the community, about 33% of the variation in infant mortality is due to the variation across the community, and about 36% of the variation in under-five mortality is due to the variation across the community.

Table 4. Results of Multivariable Multilevel Logistic Regression of Random coefficient.

| Fixed Part | Neonatal Mortality | Infant Mortality | Under-five Mortality |
|------------|--------------------|------------------|----------------------|
| Constant   | 0.47 [0.31–0.71]   | 1.44 [1.44–7.06] | 4.51 [0.92–22.0]    |

Mothers’ education level (ref. no education)

|                     | AOR (95% CI) | p-Value | AOR (95% CI) | p-Value | AOR (95% CI) | p-Value |
|---------------------|--------------|---------|--------------|---------|--------------|---------|
| Primary             | 0.89 [0.67–1.64] | 0.658   | 0.36 [0.24–0.68] | 0.001 * | 0.97 [0.82–1.13] | 0.715   |
| Secondary           | 0.78 [0.57–0.96] | 0.042 * | 0.12 [0.04–0.23] | 0.000 * | 0.75 [0.54–0.88] | 0.002 * |
| Higher              | 0.54 [0.32–0.89] | 0.000 * | 0.18 [0.09–0.26] | 0.000 * | 0.84 [0.56–1.27] | 0.427   |

Wealth index of household (ref. poorest)

|                     | AOR (95% CI) | p-Value | AOR (95% CI) | p-Value | AOR (95% CI) | p-Value |
|---------------------|--------------|---------|--------------|---------|--------------|---------|
| Poorer              | 0.18 [0.12–0.27] | 0.000 * | 0.96 [0.79–2.34] | 0.227   | 1.05 [0.86–1.29] | 0.578   |
| Middle              | 0.07 [0.03–0.16] | 0.000 * | 0.97 [0.97–1.20] | 0.609   | 0.81 [0.57–1.24] | 0.403   |
| Richer              | 0.12 [0.09–0.19] | 0.000 * | 0.37 [0.18–0.66] | 0.004 * | 0.27 [0.05–0.54] | 0.011 * |
| Richest             | 0.74 [0.55–0.99] | 0.000 * | 0.45 [0.09–0.52] | 0.001 * | 0.77 [0.77–0.83] | 0.001 * |

Age of mothers (ref. 15–24)

|                     | AOR (95% CI) | p-Value | AOR (95% CI) | p-Value | AOR (95% CI) | p-Value |
|---------------------|--------------|---------|--------------|---------|--------------|---------|
| 25–34               | 0.98 [0.86–1.11] | 0.118   | 0.96 [0.84–1.08] | 0.968   | 0.90 [0.80–1.02] | 0.128   |
| 34–44               | 0.86 [0.62–1.18] | 0.096   | 0.75 [0.91–1.29] | 0.884   | 1.23 [0.92–1.64] | 0.145   |
| 40 and above        | 0.63 [0.21–1.93] | 0.254   | 1.09 [0.47–2.54] | 0.771   | 1.26 [0.55–2.88] | 0.568   |
### Table 4. Cont.

