Maternal socioeconomic position and inequity in child deaths: An analysis of 2012 South Korean birth cohort of 466,636 children

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ABSTRACT

Background: Inequalities in child mortality occur via interactions between socio-environmental factors and their constituents. Through childhood developmental stages, we can observe changing patterns of mortality. By investigating these patterns and social inequalities by cause and developmental stage, we aim to gain insights into health policies to reduce and equalize childhood mortality.

Methods: Using vital statistics, we examined the Korean birth cohort of 2012, including all children born in 2012 up to five years of age (N = 466,636). The dependent variables were all-cause and cause-specific mortality by developmental stage (i.e., neonatal, post-neonatal, and childhood). A Cox proportional hazard regression model was built to compare child mortality according to maternal education. The distribution of inequalities in cause-specific mortality by child age was calculated using the slope index of inequality (SII).

Results: Inequalities in child mortality due to maternal education occur during the neonatal period and increase over time. After adjusting for covariates, the Cox proportional hazard models showed that “injury and external causes” (HR = 2.178; 95% CI = [1.283–3.697]) and “unknown causes” (HR = 2.299; 95% CI = [1.572–3.636]) in the post-neonatal period, and “injury and external causes” (HR = 2.153; 95% CI = [1.347–3.440]) in the childhood period significantly contributed to socioeconomic inequalities in child mortality. For each period, the leading causes of inequality were identified as follows: “congenital” (96.7%) for the neonatal period, “unknown causes” (58.2%) and “injury and external causes” (28.4%) for the post-neonatal period, and “injury and external causes” (56.9%) for the childhood period.

Conclusion: We confirmed that the main causes of death in mortality inequality vary according to child age, in accordance with the distinctive context of child development. Strengthening the health system and multisectoral efforts that consider families’ and children’s needs according to spatial contexts (e.g., home, community) may be necessary to address the social inequalities in child health.

1. Introduction

Due to improved living conditions and advances in public health intervention and medical treatment over several decades, Korea achieved an impressively low child mortality rate in 2018 (1.5% neonatal mortality, 2.7% infant mortality, and 3.2% under age 5 mortality) among the Organization for Economic Co-operation and Development (OECD) countries (World Health Organization[WHO], 2020). Nevertheless, apparent socioeconomic inequalities in child mortality have not decreased; in fact, some have increased (Son et al., 2017). Research from high-income countries shows that child mortality is influenced by interactions among children’s biological resilience, socio-physical environment, and the institutional services they receive (Sidebotham, Fraser, Covington, et al., 2014). Since many of these factors are “social,”...
some child deaths may be preventable (Spencer et al., 2019). In short, child deaths are one of the most devastating and tragic events for individuals and families, and their societal distributions reflect inequalities in social conditions experienced by various socioeconomic strata (UNICEF, 2015).

A wide range of parental socioeconomic status markers (e.g., education, occupation, income, and material possessions) are associated with child health (Pillas et al., 2014; Spencer et al., 2019), since children are dependent on their parents’ resources (Graham & Power, 2004). Five potential mechanisms are considered in explaining inequalities in child mortality (Sidebotham et al., 2014). First, socioeconomic disadvantages related to parental socioeconomic position are an underlying factor in child survival (Pillas et al., 2014). Second, adverse birth outcomes are major determinants of death in infancy and early childhood (Spencer, 2003). Third, the hazardous physical environment of homes and surroundings are crucial to injury-related deaths (Ihong et al., 2016; Sengoege et al., 2011). Fourth, parental behavioral characteristics, including smoking, alcohol and substance addiction, intimate partner violence, and maltreatment are associated with child survival (Boyer et al., 2011; Blair et al., 2006). Fifth, child mortality can result from national policy initiatives, healthcare, and welfare services. The fifth mechanism warrants an understanding of the Korean context relevant to this study. Korean parents, especially mothers, take primary responsibility for childcare and nurturing. Mothers face the double burden of caring for families and making a living in the job market (Lokteff & Piercy, 2012). Specifically, economically disadvantaged mothers suffer more from double burden, and their children are at a higher risk of neglect than others (Chung et al., 2007). In addition, socioeconomic and cultural factors, such as economic uncertainty, high housing and education costs, and difficulty in balancing work and family make it hard for young couples to raise a family (Lee & Choi, 2015). As a result, Korea exhibits the lowest fertility rate worldwide. To tackle this problem, the South Korean government launched the fourth Low-Fertility and Aged Society Master Plan (2021–2025) (Ministry of Health and Welfare, 2022). The plan stresses the government’s responsibility in upholding the fundamental rights of children and parents, which includes meeting the healthcare needs of children, with healthy development as an important component. However, the Korean health system has crucial limitations in promoting health and tackling inequality in early childhood (Park et al., 2020). Services are centered on an “in-cash” provision with an “opt-in” process based on a means test, while the few existing universal health services are segmented and fragmented.

