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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 = [1.572–3.363]) 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" (56.5%) 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,"

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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 (Hong et al., 2010; Sengoelge et al., 2011). Fourth, parental behavioral characteristics, including smoking, alcohol and substance addiction, intimate partner violence, and maltreatment are associated with child survival (Berger 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 & Khang, 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, G00G99, 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 and work, 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[2]), birth

[2] We defined "unhealthy" as "low birth weight" (LBW; <2.5 kg), "preterm birth" (PTB; <37 weeks), and "both LBW and PTB." All other children were categorized into the "healthy" group.

Table 1
Causes of death used in this study.

Codes	Korean Standard Classification of Diseases, KCD7		This study	
	Classification of disease	N	Cause of Death	N
C00-D48 D50-D89	Neoplasms Disease of the blood and blood-forming organs and certain disorders involving the immune mechanism	77	Neoplasms, blood, and immune mechanism causes	77
P00–P96	Certain conditions originating in the perinatal period	282	Perinatal period causes	282
Q00-Q99	Congenital malformations, deformations, and chromosomal abnormalities	212	Congenital causes	212
S00-T98	Injury, poisoning, and certain other consequences of external causes	136	Injury and external causes	136
R00-R99	Symptoms, signs, and abnormal clinical and laboratory findings, NEC	148	Unknown causes	148
A00-B99	Certain infectious and parasitic diseases	20	Other causes	175
E00-E90	Endocrine, nutritional, and metabolic diseases	11		
F00–F99	Mental and behavioral disorders	1		
G00-G99	Diseases of the nervous system	72		
I00–I99	Diseases of the circulatory system	31		
J00-J99	Diseases of the respiratory system	27		
K00–K93	Diseases of the digestive system	6		
M00-M99	Diseases of the musculoskeletal system and connective tissue	2		
N00–N99	Diseases of the genitourinary system	5		
H00–H59	Diseases of the eye and adnexa	0		
H60–H95	Diseases of the ear and mastoid process	0		
L00-L99	Diseases of the skin and subcutaneous tissue	0		
O00–O99	Pregnancy, childbirth, and the puerperium	0		
Total		1030	Total	1030

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.

2.3. Statistical analyses

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.

College or higher:

	Neonatal (0–1m)				Post-neonatal (1–12m)				Childhood (13–60m)			
	Person-years	N	Rate	[95% CI]	Person-years	N	Rate	[95% CI]	Person-years	N	Rate	[95% CI]
Total	333498	98	29.4	[24.1–35.8]	3664803	350	9.6	[8.6–10.6]	16313972	178	1.1	[0.9–1.3]
Children's Characteristics												
Sex												
Girl	162000	43	26.5	[19.7–35.8]	1780327	160	9.0	[7.7–10.5]	7925276	85	1.1	[0.9–1.3]
Boy	171498	55	32.1	[24.6–41.8]	1884476	190	10.1	[8.7–11.6]	8388696	93	1.1	[0.9–1.4]
Region												
Seoul	73571	22	29.9	[19.7–45.4]	808520	70	8.7	[6.8–10.9]	3599440	37	1.0	[0.7–1.4]
Metropolitan	85033	23	27.0	[18.0–40.7]	934472	85	9.1	[7.4–11.3]	4160169	40	1.0	[0.7–1.3]
Other	174894	53	30.3	[23.2–39.7]	1921811	195	10.1	[8.8–11.7]	8554363	101	1.2	[1.0–1.4]
Maternal Obstetric History												
Multiple Birth												
Singleton	322353	69	21.4	[16.9–27.1]	3542912	304	8.6	[7.7–9.6]	15771972	164	1.0	[0.9–1.2]
Multiple	11145	29	260.2	[180.8–374.4]	121891	46	37.7	[28.3–50.4]	542000	14	2.6	[1.5–4.4]
Number of total births												
1	179625	42	23.4	[17.3–31.6]	1974277	151	7.6	[6.5–9.0]	8789557	88	1.0	[0.8–1.2]
2	127286	34	26.7	[19.1–37.4]	1398627	156	11.2	[9.5–13]	6225368	75	1.2	[1.0–1.5]
≥3	26587	22	82.7	[54.5–125.7]	291899	43	14.7	[10.9–19.9]	1299047	15	1.2	[0.7–1.9]
Number of dead births												
0	332418	84	25.3	[20.4–31.3]	3653187	336	9.2	[8.3–10.2]	16262515	175	1.1	[0.9–1.2]
≥1	1080	14	1296.3	[767.7–2188.8]	11616	14	120.5	[71.4–203.5]	51457	3	5.8	[1.9–18.1]
Child health at birth												
Healthy	307723	27	8.8	[6.0–12.8]	3383517	173	5.1	[4.4–5.9]	15064832	126	0.8	[0.7–1.0]
Unhealthy	25775	71	275.5	[218.3–347.6]	281286	177	62.9	[54.3–72.9]	1249140	52	4.2	[3.2–5.5]
Parental characteristics												
Maternal age												
<35	274613	72	26.2	[20.8–33.0]	3018001	262	8.7	[7.7–9.8]	13435308	142	1.1	[0.9–1.2]
≥35	58885	26	44.2	[30.1–64.8]	646802	88	13.6	[11.0–16.8]	2878664	36	1.3	[0.9–1.7]
Maternal Occupational status												
Working	137825	37	26.8	[19.5–37.1]	1514798	119	7.9	[6.6–9.4]	6743878	65	1.0	[0.8–1.2]
Unemployed	195673	61	31.2	[24.3–40.1]	2150005	231	10.7	[9.4–12.2]	9570094	113	1.2	[1.0–1.4]
Paternal Occupational status												
Working	323173	92	28.5	[23.2–34.9]	323173	92	28.5	[23.2–34.9]	15809454	170	1.1	[0.9–1.2]
Unemployed	10325	6	58.1	[26.1–129.3]	113407	16	14.1	[8.6–23.0]	504518	8	1.6	[0.8–3.2]

High-school or lower:

	Neonatal (0–1m)				Post-neonatal (1–12m)				Childhood (13–60m)			
	Person-years	N	Rate	[95% CI]	Person-years	N	Rate	[95% CI]	Person-years	N	Rate	[95% CI]
Total	133138	54	40.6	[31.1–53.0]	1462177	233	15.9	[14.0–18.1]	6506303	117	1.8	[1.5–2.2]
Children's Characteristics												
Sex												
Girl	64994	26	40.0	[27.2–58.8]	713924	99	13.9	[11.4–16.9]	3177090	55	1.7	[1.3–2.3]
Boy	68144	28	41.1	[28.4–59.5]	748253	134	17.9	[15.1–21.2]	3329213	62	1.9	[1.5–2.4]
Region												
Seoul	17688	8	45.2	[22.6–90.4]	194282	30	15.4	[10.8–22.1]	864592	11	1.3	[0.7–2.3]
Metropolitan	32107	16	49.8	[30.5–81.3]	352533	61	17.3	[13.5–22.2]	1568742	23	1.5	[1.0–2.2]
Other	83343	30	36.0	[25.2–51.5]	915362	142	15.5	[13.2–18.3]	4072969	83	2.0	[1.6–2.5]
Maternal Obstetric History												
Multiple Birth												
Singleton	129204	40	31.0	[22.7–42.2]	1419199	216	15.2	[13.3–17.4]	6315279	111	1.8	[1.5–2.1]
Multiple	3934	14	355.9	[210.8–600.9]	42978	17	39.6	[24.6–63.6]	191024	6	3.1	[1.4–7.0]
Number of total births												
1	60491	17	28.1	[17.5–45.2]	664502	98	14.7	[12.1–18.0]	2956915	56	1.9	[1.5–2.5]
2	51048	22	43.1	[28.4–65.5]	560628	85	15.2	[12.3–18.8]	2494785	45	1.8	[1.3–2.4]
≥3	21599	15	69.4	[41.9–115.2]	237047	50	21.1	[16.0–27.8]	1054603	16	1.5	[0.9–2.5]
Number of dead births												
0	132418	49	37.0	[28.0–49.0]	1454350	227	15.6	[13.7–17.8]	6471630	115	1.8	[1.5–2.1]
≥1	720	5	694.4	[289.0–1668.4]	7827	6	76.7	[34.4–170.6]	34673	2	5.8	[1.4–23.1]
Child health at birth												
Healthy	120759	18	14.9	[9.4–23.7]	1327248	132	9.9	[8.4–11.8]	5907104	93	1.6	[1.3–1.9]
Unhealthy	12379	36	290.8	[209.8–403.2]	134929	101	74.9	[61.6–91.0]	599199	24	4.0	[2.7–6.0]
Parental characteristics												
Maternal age												
<35	104643	36	34.4	[24.8–47.7]	1149342	178	15.5	[13.4–17.9]	5114485	88	1.7	[1.4–2.1]
≥35	28495	18	63.2	[39.8–100.3]	312835	55	17.6	[13.5–22.9]	1391818	29	2.1	[1.4–3.0]
Maternal Occupational status												
Working	22840	5	21.9	[9.1–52.6]	250984	24	9.6	[6.4–14.3]	1117333	14	1.3	[0.7–2.1]
Unemployed	110298	49	44.4	[33.6–58.8]	1211193	209	17.3	[15.1–19.8]	5388970	103	1.9	[1.6–2.3]
Paternal Occupational status												
Working	125312	49	39.1	[29.6–51.7]	1376329	207	15.0	[13.1–17.2]	6124700	103	1.7	[1.4–2.0]
Unemployed	7826	5	63.9	[26.6–153.5]	85848	26	30.3	[20.6–44.5]	381603	14	3.7	[2.2–6.2]