|                        | Neonatal Mortality | Infant Mortality | Under-five Mortality |
|------------------------|--------------------|------------------|----------------------|
| **Fathers’ educational level (ref. no education)** |                    |                  |                      |
| Primary                | 0.34 [0.26–0.84]   | 0.031 *          | 1.12 [1.02–2.56]     | 0.000 *              | 0.89 [0.77–1.03] | 0.148 |
| Secondary              | 0.75 [0.52–0.99]   | 0.000 *          | 1.08 [0.86–1.36]     | 0.156                | 0.82 [0.65–1.03] | 0.092 |
| Higher                 | 0.41 [0.29–0.87]   | 0.000 *          | 0.81 [0.62–1.07]     | 0.092                | 0.72 [0.55–0.95] | 0.022 * |
| **Mothers’ working status (ref. no)** |                    |                  |                      |
| Yes                    | 0.90 [0.78–1.05]   | 0.142            | 1.04 [0.91–1.20]     | 0.365                | 1.04 [0.91–1.20] | 0.509 |
| **Birth Order Number (ref. First)** |                    |                  |                      |
| 2–4                    | 1.06 [0.88–1.27]   | 0.114            | 1.07 [0.90–1.26]     | 0.984                | 0.93 [0.79–1.10] | 0.432 |
| >4                     | 1.08 [0.89–1.33]   | 0.069            | 1.58 [0.93–2.99]     | 0.465                | 0.99 [0.82–1.19] | 0.933 |
| **Preceding birth interval (in months) (ref. <24 months)** | 0.66 [0.54–0.96]   | 0.000 *          | 0.54 [0.32–0.84]     | 0.000 *              | 0.84 [0.72–0.97] | 0.019 * |
| **Duration of breast feeding (ref. ever breastfed, not currently breastfeeding)** |                    |                  |                      |
| Never breast feeding   | 0.68 [0.43–0.99]   | 0.025 *          | 0.56 [0.32–0.74]     | 0.018 *              | 1.08 [0.79–1.47] | 0.620 |
| Still breast feeding   | 1.05 [0.93–1.20]   | 0.901            | 0.98 [0.87–1.11]     | 0.621                | 0.68 [0.60–0.77] | 0.000 * |
| **Size of child at birth (ref. very large)** |                    |                  |                      |
| Larger than average    | 1.04 [0.83–1.30]   | 0.254            | 0.97 [0.79–1.20]     | 0.961                | 1.09 [0.88–1.34] | 0.410 |
| Average                | 0.95 [0.80–1.14]   | 0.982            | 0.88 [0.74–1.05]     | 0.721                | 1.05 [0.88–1.24] | 0.562 |
| Smaller than average   | 0.83 [0.64–1.07]   | 0.145            | 0.88 [0.69–1.12]     | 0.451                | 1.22 [0.97–1.55] | 0.087 |
| Very small             | 0.97 [0.78–1.21]   | 0.632            | 0.97 [0.97–1.19]     | 0.632                | 1.41 [0.93–1.76] | 0.530 |
| **Region: (ref. Tigray)** |                    |                  |                      |
| Afar                   | 0.74 [0.52–0.92]   | 0.008 *          | 0.77 [0.58–1.02]     | 0.078                | 0.56 [0.37–1.42] | 0.079 |
| Amhara                 | 4.89 [2.24–10.3]   | 0.000 *          | 0.86 [0.66–1.12]     | 0.279                | 1.10 [0.85–1.44] | 0.438 |
| Oromia                 | 8.71 [5.55–9.21]   | 0.000 *          | 0.92 [0.71–1.18]     | 0.522                | 0.86 [0.58–0.91] | 0.000 * |
| Somali                 | 0.23 [0.09–0.17]   | 0.040 *          | 3.26 [2.59–11.4]     | 0.000 *              | 0.73 [0.56–0.94] | 0.016 * |
| Benishangul-gumuz      | 10.64 [5.51–23.9]  | 0.000 *          | 5.45 [1.83–20.4]     | 0.000 *              | 1.02 [0.78–1.35] | 0.841 |
| SNNPR                  | 1.94 [1.32–2.86]   | 0.009 *          | 0.74 [0.77–1.25]     | 0.000 *              | 0.92 [0.72–1.17] | 0.504 |
| Gambela                | 1.46 [1.26–3.77]   | 0.000 *          | 21.2 [9.30–121.2]    | 0.000 *              | 0.55 [0.41–0.76] | 0.000 * |
| Harari                 | 0.70 [0.49–0.96]   | 0.022 *          | 0.85 [0.85–1.16]     | 0.333                | 0.69 [0.57–1.13] | 0.220 |
| Addis Ababa            | 0.32 [0.21–0.48]   | 0.006 *          | 0.46 [0.32–0.67]     | 0.000 *              | 0.57 [0.21–0.82] | 0.001 * |
| Dire Dawa              | 0.67 [0.47–0.97]   | 0.000 *          | 1.02 [0.73–1.43]     | 0.884                | 0.99 [0.68–1.43] | 0.981 |
| **Place of residence (ref. urban)** | 1.05 [1.01–2.44]   | 0.000 *          | 1.28 [1.05–3.29]     | 0.008 *              | 0.54 [0.36–0.92] | 0.000 * |
| **Sex of household head (ref. male)** |                    |                  |                      |
| Female                 | 0.59 [0.34–0.94]   | 0.042 *          | 0.81 [0.68–0.95]     | 0.012 *              | 0.33 [0.09–0.44] | 0.000 * |
| **Random Part** |                    |                  |                      |
| Var (Cons.) community  | 1.772              | 1.628            | 1.884                |                      |                  |
| ICC for community      | 0.35               | 0.33             | 0.36                 |                      |                  |