Although not absent, research on childhood mortality in Korea is rare. Some studies have focused on the associations between parental socioeconomic position and inequalities in child mortality. Part of this research analyzes the contribution of different causes of death to total socioeconomic inequalities in mortality based on the absolute difference in mortality and identified external causes as the leading cause of inequalities in child deaths (Jung-Choi & Kiang, 2011; Kim et al., 2009).

However, these studies have not considered the different child development phases. Most child deaths occur in infancy, and the main cause of death varies with age (Wolfe et al., 2014). Childhood consists of various stages with distinctive levels of mental, physical, social, and emotional capacities and, therefore, dissimilar etiologies in mortality (Sidebotham, Fraser, Covington, et al., 2014). For example, in neonates, perinatal and congenital causes are the overwhelming causes of death, while acute and chronic medical conditions and unexplained causes are primarily those for post-neonatal infants, and acute and chronic medical conditions and external causes for children aged 1–4 years. Identifying the main causes of child death and its inequalities may support better social and health policymaking and will eventually help achieve equality in child mortality.

This study aims to investigate the social inequalities in child mortality due to both the major causes of death and developmental phases of early childhood using recent data. Thus, we first identified the socioeconomic inequalities in child mortality according to maternal education, considering paternal economic participation and other related maternal and child characteristics. We then investigated the inequalities in cause-specific mortality according to the early childhood developmental phases. Finally, we analyzed the contribution of the major causes of death to total inequality in child mortality.

2. Methods

2.1. Study population

We used the 2012 Under-5 Infant Birth-Death Cohort Data provided by the Microdata Integrated Service (MDIS) of the Korea National Statistics Office (Statistics Korea, 2019). This dataset contained a birth cohort of all children born in 2012 in South Korea (N = 484,550) and was followed for 60 months. Statistics Korea generated this dataset using a two-step process that linked individual birth and death registrations between 2012 and 2017. After processing the missing values for variables, such as child characteristics (N = 1819), parental characteristics (N = 16,079), and deaths (N = 16), our study population finally included 1030 deaths from a total of 466,636 births (96.3% of the total number of births in 2012).

2.2. Variables

2.2.1. The dependent variable

The dependent variables were all-cause and cause-specific mortality according to the developmental phase. We defined the parameters for neonatal mortality (<28 days), post-neonatal mortality (28–364 days), and childhood mortality (1–4 years) (Rajaratnam et al., 2010). The causes of death were identified using the tenth version of the International Classification of Diseases (ICD-10). We classified the causes of death into six major disease categories: perinatal causes (P00–P96); congenital causes (Q00–Q99); unknown causes (R00–R99); injuries and external causes (S00-T98); neoplasms, blood, and immune mechanisms (C00-D48, D50-D89); and other causes (A00-B99, E00-E90, F00–F99, G00G09, I00–I99, J00–J99, K00–K93, M00-M99, N00–N99). Except for other causes that accounted for the most common causes of death for those under the age of 5, the category “other causes” incorporated infectious diseases and diseases from specific organ systems. Table 1 illustrates the grouping of a specific disease classification and the relevant number of deaths in this study.

2.2.2. The main predictor of interest

Maternal educational was the primary predictor of interest. In Korea, where the male-breadwinner ideology – fathers go out to work and mothers stay home and take care of the household – is dominant, it is sensible to measure households’ socioeconomic position through maternal education (“college or more”; “high-school or less”) and paternal economic participation (employed/not employed). Of these, we selected maternal education as the main independent variable as it is considered to have a pervasive effect on child health through its interplay with various key proximate determinants (Wagstaff et al., 2004). Considering that Korean society is characterized by assortative marriages centered on the education of one’s self and spouse (Seok & Noh, 2013), maternal education can better capture informational resources as the main caregiver, while the material aspects of households could be better captured by paternal occupation (Kim et al., 2007).

2.2.3. Control variables

Variables of child health at birth (healthy and unhealthy), birth...
characteristics (babies’ sex and region of birth), maternal obstetric history (multiple births, number of births, number of dead births), age (35 or more; less than 35), and parental occupational status (employed or unemployed) were included as covariates.

