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Role of Parental Social Class in Preterm Births and Low Birth Weight in Association with Child Mortality: A National Retrospective Cohort Study in Korea

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Purpose: We explored the role of parental social class in preterm birth (PTB) and low birth weight (LBW) in association with child mortality in Korea.

Materials and Methods: A total of 7,302,732 births in Korea between 1995 and 2007 were used for designing the national retrospective cohort study. Kaplan-Meier survival curves and Cox proportional hazard models were used to determine the risk of child death after adjusting for covariates.

Results: Parental social class was associated with adverse birth outcomes and child mortality in Korea. Parental social class increased the strength of the relationship of adverse birth outcomes with child mortality. Child mortality was higher among PTB and LBW infants from parents with a lower social class than normal births from parents with a higher social class. In particular, the disparity in child mortality according to parental social class was greater for LBW and PTB than intrauterine growth retardation births. When one of the parents had a middle-school education or lower, the disparity in child mortality due to adverse birth outcomes was large regardless of the other spouse's educational status. Inactive economic status for the father, as well as an occupation in manual labor by the mother, increased the risk of child mortality.

Conclusion: Strong relationships for social inequalities and adverse birth outcomes with inequalities in child mortality in South Korea were found in this study. Tackling social inequalities, as well as reducing adverse birth outcomes, are needed to reduce the disparities in child mortality in South Korea.

Key Words: Social class differences, child mortality, parental social class, parental education, parental employment, low birth weight, preterm birth

INTRODUCTION

Adverse birth outcomes, such as low birth weight (LBW),[1,2] preterm birth (PTB),[1,2] and intrauterine growth retardation,[3,4] are known risk factors for infant or child mortality, as are socioeconomic factors.[5-9] Whereas most studies have treated adverse birth outcomes and socioeconomic factors as risk factors for infant or child mortality separately,[6,7,10,11-16] few investigations of the interactive effects of social class and adverse birth outcomes on child mortality have been reported. A previous study reported that parental education, the type of parental work, and employment were interactively related to adverse birth outcomes.[14] The most vulnerable populations in terms

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of adverse birth outcomes were those performing manual work or in an economically inactive state with a middle school education or lower.[14] However, the relationship of these factors on child mortality has not been addressed. Therefore, to what extents the interactive effects of social class and adverse birth outcomes impact the mortality and survival of infants and children need to be investigated.

This study aimed to investigate the role of parental social class in the relationship of adverse birth outcomes with child mortality. We hypothesized that a combination of social factors and adverse birth outcomes would increase child mortality. The primary aims of this study were to determine how parental social class and adverse birth outcomes interact and to determine the effects of this interaction on child mortality in Korea in a cohort of births from 1995–2007.

MATERIALS AND METHODS

Data for retrospective cohort study

A Korean national retrospective birth cohort of 7,344,797 infants was constructed by linking national birth and death registration records to identify deaths among all births according to individual 13-digit social security numbers collected by the Korean National Statistics Office between 1995 and 2007 and followed up to the calendar year 2007. Records deemed to be invalid were excluded, and the resulting overall matched birth cohort encompassing the period 1995–2007 was comprised of 26162 deaths among 7,302,732 births (99.43% of the total number of births during that period). The total number of person-years during this period was 52,117,426.33.

The survival status of the study cohort born in the period 1995–2007 was identified from the date of birth (as early as January 1, 1995) to December 31, 2007. It was assumed that all cohort members not found among the death certificate files were alive at the end of the study period. The survival time was calculated as the time from date of birth to date of death. The survival time of children not identified as dead was calculated as the time from the date of birth to the end of the study period.

Variables

Information on the variables used in this study was collected from the birth registry records based on birth certificates and the death registry records based on death certificates.

Parental education and employment status were used as indicators of social class. Parental education was stratified into less than elementary school (≤6 years), middle school (7–9 years), high school (10–12 years), and university or higher (≥13 years). Parental employment status was stratified into nonmanual (e.g., legislators, senior officials, managers, professionals, technicians and practical professionals, office workers, service workers, and sales workers), manual (e.g., skilled agricultural, forestry, and fishery workers, craft workers, device and machine operators and assemblers, and laborers), and economically inactive (e.g., unemployed, students, housekeepers, and soldiers).

With respect to birth characteristics, data regarding infant sex, parental age at childbirth, gestational age at childbirth, birth weight, multiple births, parity, and history of the death of a previous child were included. Parental age at childbirth was categorized into the following 5-year groups: ≤24, 25–29, 30–34, 35–39, or ≥40 years. Adverse birth outcomes were defined as LBW (birth weight <2500 g), PTB (gestational age <37 weeks), PTB-LBW (both gestational age <37 weeks and birth weight <2500 g). Multiple births and parity were classified as 1, 2 and ≥3, and the history of the death of a previous child was dichotomized as yes or no. Variables pertaining to the date and cause of death were obtained from death certificates.