* significant at ($p < 0.05$).
3.4. Neonatal Mortality

The results in Table 4 show the neonatal mortality for mothers with secondary and higher educational levels was about 22% and 46% less likely compared to mothers with no education, respectively. Similarly, the probability of neonatal death for children from the poorer, middle, richer, and richest households was about 82%, 93%, 88%, and 26% less likely compared to children from the poorest families, respectively. Regarding fathers’ educational levels, a child from a father with a primary, secondary, and higher educational level was about 66%, 25%, and 59% less likely to die within the first month of life compared to a child from a father who has no education, respectively. The odds of neonatal mortality for the children from Afar, Somali region, Harari, Addis Ababa, and Dire Dawa were about 26%, 77%, 30%, 68%, and 33% less likely compared to children from the Tigray region, respectively, while a child from the Amhara, Oromia, Benishangul, SNNP and Gambela regions was 4.89, 8.71, 10.28, 1.94, and 1.46 times more likely to succumb to neonatal mortality compared to a child from the Tigray region, respectively. Regarding area of residence, a child from a rural area of the country was about 1.05 more likely to die at the neonatal stage compared to a child from the urban area of the country. Similarly, the odds of the neonatal mortality were decreased by 41% for a child with a female household head.

3.5. Infant Mortality

The odds of infant mortality were decreased by 64%, 88%, and 82%, respectively, for the mothers with primary, secondary, and higher educational levels. Children from the richer and richest families were 63% and 55% less likely to die in infancy compared with children from the poorest families, respectively. Children whose fathers have primary education were 1.12 times more likely to die in infancy compared to a child whose father has no education. Children with preceding birth interval greater or equal to 24 months are 46% less likely to die in infancy compared to children with preceding birth interval less than 24 months. The odds of infant mortality for children from Addis Ababa were 54% less compared to children from the Tigray region, while a child from Somali, Benishangul, SNNP, and Gambela regions was 3.26, 5.45, 0.74, and 21.2 times more likely to succumb to infant mortality compared to a child from the Tigray region, respectively. The odds of infant mortality were increased 1.28 times for children from rural areas of the country. Similarly, the infant mortality rate for children of female householders decreased by 19%.

3.6. Under-Five Mortality

The odds of under-five mortality were decreased by 25% for children from mothers with a secondary educational level. Children from the richer and richest families were 27% and 73% less likely to die at under five years compared with children from the poorest families, respectively. Children whose fathers have higher education were 28% less likely to die at under five years compared to children whose fathers have no education. Regarding preceding birth interval, children with preceding birth interval greater or equal to 24 months were 16% less likely to die at under five years compared to children with preceding birth interval less than 24 months. The odds of under-five mortality for the children from Oromia, Somali, Gambela, and Addis Ababa were 14%, 27%, 45%, and 43% less compared to children from the Tigray region, respectively. The odds of under-five mortality were decreased by 46% for children from rural areas of the country. Similarly, the odds that a female householder’s child will die before the age of five was reduced by 67%.

4. Discussion

This study used a multivariable multilevel logistic regression model to determine the effect of each independent variable on the child mortality outcome variable. Thus, this study aimed at examining the major influential factors on child mortality, such as mothers’ educational level, wealth index of mothers, fathers’ educational level, preceding birth interval, duration of breastfeeding, region, place of residence, and sex of household head.
Mother’s educational level significantly influenced child neonatal, infant, and under-five mortality. Children with mothers who have no formal education or are illiterate were more likely to die than those with mothers who have a secondary educational level. Similar findings conducted in Calverton [18] suggest that children of mothers who have primary education levels are less likely to die than children of mothers with no education or who are illiterate, and children of mothers with secondary and higher education levels were less likely to die. A similar argument suggested by Griffiths et al. suggests that more-educated mothers can better utilize their limited resources than mothers with little or no education and have better health and parenting practices, which lead to better child survival and may have better information on health. [19].