Table 1: Causes of death used in this study.

| Codes   | Korean Standard Classification of Diseases, KCD7 | This study               |
|---------|--------------------------------------------------|--------------------------|
| D00-D89 | Disease of the blood and blood-forming organs and certain disorders involving the immune mechanism | Neoplasms, blood, and immune mechanism causes |
| P00-P96 | Certain conditions originating in the perinatal period | Perinatal period causes |
| Q00-Q99 | Congenital malformations, deformations, and chromosomal abnormalities | Congenital causes |
| S00-T98 | Injury, poisoning, and certain other consequences of external causes | Injury and external causes |
| R00-R99 | Symptoms, signs, and abnormal clinical and laboratory findings, NEC | Unknown causes |
| A00-B99 | Certain infectious and parasitic diseases | Other causes |
| E00-E90 | Endocrine, nutritional, and metabolic diseases |  |
| F00-F99 | Mental and behavioral disorders |  |
| G00-G99 | Diseases of the nervous system |  |
| H00-H79 | Diseases of the digestive system |  |
| M00-M99 | Diseases of the musculoskeletal system and connective tissue |  |
| N00-N99 | Diseases of the genitourinary system |  |
| H00-H59 | Diseases of the eye and adnexa |  |
| H60-H95 | Diseases of the ear and mastoid process |  |
| L00-L99 | Diseases of the skin and subcutaneous tissue |  |
| O00-O99 | Pregnancy, childbirth, and the puerperium |  |
| Total   | 1030 | Total 1030 |

The mortality rate was calculated as the number of deaths per 100,000 person-years with a 95% confidence interval.

To compare the mortality of children using maternal education, hazard ratios (HRs) were calculated using a Cox proportional hazard regression model. We calculated HRs, including birth characteristics and maternal obstetric histories, and sequentially adjusted covariates to identify potential mediating effects. The first model included child health at birth, followed by maternal age and occupational status in the second model. The last model was adjusted for paternal occupational status. To present the disparities in the trajectories of mortality according to maternal education, we produced Kaplan-Meier survival graphs.

We then analyzed mortality inequalities based on the causes of death according to child age group (i.e., neonatal, post-neonatal, and childhood) to confirm the main causes of death in early childhood. Therefore, the HRs according to maternal education for each cause of death and age group were calculated using the Cox proportional regression model. We then calculated the slope index of inequality (SII) measure to analyze the contributions of each cause of death to the total mortality inequality (Jung-Choi & Khang, 2011). The SII measures the gradient of health across socioeconomic groups using a rank that indicates the relative SEP of the individual in the population (Moreno-Betancur et al., 2015). This measure is recommended for comparing the socioeconomic inequalities in mortality by cause of death within a population (Moreno-Betancur et al., 2015). In this study, we calculated the rank score of each level of maternal education according to its relative position in the cumulative population distribution. Then, the SII was calculated with linear regression using the rank score as an independent variable and each cause of death as a dependent variable. All analyses were conducted using STATA 12.0 software (College Station, TX: Stata Corp LP).

### 3. Results

#### 3.1. Socio-economic inequalities in Under-5 mortality

Most deaths (71.4%) occurred in the first year of birth, especially during the post-neonatal period, which showed a similar trend regardless of maternal education. More children of mothers with lower maternal education in all early childhood phases died (neonatal 40.6; post-neonatal 15.9; childhood 1.8 per 100,000 person-years) compared to their counterparts (neonatal 29.4; post-neonatal 9.6; childhood 1.1 per 100,000 person-years). The all-cause mortality rate was highest in the neonatal period and decreased thereafter (Table 2).

In general, all-cause mortality encompassed infants with adverse birth outcomes and those whose mothers had more births or previous deaths of children. Among parental characteristics, the children of mothers of advanced age or unemployed fathers had greater mortality. For most variables, socioeconomic inequalities in mortality according to maternal education, were evident.

Children with lower maternal education showed higher HRs for under-5 mortalities after adjusting for children’s birth characteristics and maternal obstetric histories (HR = 1.560; 95% CI = [1.374–1.772]) in the Cox proportional hazard model. The model remained statistically significant after additionally adjusting for child health at birth (HR = 1.433; 95% CI = [1.261–1.628]), the maternal characteristics of age and occupational status (HR = 1.348; 95% CI = [1.183–1.536]), and paternal occupational status (HR = 1.322; 95% CI = [1.160–1.507]) (Table 3).