Statistical methods

The crude death rates, age-adjusted death rates, the incidence of mortality, and the number of person-years were calculated. The probability of surviving up to 13 years of age was estimated using the Kaplan-Meier method. Kaplan-Meier survival curves were used to describe the pattern of survival within early childhood for the levels of each study variable. Cox proportional hazards regression was used to examine the associations among gestational age, birth weight, and parental social class and infant and child mortality, adjusting for covariates (infant sex, maternal age, parental age, multiple births, maternal parity, death of previous children, and year of birth). Child mortality in this study was defined as death from the age of 0 to 13 years of age.

The interplay between parental social class and adverse birth outcomes and its effects on mortality were examined by calculating hazard ratios (HRs) for interactions between parental social class and adverse birth outcomes after adjusting for covariates. Two- and three-way interactions between parental social class and adverse birth outcomes with child mortality were investigated through an interaction test. The likelihood ratio statistic was used to test for interactions between the risk factors.

SAS (version 9.3, SAS Institute, Cary, NC, USA) was used for all analyses. The threshold for statistical significance was set at $p<0.05$ for the main effects.

This study was approved by the Institutional Review Board of Kangwon National University Hospital (KNUH-2019-11-002).

RESULTS

The role of combined social class on child mortality

An effect of social inequality on child mortality was found in this study. Births to parents with education levels of high school and middle school or lower were associated with higher child mortality than in parents with a university education or higher.

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Table 1. The Difference in Child Mortality According to Parental Education and Employment Status, PTB and LBW

	Births (N)	Deaths (N)	Incidence density*	Crude death rates†	Age-adjusted death rates‡	HR (95% CI)	
						Unadjusted	Adjusted§
Paternal education							
≥University	3649643	9454	39.42 (38.64–40.22)	259.04	263.82	1.00 (Reference)	1.00 (Reference)
High school	3231419	13368	54.37 (53.46–55.30)	413.69	405.21	1.50 (1.46, 1.54)	1.33 (1.30, 1.37)
≤Middle school	396466	3128	92.12 (88.95–95.40)	788.97	762.87	2.72 (2.62, 2.84)	2.10 (2.01, 2.19)
Maternal education							
≥University	2930443	7126	40.02 (39.11–40.96)	243.17	248.03	1.00 (Reference)	1.00 (Reference)
High school	4008659	16083	51.67 (50.87–52.47)	401.21	394.44	1.49 (1.44, 1.53)	1.29 (1.25, 1.33)
≤Middle school	349997	2856	92.31 (88.99–95.76)	816.01	795.56	2.88 (2.76, 3.01)	2.08 (1.99, 2.18)
Paternal employment							
Non-manual	3899770	11133	41.60 (40.83–42.38)	285.48	291.04	1.00 (Reference)	1.00 (Reference)
Manual	2962521	13149	58.45 (57.46–59.45)	443.84	435.69	1.49 (1.45, 1.53)	1.33 (1.30, 1.36)
Inactive	367008	1582	61.42 (58.47–64.53)	431.05	413.51	1.48 (1.40, 1.56)	1.37 (1.30, 1.44)
Maternal employment							
Non-manual	917167	2115	37.63 (36.06–39.26)	230.60	238.01	1.00 (Reference)	1.00 (Reference)
Manual	264668	1221	69.13 (65.36–73.12)	461.33	456.20	1.93 (1.80, 2.07)	1.61 (1.50, 1.73)
Inactive	6083714	22658	50.90 (50.24–51.57)	372.44	370.12	1.49 (1.42, 1.55)	1.27 (1.21, 1.33)
LBW							
No LBW	7029565	21494	42.71 (42.14–43.29)	305.77	305.48	1.00 (Reference)	1.00 (Reference)
LBW	273167	4668	260.44 (253.07–268.02)	1708.84	1703.08	5.83 (5.65, 6.01)	5.84 (5.64, 6.04)
PTB							
No PTB	7016540	22135	44.00 (43.43–44.59)	315.47	315.05	1.00 (Reference)	1.00 (Reference)
PTB	286192	4027	221.94 (215.19–228.90)	1407.10	1401.08	4.71 (4.55, 4.87)	4.45 (4.29, 4.61)
PTB-LBW							
No PTB-LBW	7159637	22893	44.69 (44.11–45.27)	319.75	319.43	1.00 (Reference)	1.00 (Reference)
PTB-LBW	143095	3269	367.65 (355.26–380.47)	2284.50	2277.52	7.64 (7.36, 7.92)	7.41 (7.12, 7.72)
Total	7302732	26162	50.19 (49.59–50.81)	358.25	357.99		

HR, hazard ratios; 95% CI, 95% confidence interval; LBW, low birth weight; PTB, preterm birth.
*Among 100000 person-years, †Among 100000 children, ‡Rate per 100000, §Adjusted with sex, parental age, multiple birth, parity, death of previous children, birth year, parental education, parental employment.