a. The unit of 'Rate' is 100,000 people.

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		8.837***[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]
Paternal Occupational status				
Working (Ref.)				
Unemployed				1.745***[1.377–2.211]
N (obs)	466,636	466,636	466,636	466,636
N (failure)	1030	1030	1030	1030
Chi2	344.19	1142.5	1161.19	1179.45
Log Likelihood	−13271.757	−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. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

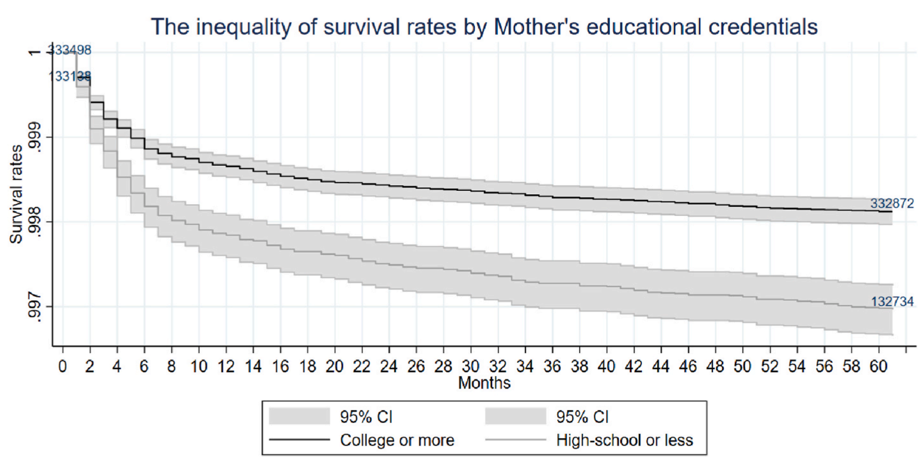

Fig. 1. The Kaplan-Meier survival graph according to maternal educational credentials.

"unknown causes" (HR = 2.299; 95% CI = [1.572–3.363]) was significant in the post-neonatal period. "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. Post-neonatal SII accounted for the largest percentage (59.2%) of the total SII. 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 4
The hazard ratios of Under-5 mortalities for each cause of deaths.