The Kaplan-Meier survival graphs showed that children of mothers with lower maternal education died more often and faster than their counterparts (Fig. 1). The 95% intervals of the two educational groups did not overlap after the 1st month, indicating that the difference in survival was statistically significant throughout the analysis period. Furthermore, this difference increased until the 60th month; thus, inequality in child mortality was only exacerbated over time.

#### 3.2. The causes and phases of inequalities in Under-5 mortality

Inequalities in under-5 mortality varied according to the cause of death and developmental phase. The fully adjusted model (Model 2) confirmed that children of mothers with lower maternal education suffer from a higher risk of mortality due to “injury and external causes” (HR = 2.186, 95% CI = [1.541–3.101]), “unknown causes” (HR = 2.080, 95% CI = [1.484–2.915]), and “congenital causes” (HR = 1.358, 95% CI = [1.017–1.814]) (Table 4).

Different causes appeared significant when we repeated these analyses by developmental stage. No single cause was statistically significant in the neonatal period; however, the risk of mortality due to “injury and external causes” (HR = 2.178; 95% CI = [1.283–3.697]) and
| Table 2 | The unadjusted mortality rates of children by variables and age-groups. |
|---------|---------------------------------------------------------------|
| **Children’s Characteristics** | |
| **Sex** | |
| Girl | 162000 | 43 | 26.5 | [19.7-35.8] |
| Boy | 171498 | 55 | 32.1 | [24.6-41.8] |
| **Region** | |
| Seoul | 73571 | 22 | 29.9 | [19.7-45.4] |
| Metropolitan | 85033 | 23 | 27.0 | [18.0-40.7] |
| Other | 174894 | 53 | 30.3 | [23.2-39.7] |
| **Maternal Obstetric History** | |
| Singleton | 322553 | 69 | 21.4 | [16.9-27.1] |
| Multiple | 11145 | 29 | 260.2 | [180.8-374] |
| **Number of total births** | |
| 1 | 179625 | 42 | 23.4 | [17.3-31.6] |
| 2 | 127286 | 34 | 26.7 | [19.1-37.4] |
| ≥3 | 26587 | 22 | 82.7 | [54.3-123.7] |
| **Number of dead births** | |
| 0 | 352418 | 84 | 25.3 | [20.4-31.3] |
| ≥1 | 1080 | 12 | 1296.3 | [767.7-2188.8] |
| **Child health at birth** | |
| Healthy | 307723 | 27 | 8.8 | [6.0-12.8] |
| Unhealthy | 25775 | 71 | 275.5 | [218.3-347.6] |
| **Parental characteristics** | |
| Maternal age | |
| <35 | 274613 | 72 | 26.2 | [20.8-33.6] |
| ≥35 | 58885 | 26 | 44.2 | [30.1-64.8] |
| Maternal Occupational status | |
| Working | 137825 | 37 | 26.8 | [19.5-37.1] |
| Unemployed | 195673 | 61 | 31.2 | [24.3-40.1] |
| **Paternal Occupational status** | |
| Working | 323173 | 92 | 28.5 | [23.2-34.9] |
| Unemployed | 10325 | 6 | 58.1 | [26.1-129.3] |

**a.** The unit of ‘Rate’ is 100,000 people.
Injury and external causes (HR = 2.153; 95% CI = [1.347–3.440]) maintained their significant effect on inequalities among 13–60 months-old children.

The absolute inequalities and contributions of each cause of death to all-cause mortality inequality presented with a similar pattern according to the developmental stage (Table 5). Mortality inequalities were largest in the post-neonatal period. In the neonatal period, “congenital” (96.7%) and “unknown” (63.6%) causes were the leading causes of mortality inequality. In the post-neonatal period, “unknown causes” (58.2%), “injury and external causes” (28.4%), and “congenital causes” (23.9%) accounted for the largest proportion of total mortality inequality. Finally, during the childhood period, the contribution of “unknown causes” dramatically decreased. However, the proportion of “injury and external causes” increased to 56.5%, making it the primary cause of mortality inequality in children.

4. Discussion

The inequalities in child mortality due to maternal education were sustained and increased throughout early childhood. We confirmed that the main causes of death related to mortality inequality varied according to developmental stage. For example, congenital causes (neonatal mortality), unknown causes (post-neonatal mortality), and injuries and external causes (childhood mortality) have been identified as the main causes of inequalities in mortality, and the considerable impact of congenital causes persists throughout early childhood. In addition to other studies that have reported similar findings (Hong et al., 2010; Jung-Choi & Khang, 2011; Kim et al., 2009; Son et al., 2017), this study differentiated the major causes of death that suggest social inequalities in child mortality in accordance with the developmental context of children by age.