The effect of parental educational level on child mortality was stronger than that of parental employment status (Table 1).

Child mortality was also affected by adverse birth outcomes. Births with adverse birth outcomes (PTB, LBW) had a higher risk of death than normal births (Table 1).

The combined parental social class showed an adverse linear relationship with child mortality from higher to lower social class. Child mortality was highest among fathers with middle school education or lower, as well as those in the economically inactive group. Child mortality was highest among mothers with middle school education level or lower, as well as those engaged in manual work, compared to mothers who were economically inactive (Table 2).

The role of effect modification by social class on the relationship of adverse birth outcomes with child mortality

Significant interactions were found between parental education or employment and adverse birth outcomes with child mortality (log-likelihood test, $p<0.001$) (Tables 2–5). A lower social class among parents increased the association between adverse birth outcomes and child mortality. The adjusted HRs of births with adverse birth outcomes relative to those of normal births increased when parental education level was lower and when parental employment status was economically inactive or manual labor. The disparity in child mortality between normal births and LBW was the greatest for fathers with a middle-school education or lower {HR=9.62 [95% confidence interval (CI): 8.78, 10.53]}, followed by fathers with a high school education [HR= 7.91 (95% CI: 7.54, 8.31)] and fathers with a university education [HR=7.03 (95% CI: 6.67, 7.42)]. The results for mothers were similar [HR=9.64 (95% CI: 8.76, 10.53); HR=7.73 (95% CI: 7.37, 8.11), and HR=7.51 (95% CI: 7.07, 7.97), respectively] (Table 3). The adjusted HRs were larger for LBW than for PTB births and thus, the interactive effects between parental education and adverse birth outcome were greater for LBW than for PTB births (Table 3, Supplementary Table 1, only online). The interactive relationships between parental employment status and adverse birth outcomes with child mortality were similar to but weaker than those between parental

Table 2. Interactive Effects of Parental Education and Parental Employment on Child Mortality

		Births (N)	Deaths (N)	HR (95% CI)		
				Unadjusted	Adjusted 1*	Adjusted 2*
Paternal education	Paternal employment					
≥University	Non-manual	2671894	6544	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
	Manual	764567	2304	1.24 (1.18, 1.30)	1.22 (1.16, 1.27)	1.22 (1.17, 1.28)
	Inactive	182356	561	1.21 (1.11, 1.32)	1.21 (1.11, 1.32)	1.21 (1.11, 1.32)
High school	Non-manual	1168864	4234	1.41 (1.35, 1.46)	1.32 (1.27, 1.37)	1.00
	Manual	1885366	8326	1.67 (1.62, 1.73)	1.51 (1.46, 1.56)	1.14 (1.10, 1.19)
	Inactive	157471	760	1.90 (1.76, 2.04)	1.73 (1.60, 1.87)	1.30 (1.20, 1.41)
≤Middle school	Non-manual	57385	349	2.31 (2.08, 2.57)	2.02 (1.82, 2.26)	1.00
	Manual	310941	2509	2.91 (2.78, 3.05)	2.35 (2.24, 2.47)	1.18 (1.05, 1.32)
	Inactive	26378	257	3.85 (3.40, 4.36)	3.27 (2.88, 3.71)	1.60 (1.36, 1.89)
Maternal education	Maternal employment					
≥University	Non-manual	697990	1450	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
	Manual	94291	248	1.34 (1.17, 1.53)	1.34 (1.17, 1.54)	1.37 (1.19, 1.56)
	Inactive	2125187	5401	1.18 (1.11, 1.25)	1.12 (1.06, 1.19)	1.13 (1.07, 1.20)
High school	Non-manual	216600	646	1.30 (1.19, 1.43)	1.23 (1.12, 1.35)	1.00
	Manual	143973	647	1.95 (1.77, 2.13)	1.65 (1.50, 1.81)	1.34 (1.20, 1.50)
	Inactive	3632860	14735	1.71 (1.62, 1.80)	1.46 (1.38, 1.54)	1.19 (1.10, 1.28)
≤Middle school	Non-manual	2077	17	3.44 (2.13, 5.55)	2.24 (1.30, 3.87)	1.00
	Manual	26163	324	4.94 (4.38, 5.58)	3.45 (3.05, 3.91)	1.58 (0.91, 2.75)
	Inactive	320053	2503	3.15 (2.95, 3.36)	2.37 (2.22, 2.54)	1.06 (0.62, 1.83)