DV	Mortality rates of children with lower maternal educational credential											
Age	Total			Neonatal (0–1)			Post-neonatal (2-12)			Childhood (13–60)		
Cause	Deaths	HRs	[95% CI]	Deaths	HRs	[95% CI]	Deaths	HRs	[95% CI]	Deaths	HRs	[95% CI]
Model 1												
Total	1030	1.560***	[1.374–1.772]	152	1.308	[0.932–1.835]	583	1.603***	[1.354–1.897]	295	1.625***	[1.283–2.059]
Injury and External	136	2.624***	[1.864–3.694]	1	–	–	60	2.567***	[1.533–4.297]	75	2.605***	[1.645–4.126]
Unknown	148	2.303***	[1.659–3.198]	7	–	–	117	2.506***	[1.732–3.626]	24	1.410	[0.611–3.253]
Perinatal	282	1.139	[0.883–1.469]	104	1.101	[0.722–1.677]	172	1.159	[0.837–1.603]	6	–	–
Congenital	212	1.617**	[1.223–2.140]	37	1.659	[0.850–3.240]	137	1.576*	[1.111–2.234]	38	1.733	[0.899–3.340]
Other	175	1.372*	[1.003–1.877]	2	–	–	78	1.295	[0.809–2.072]	95	1.422	[0.930–2.174]
Neoplasms, Blood, and Immunization	77	0.982	[0.595–1.622]	1	–	–	19	0.823	[0.291–2.328]	57	1.066	[0.600–1.894]
Model 2												
Total	1030	1.322***	[1.160–1.507]	152	1.078	[0.760–1.529]	583	1.332**	[1.120–1.585]	295	1.447**	[1.134–1.846]
Injury and External	136	2.186***	[1.541–3.101]	1	–	–	60	2.178**	[1.283–3.697]	75	2.153**	[1.347–3.440]
Unknown	148	2.080***	[1.484–2.915]	7	–	–	117	2.299***	[1.572–3.363]	24	1.207	[0.513–2.837]
Perinatal	282	0.915	[0.704–1.189]	104	0.943	[0.611–1.457]	172	0.899	[0.644–1.255]	6	–	–
Congenital	212	1.358*	[1.017–1.814]	37	1.308	[0.661–2.587]	137	1.339	[0.933–1.923]	38	1.484	[0.750–2.937]
Other	175	1.170	[0.849–1.613]	2	–	–	78	1.053	[0.652–1.699]	95	1.274	[0.823–1.973]
Neoplasms, Blood, and Immunization	77	0.923	[0.552–1.542]	1	–	–	19	0.655	[0.229–1.871]	57	1.089	[0.603–1.968]

a. *$p \leq 0.05$, **$p \leq 0.01$, ***$p \leq 0.001$.
b. All HRs are the hazard ratio of children with 'High-school or lower mothers' compared to children with 'College or higher mothers'.
c. Model 1: Sex and region of birth were adjusted.
d. Model 2: Sex, region of birth, multiple births, the number of births, the number of dead births, maternal age, and parental occupational status were fully adjusted.
e. The HRs and 95%CI were not reported if the deaths were under 10.

confirmed injury 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 child 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).

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 (59.5%), 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

Table 5
Absolute inequalities (SII) and contributions to total mortalities of each cause of deaths.