To the best of our knowledge, similar studies that examine the contribution of major causes of death to social inequalities in childhood mortality in other countries are scarce. A study from New Zealand

| Table 3 | The hazard ratios of Under-5 mortalities. |
|-----------------|-----------------|-----------------|-----------------|-----------------|
| Dependent Variable | Mortality Rates | Model 1 | Model 2 | Model 3 | Model 4 |
|                  | HRs[95% CI] | HRs[95% CI] | HRs[95% CI] | HRs[95% CI] |
| Maternal Educational Credentials |  |  |  |  |
| College or higher (Ref.) |  |  |  |  |
| High-school or lower | 1.560***[1.374–1.772] | 1.433***[1.261–1.628] | 1.348***[1.183–1.536] | 1.322***[1.160–1.507] |
| Child health at birth |  |  |  |  |
| Healthy (Ref.) |  |  |  |  |
| Unhealthy | 8.537***[7.733–10.098] | 8.752***[7.658–10.003] | 8.728***[7.637–9.976] |
| Parental characteristics |  |  |  |  |
| Maternal age |  |  |  |  |
| <35 (Ref.) | 1.166*[1.007–1.351] | 1.175*[1.014–1.361] |
| ≥35 |  |  |  |  |
| Maternal Occupational status |  |  |  |  |
| Working (Ref.) |  |  |  |  |
| Unemployed | 1.323***[1.144–1.529] | 1.303***[1.127–1.507] |
| Parental Occupational status |  |  |  |  |
| Working (Ref.) |  |  |  |  |
| Unemployed | 1.745***[1.377–2.211] |

N (obs) 466,636 | 466,636 | 466,636 | 466,636 | 466,636
N (failure) 1030 | 1030 | 1030 | 1030 | 1030
Chi2 344.19 | 1142.5 | 1161.19 | 1179.45 |
Log Likelihood -13271.759 | -12872.6 | -12863.26 | -12854.12 |
AIC 26559.51 | 25763.2 | 25748.51 | 25732.25 |
BIC 26647.94 | 25862.68 | 25870.1 | 25864.89 |

a. All models were already adjusted for the sex and region of births, and the maternal obstetric histories (multiple births, number of births, number of dead births).
b. *p < 0.05, **p < 0.01, ***p < 0.001.

Fig. 1. The Kaplan-Meier survival graph according to maternal educational credentials.
Table 4: The hazard ratios of Under-5 mortalities for each cause of deaths.

| Age     | Total Deaths | Deaths | [95% CI] | HRb | [95% CI] | HRc | [95% CI] |
|---------|--------------|--------|----------|------|----------|------|----------|
| Neoplasms, Blood, and Immunization | 1030 | 0.982 | (0.926-1.042) | 1.017* | (0.955-1.079) | 1.047*** | (1.003-1.092) |
| Unintentional injury | 1030 | 1.197 | (1.061-1.346) | 1.078 | (0.922-1.254) | 1.054 | (0.884-1.262) |
| Infections | 1030 | 1.084 | (0.970-1.205) | 1.036 | (0.917-1.168) | 1.062 | (0.921-1.221) |
| Other | 77 | 0.923 | (0.952-1.152) | - | - | - | - |
| Total | 1030 | 1.084 | (1.035-1.137) | 1.047*** | (1.003-1.092) | 1.054 | (0.921-1.221) |

The HRs and 95%CI were not reported if the deaths were under 10.

4.1. Potential mechanisms of inequalities in cause-specific mortality by developmental phase

Similar to Kim et al. (2009), we confirmed the considerable social inequalities in mortality owing to congenital causes. Further analysis showed that cardiovascular malformations accounted for most congenital causes of death in neonates (50.5%), postnatally (61.3%), and in childhood (50.0%). CHD-related mortality is known to be associated with socioeconomic disadvantages and poor healthcare systems, such as inappropriate care from parents or delayed and insufficient medical care, respectively (Best et al., 2019). Although considerable improvements have been achieved in CHD surgical outcomes over the last three decades in Korea (Lee, 2020), children with CHD are at a high risk of readmission, surgery, and mortality from infections (Curtis & Stuart, 2005). The Korean government has managed the registry system for congenital diseases; however, services for children with special needs are limited to assisting with medical expenses, which is also restricted to low-income families (Park et al., 2020).