HR, hazard ratios; 95% CI, 95% confidence interval.
*Adjusted with sex, parental age, multiple birth, parity, death of previous children, birth year.

education and adverse birth outcomes with child mortality (Table 4). The disparity in child mortality between adverse births and normal births was greater when the fathers were economically inactive and the mothers were engaged in manual employment.

Kaplan-Meier survival curves showed that the gap in survival curves was higher for adverse births from parents with a lower level of education or parents with manual employment or in an economically inactive status, compared to normal births from parents with higher education or with non-manual employment status. The disparity in survival rates according to parental social class was greater for PTB-LBW or LBW than for PTB births.

The role of combined social class on the relationship of adverse birth outcomes and child mortality

Three-way interactive analysis showed that combined lower social class for parents increased the relationship between adverse birth outcomes and child mortality (Table 5). The differences in child mortality between normal births and LBW were greatest for fathers with a middle-school education or lower and mothers with a university education or higher [HR=14.18 (95% CI: 9.41, 21.37)], followed by a middle-school education or lower for both parents [HR=10.95 (95% CI: 9.72, 12.33)], fathers with a university education or higher, and mothers with a middle-school education or lower [HR=10.56 (95% CI: 5.99, 18.61)] (Table 5).

Regarding employment status, the results were similar to those for education level, although the strength of the relationship was greater. The disparity was greatest for economically inactive fathers and mothers in manual employment [HR=15.23 (95% CI: 8.83, 26.29)], followed by economically inactive fathers and mothers in non-manual employment [HR=12.29 (95% CI: 8.27, 18.27)] and economically inactive parents [HR=10.45 (95% CI: 9.19, 11.88)] (Table 5).

Interestingly, the disparity in child mortality between adverse birth outcomes was greater when one of the parents had lower social status (e.g., middle school education or lower and economically inactive or manual work). When one of the parents had a middle-school education or lower, the disparity in child mortality due to LBW was larger regardless of the spouse's level of education. The father's education level had more effect than the mother's on child mortality. The results for employment status were similar. The disparity was larger when the father was economically inactive, regardless of the maternal employment status. A father's inactive economic status had a greater effect than the mother's on child mortality in general. However, child mortality was highest for a combination of an economically inactive father and an occupation in manual labor for the mother (Table 5).

Kaplan-Meier survival probabilities showed a gap in survival curves for a combination of PTB and LBW. The disparity was

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greater for parents with a middle-school education or lower and fathers in an economically inactive state and mothers employed in manual labor (Figs. 1 and 2).

DISCUSSION

The key findings of this study were the effects of social inequalities on child mortality and the individual and interactive ef-

Table 3. Interactive Effects of Parental Education, PTB and LBW on Child Mortality