Age	Total		Neonatal (0–1)		Post-neonatal (2-12)		Childhood (13–60)	
Causes	SII	(%)	SII	(%)	SII	(%)	SII	(%)
Total	142.24	(100.0)	5.17	(100.0)	84.14	(100.0)	53.04	(100.0)
Injury and External	54.98	(38.7)	1.17	(22.6)	23.92	(28.4)	29.97	(56.5)
Unknown	54.51	(38.3)	3.29	(63.6)	48.97	(58.2)	2.28	(4.3)
Perinatal	13.61	(9.6)	0.41	(7.8)	2.31	(2.8)	10.91	(20.6)
Congenital	32.47	(22.8)	5.00	(96.7)	20.07	(23.9)	7.41	(14.0)
Other	−10.70	(-7.5)	−3.49	(-67.5)	−7.62	(-9.1)	0.39	(0.7)
Neoplasms, blood, and immune system	−2.63	(-1.9)	−1.19	(-23.0)	−3.51	(-4.2)	2.09	(3.9)

a. SII: Slope index of inequality (deaths per 100,000 people).
b. The percentages (%) means the contributions of each cause of deaths to total under-5 mortalities inequalities.
c. All other variables were fully adjusted.

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 (Sengoelge 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 (Wolfe 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 proportionate 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 (Wolfe 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.

[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)	
		N	(%)	N	(%)	N	(%)	N	(%)
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)	
		N	(%)	N	(%)	N	(%)	N	(%)
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	Foreign body in respiratory tract	20	(14.7)	0	(0.0)	17	(28.3)	3	(4.0)
T75	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)

Codes	Events or circumstances of injuries	Total(N = 136)		Neonatal(N = 1)		Post-neonatal(N = 60)		Childhood(N = 75)	
		N	(%)	N	(%)	N	(%)	N	(%)
V031–V892	Traffic accident	35	(25.7)	0	(0.0)	5	(8.3)	30	(40.0)
W040–W200	Fall	19	(14.0)	0	(0.0)	7	(11.7)	12	(16.0)
W650-749	Drowning	11	(8.1)	0	(0.0)	2	(3.3)	9	(12.0)
W750–W760	Accidental suffocation and strangulation	16	(11.8)	0	(0.0)	15	(25.0)	1	(1.3)
W780–W809	Inhalation of gastric contents or food	14	(10.3)	0	(0.0)	13	(21.7)	1	(1.3)
W840–W849	Unspecified threats to breathing	9	(6.6)	1	(100.0)	6	(10.0)	2	(2.7)
X090-X378	Exposure to smoke, fire, flames, etc.	5	(3.7)	0	(0.0)	2	(3.3)	3	(4.0)
X880-Y070	Assaulted by strangulations, drowning, etc.	21	(15.4)	0	(0.0)	7	(11.7)	14	(18.7)
Y340–Y349	Unspecified event	6	(4.4)	0	(0.0)	3	(5.0)	3	(4.0)

Congenital causes

Codes	Diseases	Total(N = 212)		Neonatal(N = 37)		Post-neonatal(N = 137)		Childhood(N = 38)	
		N	(%)	N	(%)	N	(%)	N	(%)
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)	
		N	(%)	N	(%)	N	(%)	N	(%)
P22	Respiratory distress of newborn	97	(34.4)	51	(49.0)	46	(26.7)	0	(0.0)
P36	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)	
		N	(%)	N	(%)	N	(%)	N	(%)
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 reticulohistiocytic tissue	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)	
		N	(%)	N	(%)	N	(%)	N	(%)
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)

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. **Daseul Moon**: Conceptualization, writing–original draft preparation, writing–review and editing. **Sodam Kim**: Writing–original draft preparation. **Kyunghee 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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References

Bartick, M., & Tomori, C. (2019). Sudden infant death and social justice: A syndemics approach. *Maternal and Child Nutrition, 15*(1), Article e12652.

Berger, R. P., Fromkin, J. B., Stutz, H., Makoroff, K., Scribano, P. V., Feldman, K., Tu, L. C., & Fabio, A. (2011). Abusive head trauma during a time of increased unemployment: A multicenter analysis. *Pediatrics, 128*(4), 637–643.

Best, K. E., Vieira, R., Glinianaia, S. V., & Rankin, J. (2019). Socio-economic inequalities in mortality in children with congenital heart disease: A systematic review and meta-analysis. *Paediatric & Perinatal Epidemiology, 33*(4), 291–309.