Social inequalities in mortality from unknown causes require further investigation (Son et al., 2017). SIDS (65.3%) and unspecified causes (22.6%) were dominant among unknown causes in the post-neonatal period. The estimated SIDS rate in Korea (0.2 per 1000 in 2018) (Statistics Korea, 2021) is similar to that of other wealthy countries (0.1–0.4 in 2014–15) (Bartick & Tomori, 2019). A Korean review study of autopsy-diagnosed cases among SIDS incidence identified that marginalized infants may suffer from housing poverty, lack of proper care, or a high risk of violence (Yoo et al., 2013).

Deaths from injuries and external causes are crucial to the inequalities in mortality rates. Specific mechanisms exhibit distinct characteristics according to the developmental stage (Hong et al., 2010). Asphyxiation (35.0%) and foreign body in respiratory tract (28.3%) in the post-neonatal period and head injuries (34.7%) in the childhood period were identified as the most frequent mechanisms. The main causes of injuries in the post-neonatal period were accidental suffocation and strangulation (25.0%), whereas traffic accidents (40.0%) were the most frequent in the childhood period. Inequalities in unintentional injury deaths are related to the socioeconomic disadvantages in the home environment, including care for children, neighborhood environment, and relevant regulations (LaFlamme et al., 2010). Specifically, transport accident deaths in Korea (8.2 per 100,000 population) are confirmed as the main contributor to social inequalities in child deaths aged 1–14 years (Shaw et al., 2005). Studies on child deaths usually focus on identifying distinctive patterns of mortality by age in major categories of death (Pearson & Stone, 2009; Sidebotham, Fraser, Covington, et al., 2014; Wolfe et al., 2014). Our results on the major causes of death and their potential mechanisms by age are similar to those in these studies. For example, perinatal causes such as respiratory distress in newborns and congenital causes such as congenital heart disease (CHD) are crucial causes of death in neonates, unexplained causes including sudden infant death syndrome (SIDS) in post-neonatal infants, and acute and chronic diseases (e.g. diseases of the nervous system) and injuries including traffic injury in children aged 1–4 years (Table 6). Although most deaths occurred during the neonatal period, and death from other acute and chronic disease showed the highest frequency in the post-neonatal period (Sidebotham, Fraser, Covington, et al., 2014), our results revealed that most deaths occurred in the post-neonatal period, and deaths from other causes were the second-highest cause in the post-neonatal period. Nonetheless, the potential mechanisms of other causes (diseases of the nervous, respiratory, and circulatory systems and infections) were similar to those of previous studies. Notably, these are related to preterm births, which are risk factors for neonatal mortality (Viner et al., 2014); thus Korea’s birth registration system may affect this difference as it is obligated to register the birth and death of a baby within a month, which may lead to birth registration omissions (Song, 2017).
higher than those in other OECD countries (6.4 per 100,000) \(^3\) (OECD, 2022). Despite the Korean government’s measures to prevent traffic injury deaths since 1990, relevant policies are still in their early stages; for instance, compulsory seat belts for all car occupants were only enforced in 2018 (ITF, 2021). Drivers’ poor safety consciousness, such as speeding and driving under the influence of alcohol, as well as poor infrastructure, such as lack of sidewalks, were identified as major causes of road fatalities in Korea (International Transport Forum[ITF], 2021). These road traffic injury deaths are disproportionately distributed to the people living in deprived areas (Park et al., 2010).

However, deaths due to intentional injury require urgent attention. These accounted for the second largest cause (15.4%) of injury-related early childhood mortality, second only to traffic accidents (25.7%). Family discord, economic problems, and parental mental illness are considered the main causes of filicides in Korea (Jung et al., 2014). Non-fatal maltreatment, such as inadequate supervision, may also be an important factor (Jonson-Reid et al., 2007) because it is difficult to distinguish between accidents, poor supervision, or homicides in deaths at home (Sibert & Sidebotham, 2007).  

### 4.2. Tackling social determinants of child death inequality by developmental phase

Considerable effort may be necessary to tackle the social inequalities in mortality in early childhood. A systematic review of all child deaths may be essential for preventing future child deaths. In Korea, suspicious cases are initially handled by the National Forensic Service (Jung et al., 2020). However, if all child deaths are scrutinized, we can draw an assessment framework for Korean children’s deaths (Fraser et al., 2014). Health systems play a unique role in promoting child health before school age because children’s health needs vary according to their developmental stage (Nicholson & Greenwood, 2018). In general, a high-quality universal home-visiting program is recommended for health promotion during early childhood (Sengoelelg et al., 2011). Such a program could help identify home-based risk factors and provide proper programs for families, even when mothers are unaware of their needs (Nicholson & Greenwood, 2018). This is desirable to be provided in terms of a “continuum of care,” which means integrated care throughout the early-life stages (adolescence, pregnancy, childbirth, childhood) and place of caregiving (home, community, primary and secondary care) (Kerber et al., 2007). In Korea, a national pilot project for home-visit programs has been implemented (Khang et al., 2018). Moreover, establishing a care model for children with chronic health conditions may be important as the majority of children survive but suffer chronic health conditions (Wolfle et al., 2013).  