		Births (N)	Deaths (N)	HR (95% CI)		
				Unadjusted	Adjusted 1*	Adjusted 2*
Paternal education						
≥University	No LBW	3521373	7680	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
	LBW	128270	1774	6.65 (6.32, 7.01)	7.03 (6.67, 7.42)	7.09 (6.70, 7.50)
High school	No LBW	3108000	11080	1.53 (1.49, 1.58)	1.39 (1.35, 1.43)	1.00
	LBW	123419	2288	8.30 (8.92, 8.69)	7.91 (7.54, 8.31)	5.68 (5.41, 5.96)
≤Middle school	No LBW	376652	2605	2.83 (2.71, 2.96)	2.31 (2.21, 2.42)	1.00
	LBW	19814	523	11.21 (10.26, 12.25)	9.62 (8.78, 10.53)	4.10 (3.71, 4.52)
Maternal education						
≥University	No LBW	2825792	5695	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
	LBW	104651	1431	7.10 (6.70, 7.53)	7.51 (7.07, 7.97)	7.50 (7.04, 7.99)
High school	No LBW	3858879	13378	1.55 (1.50, 1.60)	1.36 (1.31, 1.40)	1.00
	LBW	149780	2705	8.42 (8.04, 8.81)	7.73 (7.37, 8.11)	5.69 (5.44, 5.95)
≤Middle school	No LBW	331943	2365	3.03 (2.89, 3.18)	2.33 (2.21, 2.45)	1.00
	LBW	18054	491	12.01 (10.96, 13.17)	9.64 (8.76, 10.61)	4.16 (3.75, 4.62)
Paternal education						
≥University	No PTB	3509876	7864	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
	PTB	139767	1590	5.35 (5.07, 5.65)	5.15 (4.87, 5.44)	5.18 (4.88, 5.48)
High school	No PTB	3104866	11420	1.54 (1.49, 1.58)	1.39 (1.35, 1.44)	1.00
	PTB	126553	1948	6.81 (6.48, 7.16)	6.05 (5.74, 6.36)	4.32 (4.10, 4.54)
≤Middle school	No PTB	378261	2717	2.86 (2.74, 2.99)	2.33 (2.23, 2.44)	1.00
	PTB	18205	411	9.48 (8.58, 10.46)	7.69 (6.95, 8.50)	3.26 (2.92, 3.63)
Maternal education						
≥University	No PTB	2815919	5830	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
	PTB	114524	1296	5.74 (5.40, 6.09)	5.49 (5.16, 5.84)	5.48 (5.13, 5.84)
High school	No PTB	3854395	13792	1.55 (1.51, 1.60)	1.36 (1.32, 1.40)	1.00
	PTB	154264	2291	6.83 (6.51, 7.17)	5.83 (5.54, 6.13)	4.27 (4.07, 4.47)
≤Middle school	No PTB	333250	2455	3.05 (2.91, 3.20)	2.35 (2.23, 2.47)	1.00
	PTB	16747	401	10.42 (9.42, 11.53)	7.83 (7.05, 8.69)	3.38 (3.02, 3.78)
Paternal education						
≥University	No PTB-LBW	3580641	8137	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
	PTB-LBW	69002	1317	9.00 (8.49, 9.54)	9.06 (8.53, 9.63)	9.20 (8.63, 9.81)
High school	No PTB-LBW	3167600	11807	1.54 (1.49, 1.58)	1.39 (1.35, 1.43)	1.00
	PTB-LBW	63819	1561	10.76 (10.20, 11.36)	9.92 (9.37, 10.49)	7.06 (6.67, 7.48)
≤Middle school	No PTB-LBW	387100	2809	2.85 (2.73, 2.98)	2.33 (2.22, 2.43)	1.00
	PTB-LBW	9366	319	14.17 (12.67, 15.85)	11.81 (10.54, 13.23)	4.98 (4.40, 5.63)
Maternal education						
≥University	No PTB-LBW	2873877	6049	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
	PTB-LBW	56566	1077	9.67 (9.06, 10.31)	9.72 (9.09, 10.40)	9.77 (9.09, 10.49)
High school	No PTB-LBW	3931234	14234	1.55 (1.50, 1.59)	1.35 (1.31, 1.40)	1.00
	PTB-LBW	77425	1849	10.92 (10.36, 11.50)	9.67 (9.16, 10.22)	7.10 (6.73, 7.48)
≤Middle school	No PTB-LBW	341239	2551	3.04 (2.91, 3.19)	2.34 (2.23, 2.46)	1.00
	PTB-LBW	8758	305	15.00 (13.37, 16.82)	11.47 (10.18, 12.93)	4.95 (4.35, 5.62)

HR, hazard ratios; 95% CI, 95% confidence interval; LBW, low birth weight; PTB, preterm birth.
*Adjusted with sex, parental age, multiple birth, parity, death of previous children, birth year.

fects of parental social class (parental educational level and employment status) and adverse birth outcomes with child mortality. The interaction between parental social class and adverse birth outcomes with child mortality was stronger than that for other factors. The differences in child mortality between normal births and adverse births were greatest for parents with lower levels of education (middle school education or lower) and when the fathers were economically inactive and the mothers were engaged in manual employment. Child mortality in adverse births was predominantly influenced by

Table 4. Interactive Effects of Parental Employment Status, PTB and LBW on Child Mortality