Blair, P. S., Sidebotham, P., Berry, P. J., Evans, M., & Fleming, P. J. (2006). Major epidemiological changes in sudden infant death syndrome: A 20-year population-based study in the UK. *Lancet, 367*(9507), 314–319.

Chung, M., Kwak, E., & Yoon, J. (2007). Comparison of parenting between middle and low income families. *Journal of Korea Open Association for Early Childhood Education, 12*(4), 347–369.

Curtis, S. L., & Stuart, A. G. (2005). Outcome in congenital heart disease. *Current Paediatrics, 15*(7), 549–556.

Fraser, J., Sidebotham, P., Frederick, J., Covington, T., & Mitchell, E. A. (2014). Learning from child death review in the USA, England, Australia, and New Zealand. *Lancet, 384*(9946), 894–903.

Graham, H., & Power, C. (2004). *Childhood disadvantage and adult health: A lifecourse framework*. Citeseer.

Han, Y., Lee, S., Jang, Y., Kim, D., & Lee, S. (2002). *Infant and perinatal mortality rates of Korea in 1999 and 2000*. Korea Institute for Health and Social Affairs.

Hong, J., Lee, B., Ha, E. H., & Park, H. (2010). Parental socioeconomic status and unintentional injury deaths in early childhood: Consideration of injury mechanisms, age at death, and gender. *Accident Analysis & Prevention, 42*(1), 313–319.

International Transport Forum [ITF]. (2021). *Korea: Road safety country profile*. https://www.itf-oecd.org/sites/default/files/korea-road-safety.pdf.

Jonson-Reid, M., Chance, T., & Drake, B. (2007). Risk of death among children reported for nonfatal maltreatment. *Child Maltreatment, 12*(1), 86–95.

Jung-Choi, K., & Khang, Y. H. (2011). Contribution of different causes of death to socioeconomic mortality inequality in Korean children aged 1–9: Findings from a national mortality follow-up study. *Journal of Epidemiology & Community Health, 65*(2), 124–129.

Jung, K., Kim, H., Lee, E., Choi, I., Lim, H., Lee, B., Choi, B., Kim, J., Kim, H., & Hong, H.-G. (2020). Cluster analysis of child homicide in South Korea. *Child Abuse & Neglect, 101*, Article 104322.

Jung, S.-K., Lee, J.-R., Kim, J.-Y., Taq, G.-J., Oh, I.-J., & Myoung, E.-C. (2014). Analysis of parricide and filicide in Korea. *Korean Journal of Legal Medicine, 38*(2), 66–72.

Kerber, K. J., de Graft-Johnson, J. E., Bhutta, Z. A., Okong, P., Starrs, A., & Lawn, J. E. (2007). Continuum of care for maternal, newborn, and child health: From slogan to service delivery. *Lancet, 370*(9595), 1358–1369.

Khang, Y.-H., Cho, S.-H., June, K. J., Lee, J. Y., Kim, Y.-M., & Cho, H.-J. (2018). The seoul healthy step project: Introduction and expansion, program content and performance, and future challenges. *The Korean Society of Maternal and Child Health, 22*(2), 63–76.

Kim, J., Son, M., Kawachi, I., & Oh, J. (2009). The extent and distribution of inequalities in childhood mortality by cause of death according to parental socioeconomic positions: A birth cohort study in South Korea. *Social Science & Medicine, 69*(7), 1116–1126.

Kim, M.-H., Subramanian, S. V., Kawachi, I., & Kim, C.-Y. (2007). Association between childhood fatal injuries and socioeconomic position at individual and area levels: A multilevel study. *Journal of Epidemiology & Community Health, 61*(2), 135–140.

Laflamme, L., Hasselberg, M., & Burrows, S. (2010). 20 years of research on socioeconomic inequality and children's—unintentional injuries understanding the cause-specific evidence at hand. *International Journal of Pediatrics*. https://doi.org/10.1155/2010/819687, 2010.

Lee, J. Y. (2020). Global burden of congenital heart disease: Experience in Korea as a potential solution to the problem. *Korean Circulation Journal, 50*(8), 691–694.