In addition, strategies for mitigating traffic injury-related deaths should focus on pedestrian safety, which has been confirmed as areas of weakness in Korea. In this regard, multisectoral efforts may be necessary not only to improve emergency and trauma care for children, but also to invest in the community’s physical resources and institutional support, especially for disadvantaged communities (McFarland & Laird, 2018; Park et al., 2010; Roberts et al., 1995).  

To address the social inequalities in child mortality in these issues, services based on a disproportionate universalist approach – providing universal services with an intensity proportional to the degree of need (Lynch et al., 2010) – could be helpful, as socially disadvantaged children may have complicated problems from family circumstances that require additional support (World Health Organization, 2018).

### 4.3. Strengths, weaknesses, and future studies

To the best of our knowledge, this is the first study to reveal social inequalities in child mortality by both developmental stage and major causes of death, using relatively recent vital statistics. We further demonstrate the contribution of the role played by the major causes of death to the total rate of mortality inequalities according to each stage of development.

We acknowledge some limitations to this study. In some instances, the number of samples was small when stratified by both developmental phase and major causes of death. In addition, neonatal mortality among disadvantaged families may have been underreported because parents are obligated to register the birth and death of a baby only within a month (Han et al., 2002). Finally, we restricted our study sample to cases in which both the mother and father were present; therefore, children from single-parent families who are considered the most vulnerable were excluded from this study. Future studies should consider children with such disadvantaged parents because they may suggest different aspects of social inequalities (Weitoft et al., 2003). In particular, although the epidemiological perspective is important, a follow-up study from a sociological perspective is needed to investigate the point where the social status of Korean women and the socioeconomic inequality of child mortality intersect and the social structure that affects it. Finally, an international comparative study may offer lessons regarding preventable deaths from different priorities in government, social values, and the systems and services for child development and health (Wolfle et al., 2014).

### 5. Conclusion

Inequalities in child mortality are unjust and avoidable, at least in part. To promote child health and health equity, improvements in the healthcare system and policy based on multisectoral collaboration may be necessary. Considering children’s and families’ needs based on child developmental stage may be helpful in alleviating social inequalities in child mortality. In doing so, we must remember that our goal is not the mere survival of children but the prosperous development and well-being of all children.

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\(^3\) In terms of 2020, or the latest available value, the lowest road traffic mortality was 2 per 100,000 in Ireland, whereas the highest was 16.4 per 100,000 in Columbia (France, Italy, New Zealand, and Turkey did not report).
Table 6
Major specific causes of death according to each cause of death.

### Unknown causes

| Codes | Disease | Total(N = 148) | Neonatal(N = 7) | Post-neonatal(N = 117) | Childhood(N = 27) |
|-------|---------|---------------|----------------|------------------------|-------------------|
| R95  | Sudden infant death syndrome | 84 (56.8) | 4 (57.1) | 77 (65.8) | 3 (12.5) |
| R99  | Other ill-defined and unspecified causes of mortality | 41 (27.7) | 3 (42.9) | 25 (21.4) | 13 (54.2) |

### Injuries and external causes

| Codes | Disease | Total(N = 136) | Neonatal(N = 1) | Post-neonatal(N = 60) | Childhood(N = 75) |
|-------|---------|---------------|----------------|------------------------|-------------------|
| T71  | Asphyxiation | 27 (19.9) | 0 (0.0) | 21 (35.0) | 6 (8.0) |
| S06  | Intracranial injury | 26 (19.1) | 0 (0.0) | 8 (13.3) | 18 (24.0) |
| T17  | Effects of other external causes | 15 (11.1) | 0 (0.0) | 2 (3.3) | 13 (17.3) |
| S02  | Fracture of skull and facial bones | 12 (8.8) | 0 (0.0) | 5 (8.3) | 7 (9.3) |
| S09  | Other and unspecified injuries of head | 1 (0.7) | 0 (0.0) | 0 (0.0) | 1 (1.3) |