It was also found that preceding birth interval was significant to child neonatal, infant, and under-five mortality. This outcome means short preceding birth intervals and high parity largely increase child neonatal, infant, and under-five mortality risk after accounting for unobserved heterogeneity between them [20]. Previous research conducted in sub-Saharan Africa countries suggests that this observation could be related to maternal depletion syndrome and resource competition between the siblings in addition to lack of care and attention experienced by high-order children [21–23].

The sex of the household head was another significant factor in this study. Children from female-headed households were less likely to die than those from male-headed households regarding the child neonates, infants, and those under five years. Similar findings from Nepal and Nigeria [24,25] show that women from female-headed households were less likely to experience the death of a child than women from male-headed households. Hence, women could talk more easily with the female heads of the household, especially about their reproductive health problems and children’s illnesses. The similar study conducted in India [26] reiterates that more female autonomy results in a significant reduction in child mortality because of the greater prenatal care and greater possibility of delivery in the hospital.

The father’s educational level was significant. It is logical to infer that educated fathers usually improve the agency to influence family and child-care decisions. Previous studies conducted in Bangladesh and Comoros by [27–29] contradict with this identified association and argued that an educated father is likely to have a better income, which plays a key role in the financial strength of the family and the provision of necessary health services for the family. Similarly, in this study, the factor of wealth index of mothers was significant. This result is consistency with other studies carried out by Gizachew, Addisalem et al. and Desalegn et al. [30–32]; however, a study conducted in Ethiopia [33] contradicts this finding and suggested that the wealth index of the household is not significant to child mortality. Wealthier families have better living standards or quality of life and better accessibility of health services. This status helps to reduce the likelihood of child mortality among wealthier families [34]. Comparatively, households with lower wealth status are less likely to have availability of health services and access to basic facilities of sanitation, hygienic toilets, and clean drinking water [35,36].

For place of residence, child mortality of families who resided in rural areas was higher than those who resided in urban areas. Usually, health infrastructural efforts nad basic social amenities made in rural areas are not complemented by work done in urban areas. Similar findings from Tsala et al. and Honwana and Melesse [37,38] suggest that living in urban areas decreased the risk for child mortality as compared to living in rural areas because of specific individual level or socio-ecological factors. Living in urban areas serves as a further protective factor for mothers whose children previously died and were more educated, and also reduced the promoting effects of older ages in mothers [39,40]. Even so, living in urban areas also reduced the health-promoting alternative of the poor and good-structural quality of housing. In addition, permanent housing quality in urban areas offered a risk factor for neonates, infants, and under-five child mortality as compared to housing conditions in rural areas [41].
Strengths and Limitation

This study shares some of the limitations inherent in the use of cross-sectional datasets. Since respondents were interviewed at a point in time, the opportunity to establish a cause–effect relationship between predictor and outcome variables (neonates, infants, and under-five child mortality) is lost. More so, through the analysis in this study, more vigorous and thorough information would have been provided if there had been variables measuring other child indicators. However, throughout this study, the datasets considered were limited to the indicators discussed. Despite these limitations, the study analyzed child mortality problems through the three mortality outcomes and provided valuable information on the factors that are associated with child mortality in Ethiopia.

5. Conclusions

The problem of neonatal, infant, and under-five mortality is a serious problem in Ethiopia. The results revealed that factors influencing this phenomenon include mother’s educational level, wealth index of mothers, father’s educational level, preceding birth interval, duration of breastfeeding, region, place of residence, and sex of household head. Stakeholders should aim at reducing child mortality in the country by incorporating these factors through appropriate intervention programmes (e.g., health education and promotion, provision of basic social amenities, especially in rural areas). Such interventions, including policies should target these characteristics to improve child health outcomes in Ethiopia.

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