Lee, S., & Choi, H. (2015). Lowest-low fertility and policy responses in South Korea. In R. R. Rinduss, & M. K. Choe (Eds.), *Low and lower fertility* (pp. 107–123). Springer.

Lokteff, M., & Piercy, K. W. (2012). 'Who cares for the children?' lessons from a global perspective of child care policy. *Journal of Child and Family Studies, 21*(1), 120–130.

Lynch, J. W., Law, C., Brinkman, S., Chittleborough, C., & Sawyer, M. (2010). Inequalities in child healthy development: Some challenges for effective implementation. *Social Science & Medicine, 71*(7), 1244–1248.

McFarland, L., & Laird, S. G. (2018). Parents' and early childhood educators' attitudes and practices in relation to children's outdoor risky play. *Early Childhood Education Journal, 46*(2), 159–168.

Ministry of Health and Welfare. (2022). *The 4th master plan for low fertility and population ageing*. https://www.mohw.go.kr/react/gm/sgm0704vw.jsp?PAR_MENU_ID=13&MENU_ID=13040801&page=1&CONT_SEQ=358262&PAR_CONT_SEQ=356080.

Moreno-Betancur, M., Latouche, A., Menvielle, G., Kunst, A. E., & Rey, G. (2015). Relative index of inequality and slope index of inequality: A structured regression framework for estimation. *Epidemiology, 26*(4), 518–527.

Nicholson, W., & Greenwood, P. (2018). *Best start in life and beyond: Improving public health outcomes for children, young people and families: Guidance to support the commissioning of the Healthy Child Programme 0-19: Health visiting and school nursing services*. UK: Public Health England. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/960708/Commissioning_guide_2.pdf.

Organization for Economic Co-operation and Development [OECD]. (2020). *Health at a glance: Asia/Pacific 2020 measuring progress towards universal health coverage: Measuring progress towards universal health coverage*. OECD Publishing.

Organization for Economic Co-operation and Development [OECD]. (2022). *Mortality from transport accidents*. https://stats.oecd.org/Index.aspx?ThemeTreeId=9.

Park, K., Hwang, S.-S., Lee, J.-S., Kim, Y., & Kwon, S. (2010). Individual and areal risk factors for road traffic injury deaths: Nationwide study in South Korea. *Asia-Pacific Journal of Public Health, 22*(3), 320–331.

Park, I.-h., Moon, D., Lee, J., Oh, I., & Chung, H. (2020). An analysis of maternal and child healthcare services in South Korea. *Korean Social Security Studies, 36*(4), 1–32.

Pearson, J., & Stone, D. H. (2009). Pattern of injury mortality by age-group in children aged 0–14 years in Scotland, 2002–2006, and its implications for prevention. *BMC Pediatrics, 9*(1), 26.

Pillas, D., Marmot, M., Naicker, K., Goldblatt, P., Morrison, J., & Pikhart, H. (2014). Social inequalities in early childhood health and development: A European-wide systematic review. *Pediatric Research, 76*(5), 418–424.

Rajaratnam, J. K., Marcus, J. R., Flaxman, A. D., Wang, H., Levin-Rector, A., Dwyer, L., Costa, M., Lopez, A. D., & Murray, C. J. (2010). Neonatal, postneonatal, childhood, and under-5 mortality for 187 countries, 1970–2010: A systematic analysis of progress towards millennium development goal 4. *Lancet, 375*(9730), 1988–2008.

Roberts, I., Norton, R., Jackson, R., Dunn, R., & Hassall, I. (1995). Effect of environmental factors on risk of injury of child pedestrians by motor vehicles: A case-control study. *BMJ, 310*(6972), 91–94.

Sengoelge, M., Hasselberg, M., & Laflamme, L. (2011). Child home injury mortality in europe: A 16-country analysis. *The European Journal of Public Health, 21*(2), 166–170.