### Congenital causes

| Codes | Diseases | Total(N = 212) | Neonatal(N = 37) | Post-neonatal(N = 137) | Childhood(N = 38) |
|-------|----------|---------------|----------------|------------------------|-------------------|
| Q20  | Congenital malformations of cardiac chambers and connections | 31 (14.6) | 6 (16.2) | 17 (12.4) | 8 (21.1) |
| Q21  | Congenital malformations of cardiac septa | 31 (14.6) | 3 (8.1) | 26 (19.0) | 2 (5.3) |
| Q25  | Congenital malformations of great arteries | 17 (8.0) | 5 (13.5) | 9 (6.6) | 3 (7.9) |
| Q23  | Congenital malformations of aortic and mitral valves | 15 (7.1) | 1 (2.7) | 12 (8.8) | 2 (5.3) |
| Q26  | Congenital malformations of great veins | 11 (5.2) | 2 (5.4) | 7 (5.1) | 2 (5.3) |
| Q24  | Other congenital malformations of heart | 10 (4.7) | 1 (2.7) | 7 (5.1) | 2 (5.3) |
| Q22  | Congenital malformations of pulmonary and tricuspid valves | 9 (4.3) | 3 (8.1) | 6 (4.4) | 0 (0.0) |
| Q28  | Other congenital malformations of circulatory system | 1 (0.5) | 1 (2.7) | 0 (0.0) | 0 (0.0) |

### Perinatal causes

| Codes | Diseases | Total(N = 282) | Neonatal(N = 104) | Post-neonatal(N = 172) | Childhood(N = 6) |
|-------|----------|---------------|----------------|------------------------|-------------------|
| F22  | Respiratory distress of newborn | 97 (34.4) | 51 (49.0) | 46 (26.7) | 0 (0.0) |
| F36  | Bacterial sepsis of newborn | 36 (12.8) | 6 (5.8) | 30 (17.4) | 0 (0.0) |
| P27  | Chronic respiratory disease originating in the perinatal period | 32 (11.4) | 1 (1.0) | 27 (15.7) | 4 (66.7) |

### Neoplasms, blood, and immune mechanism causes

| Codes | Diseases | Total(N = 77) | Neonatal(N = 1) | Post-neonatal(N = 19) | Childhood(N = 57) |
|-------|----------|---------------|----------------|------------------------|-------------------|
| C71  | Malignant neoplasm of brain | 21 (27.3) | 0 (0.0) | 4 (21.1) | 17 (29.8) |
| C74  | Malignant neoplasm of adrenal gland | 8 (10.4) | 0 (0.0) | 1 (5.3) | 7 (12.3) |
| C92  | Myeloid leukemia | 7 (9.1) | 0 (0.0) | 3 (15.8) | 4 (7.0) |
| D76  | Other specified diseases with participation of lymphoreticular and reticuloendothelial system | 7 (9.1) | 0 (0.0) | 3 (15.8) | 4 (7.0) |
| C91  | Lymphoid leukemia | 6 (7.8) | 0 (0.0) | 0 (0.0) | 6 (10.5) |

### Other causes

| Codes | Diseases | Total(N = 175) | Neonatal(N = 2) | Post-neonatal(N = 78) | Childhood(N = 95) |
|-------|----------|---------------|----------------|------------------------|-------------------|
| G71  | Primary disorders of muscles | 13 (7.4) | 0 (0.0) | 7 (9.0) | 6 (6.3) |
| G93  | Other disorders of brain | 13 (7.4) | 0 (0.0) | 5 (6.4) | 8 (8.4) |
| G40  | Epilepsy | 10 (5.7) | 0 (0.0) | 0 (0.0) | 10 (10.5) |
| I40  | Acute myocarditis | 9 (5.1) | 0 (0.0) | 4 (5.1) | 5 (5.3) |
M. Jo et al.

CRediT author contributions

Minjin Jo: Conceptualization, investigation, writing–original draft preparation, writing–review and editing. Inseong Oh: Formal analysis, data curation, writing – original draft preparation, visualization. Dae seul Moon: Conceptualization, writing–original draft preparation, writing–review and editing. Sodam Kim: Writing–original draft preparation. Kyungsoo Jung-Choi: Methodology, writing–review and editing, project administration. Haejoo Chung: Conceptualization, methodology, writing–review and editing, project administration, supervision.

Ethical approval

The study protocol was approved by the Institutional Review Board of Korea University (IRB No. KUIRB-2019-0223-01).

Declaration of competing interest

None.

Data availability

Data will be made available on request.

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