		Births (N)	Deaths (N)	Crude HR	Adjusted HR1*	Adjusted HR2*
Paternalemployment						
Non-manual	No LBW	3760301	9058	1.00	1.00	1.00
	LBW	139469	2075	6.47 (6.17–6.79)	6.84 (6.51–7.19)	6.85 (6.50-7.21)
Manual	No LBW	2847305	10998	1.53 (1.49–1.58)	1.39 (1.35–1.43)	1.00
	LBW	115216	2151	7.68 (7.33–8.05)	7.31 (6.96–7.67)	5.25 (4.99-5.51)
Inactive	No LBW	352214	1250	1.44 (1.36–1.53)	1.38 (1.30–1.47)	1.00
	LBW	14794	332	9.57 (8.58–10.68)	9.35 (8.37–10.46)	6.64 (5.82-7.57)
Maternalemployment						
Non-manual	No LBW	884044	1700	1.00	1.00	1.00
	LBW	33123	415	6.84 (6.14–7.61)	7.17 (6.43–7.99)	7.25 (6.45–8.14)
Manual	No LBW	254096	1044	2.06 (1.91–2.22)	1.75 (1.62–1.89)	1.00
	LBW	10572	177	8.64 (7.40–10.09)	7.55 (6.44–8.84)	4.38 (3.69–5.20)
Inactive	No LBW	5855849	18634	1.52 (1.45–1.60)	1.31 (1.25–1.38)	1.00
	LBW	227865	4024	8.82 (8.33–9.33)	7.94 (7.49–8.42)	6.04 (5.82–6.27)
Paternal employment						
Non-manual	No PTB	3750933	9320	1.00	1.00	1.00
	PTB	148837	1813	5.18 (4.93–5.45)	5.02 (4.76–5.29)	5.00 (4.74–5.28)
Manual	No PTB	2844459	11333	1.53 (1.49–1.58)	1.39 (1.35–1.43)	1.00
	PTB	118062	1816	6.24 (5.93–6.56)	5.54 (5.26–5.83)	4.00 (3.80–4.22)
Inactive	No PTB	351675	1286	1.44 (1.36–1.53)	1.38 (1.30–1.46)	1.00
	PTB	15333	296	8.03 (7.15–9.01)	7.28 (6.47–8.19)	5.14 (4.49–5.89)
Maternalemployment						
Non-manual	No PTB	881519	1744	1.00	1.00	1.00
	PTB	35648	371	5.53 (4.95–6.19)	5.32 (4.75–5.96)	5.35 (4.74–6.03)
Manual	No PTB	253368	1057	2.03 (1.88–2.19)	1.73 (1.60–1.87)	1.00
	PTB	11300	164	7.41 (6.31–8.69)	6.01 (5.10–7.09)	3.59 (3.01–4.28)
Inactive	No PTB	5846118	19210	1.53 (1.46–1.61)	1.32 (1.25–1.39)	1.00
	PTB	237596	3448	7.13 (6.73–7.56)	5.97 (5.62–6.33)	4.52 (4.34–4.69)
Paternal employment						
Non-manual	No PTB-LBW	3825746	9647	1.00	1.00	1.00
	PTB-LBW	74024	1486	8.54 (8.08–9.02)	8.64 (8.16–9.15)	8.67 (8.16–9.20)
Manual	No PTB-LBW	2903288	11709	1.53 (1.49–1.57)	1.39 (1.35–1.43)	1.00
	PTB-LBW	59233	1440	9.78 (9.26–10.34)	9.00 (8.49–9.53)	6.48 (6.11–6.87)
Inactive	No PTB-LBW	359205	1331	1.44 (1.36–1.52)	1.37 (1.30–1.46)	1.00
	PTB-LBW	7803	251	13.50 (11.91–15.30)	12.67 (11.15–14.40)	9.06 (7.81–10.51)
Maternalemployment						
Non-manual	No PTB-LBW	899292	1805	1.00	1.00	1.00
	PTB-LBW	17875	310	9.27 (8.22–10.46)	9.31 (8.24–10.52)	9.48 (8.30–10.82)
Manual	No PTB-LBW	259108	1091	2.02 (1.87–2.18)	1.72 (1.59–1.85)	1.00
	PTB-LBW	5560	130	11.88 (9.94–14.19)	10.09 (8.41–12.11)	6.13 (5.04–7.47)
Inactive	No PTB-LBW	5964901	19871	1.53 (1.46–1.60)	1.32 (1.25–1.38)	1.00
	PTB-LBW	118813	2787	11.49 (10.83–12.19)	9.97 (9.37–10.61)	7.55 (7.23–7.88)

HR, hazard ratios; LBW, low birth weight; PTB, preterm birth.
*Adjusted with sex, parental age, mutiple birth, death of previous children, the number of total births, birth year.

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one parent's lower social class, regardless of the spouse's social class.