Seok, J. E., & Noh, H. J. (2013). The impact of assortative mating on household income inequality in Korea: Focusing on educational and occupational assortative mating. *Korean Social Security Studies, 29*(2), 167–195.

Shaw, C., Blakely, T., Crampton, P., & Atkinson, J. (2005). The contribution of causes of death to socioeconomic inequalities in child mortality: New Zealand 1981–1999. *New Zealand Medical Journal, 118*(1227), Article U1779.

Sibert, J., & Sidebotham, P. (2007). Deaths from unintentional injuries. In P. Sidebotham, & P. Fleming (Eds.), *Unexpected death in childhood: A handbook for practitioners* (pp. 61–74). Wiley & Sons.

Sidebotham, P., Fraser, J., Covington, T., Freemantle, J., Petrou, S., Pulikottil-Jacob, R., … Ellis, C. (2014). Understanding why children die in high-income countries. *Lancet, 384*(9946), 915–927.

Sidebotham, P., Fraser, J., Fleming, P., Ward-Platt, M., & Hain, R. (2014). Patterns of child death in england and Wales. *Lancet, 384*(9946), 904–914.

Son, M., An, S.-J., & Kim, Y.-J. (2017). Trends of social inequalities in the specific causes of infant mortality in a nationwide birth cohort in Korea, 1995–2009. *Journal of Korean Medical Science, 32*(9), 1401–1414.

Song, H. J. (2017). Ways to improve Korea's birth registration system-focusing on the introduction of a hospital-based birth notification system. *Family Law Study, 31*(20), 169–198.

Spencer, N. (2003). *Weighing the evidence: How is birthweight determined?* Radcliffe Publishing.

Spencer, N., Raman, S., O'Hare, B., & Tamburlini, G. (2019). Addressing inequities in child health and development: Towards social justice. *BMJ Paediatrics Open, 3*(1).

Statistics Korea. (2019). *Under-5 infant birth-death cohorts*. https://mdis.kostat.go.kr/index.do.

Statistics Korea. (2021). *Causes of death statistics*. http://www.kostat.go.kr/portal/korea/kor_nw/1/6/2/index.board.

UNICEF. (2015). *World Bank group, united nations, Levels and trends in child mortality report 2017: Estimates developed by the UN inter-agency group for child mortality estimation*. https://www.unicef.org/reports/levels-and-trends-child-mortality-report-2017.

Viner, R. M., Hargreaves, D. S., Coffey, C., Patton, G. C., & Wolfe, I. (2014). Deaths in young people aged 0–24 years in the UK compared with the EU15+ countries, 1970–2008: Analysis of the WHO mortality database. *Lancet, 384*(9946), 880–892.

Wagstaff, A., Bustreo, F., Bryce, J., Claeson, M., & WHO-World Bank Child Health and Poverty Working Group. (2004). Child health: Reaching the poor. *American Journal of Public Health, 94*(5), 726–736.

Weitoft, G. R., Hjern, A., Haglund, B., & Rosén, M. (2003). Mortality, severe morbidity, and injury in children living with single parents in Sweden: A population-based study. *Lancet, 361*(9354), 289–295.

Wolfe, I., Macfarlane, A., Donkin, A., Marmot, M., & Viner, R. (2014). *Why children die: Death in infants, children, and young people in the UK—Part A*. Royal College of Paediatrics and Child Health.

Wolfe, I., Thompson, M., Gill, P., Tamburlini, G., Blair, M., & van den Bruel, A. (2013). Health services for children in Western europe. *Lancet, 381*(9873), 1224–1234.

World Health Organization [WHO]. (2018). *Nurturing care for early childhood development: A framework for helping children survive and thrive to transform health and human potential*. World Health Organization.

Yoo, S. H., Kim, A. J., Kang, S.-M., Lee, H. Y., Seo, J.-S., Kwon, T. J., & Yang, K.-M. (2013). Sudden infant death syndrome in Korea: A retrospective analysis of autopsy-diagnosed cases. *Journal of Korean Medical Science, 28*(3), 438–442.