This study showed that differences in parental social status can affect child mortality. Child mortality was higher among births from lower educated parents, economically inactive fathers, and mothers in employed in manual labor, concurring with the results of previous studies in Korea[12,13,15,16] and worldwide.[17-21] This study also showed a linear relationship between combined parental social class (parental education and employment) and child mortality. This result was similar to a previous study,[14] although the effect on child mortality in this study was greater than that of adverse birth outcomes in the previous study. The association between lower parental social class and higher child mortality suggests that parental social class

Table 5. Three-Way Interactions of Paternal Education and Maternal Education with LBW, and Paternal Employment and Maternal Employment with LBW on Child Mortality

			Births (N)	Deaths (N)	HR (95% CI)		
					Unadjusted	Adjusted 1*	Adjusted 2*
Paternal education	Maternal education						
≥University	≥University	No LBW	2422946	4686	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
		LBW	88469	1172	7.18 (6.74, 7.66)	7.59 (7.11, 8.11)	7.64 (7.14, 8.18)
	High school	No LBW	1085872	2957	1.29 (1.23, 1.35)	1.17 (1.12, 1.23)	1.17 (1.12, 1.23)
		LBW	39175	589	7.45 (6.83, 8.11)	7.19 (6.59, 7.84)	7.20 (6.59, 7.87)
	≤Middle school	No LBW	9924	32	1.57 (1.11, 2.22)	1.34 (0.95, 1.90)	1.33 (0.94, 1.88)
		LBW	511	12	11.80 (6.69, 20.79)	10.56 (5.99, 18.61)	10.42 (5.91,18.37)
High school	≥University	No LBW	383783	935	1.29 (1.20, 1.38)	1.28 (1.19, 1.37)	1.00
		LBW	15087	234	8.47 (7.43, 9.66)	8.78 (7.69, 10.02)	6.85 (5.93, 7.92)
	High school	No LBW	2582744	9337	1.68 (1.62, 1.74)	1.47 (1.42, 1.52)	1.16 (1.08, 1.24)
		LBW	101148	1889	9.05 (8.58, 9.55)	8.35 (7.90, 8.82)	6.55 (6.04, 7.11)
	≤Middle school	No LBW	136500	789	2.60 (2.41, 2.80)	2.08 (1.93, 2.25)	1.65 (1.50, 1.82)
		LBW	6931	161	10.81 (9.24, 12.65)	9.09 (7.75, 10.65)	7.23 (6.10, 8.56)
≤Middle school	≥University	No LBW	14870	60	2.04 (1.58, 2.63)	1.95 (1.51, 2.51)	1.00
		LBW	846	23	14.17 (9.41, 21.35)	14.18 (9.41, 21.37)	7.22 (4.46, 11.69)
	High school	No LBW	177617	1020	2.62 (2.45, 2.80)	2.18 (2.03, 2.33)	1.15 (0.89, 1.50)
		LBW	8549	196	10.85 (9.41, 12.52)	9.38 (8.12, 10.84)	4.93 (3.68, 6.60)
	≤Middle school	No LBW	181609	1505	3.63 (3.42, 3.84)	2.81 (2.64, 2.98)	1.54 (1.19, 2.00)
		LBW	10249	300	13.30 (11.83, 14.94)	10.95 (9.72, 12.33)	5.90 (4.45, 7.81)
Paternal employment	Maternal employment						
Non-manual	Non-manual	No LBW	716920	1318	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
		LBW	26645	308	6.60 (5.83, 7.47)	6.94 (6.12, 7.86)	6.94 (6.12, 7.87)
	Manual	No LBW	64764	124	1.07 (0.89, 1.28)	1.05 (0.87, 1.26)	1.05 (0.87, 1.26)
		LBW	2480	28	6.56 (4.51, 9.54)	6.74 (4.64, 9.81)	6.73 (4.63, 9.79)
	Inactive	No LBW	2965171	7584	1.30 (1.22, 1.38)	1.17 (1.10, 1.24)	1.17 (1.10, 1.24)
		LBW	109816	1736	8.39 (7.81, 9.02)	8.00 (7.44, 8.61)	8.01 (7.43, 8.63)
Manual	Non-manual	No LBW	129123	302	1.25 (1.10, 1.42)	1.22 (1.08, 1.38)	1.00
		LBW	5034	77	8.59 (6.82, 10.80)	8.75 (6.95, 11.02)	7.17 (5.58, 9.21)
	Manual	No LBW	175943	864	2.50 (2.30, 2.73)	2.06 (1.89, 2.25)	1.69 (1.48, 1.93)
		LBW	7367	128	9.09 (7.58, 10.90)	7.78 (6.49, 9.34)	6.40 (5.20, 7.87)
	Inactive	No LBW	2529663	9777	1.89 (1.78, 2.00)	1.57 (1.48, 1.67)	1.29 (1.15, 1.45)
		LBW	102258	1934	9.58 (8.93, 10.28)	8.36 (7.78, 8.98)	6.85 (6.06, 7.74)
Inactive	Non-manual	No LBW	32108	69	1.11 (0.87, 1.42)	1.12 (0.88, 1.42)	1.00
		LBW	1173	26	12.14 (8.23, 17.89)	12.29 (8.27, 18.27)	10.86 (6.85, 7.22)
	Manual	No LBW	9721	36	2.00 (1.44, 2.79)	1.89 (1.36, 2.63)	1.60 (1.07, 2.40)
		LBW	463	13	15.99 (9.27, 27.60)	15.23 (8.83, 26.29)	12.82 (7.07, 3.25)
	Inactive	No LBW	308692	1130	1.83 (1.69, 1.98)	1.60 (1.48, 1.74)	1.39 (1.09, 1.78)
		LBW	13063	291	11.71 (10.31, 13.29)	10.45 (9.19, 11.88)	8.90 (6.80, 11.66)

HR, hazard ratios; 95% CI, 95% confidence interval; LBW, low birth weight.
*Adjusted with sex, parental age, multiple birth, parity, death of previous children, birth year.

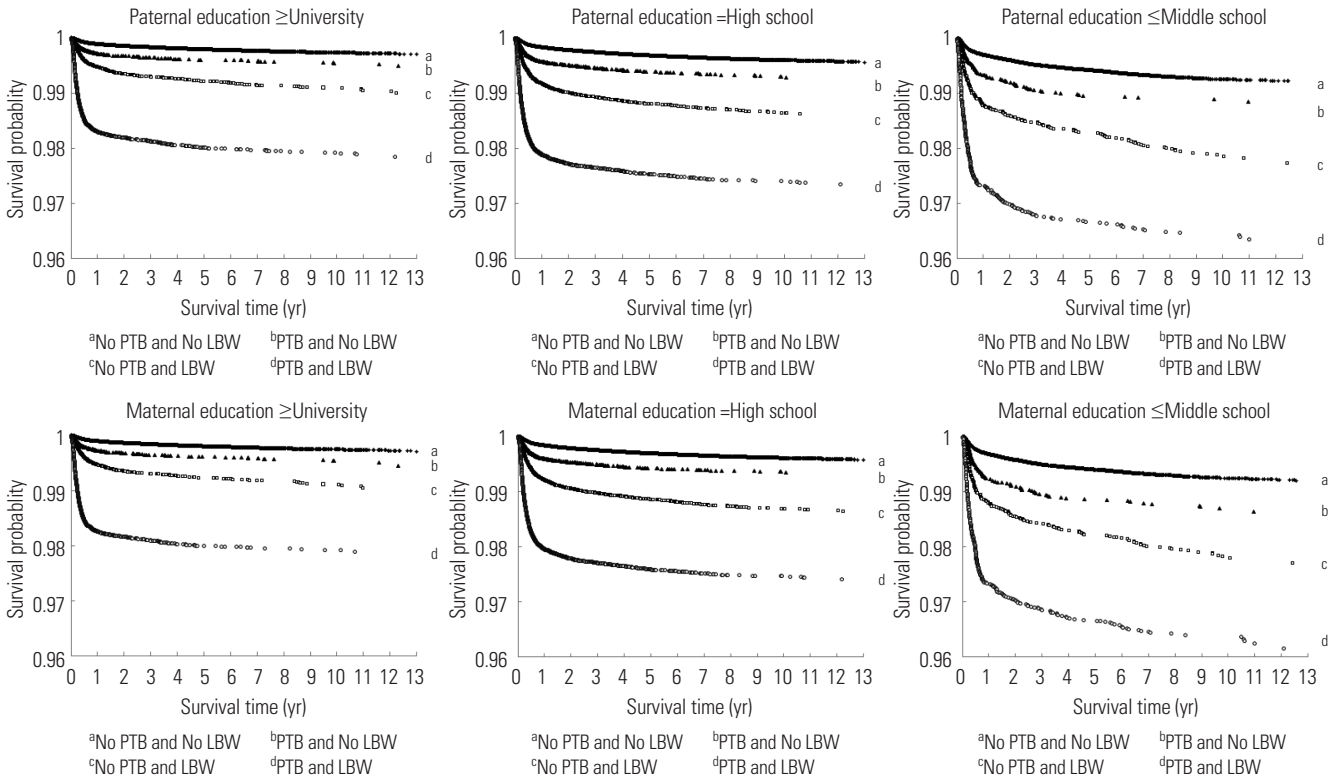

Fig. 1. Kaplan-Meier survival probabilities according to the combination of gestational age and LBW, stratified according to parental education level. PTB, preterm birth; LBW, low birth weight.

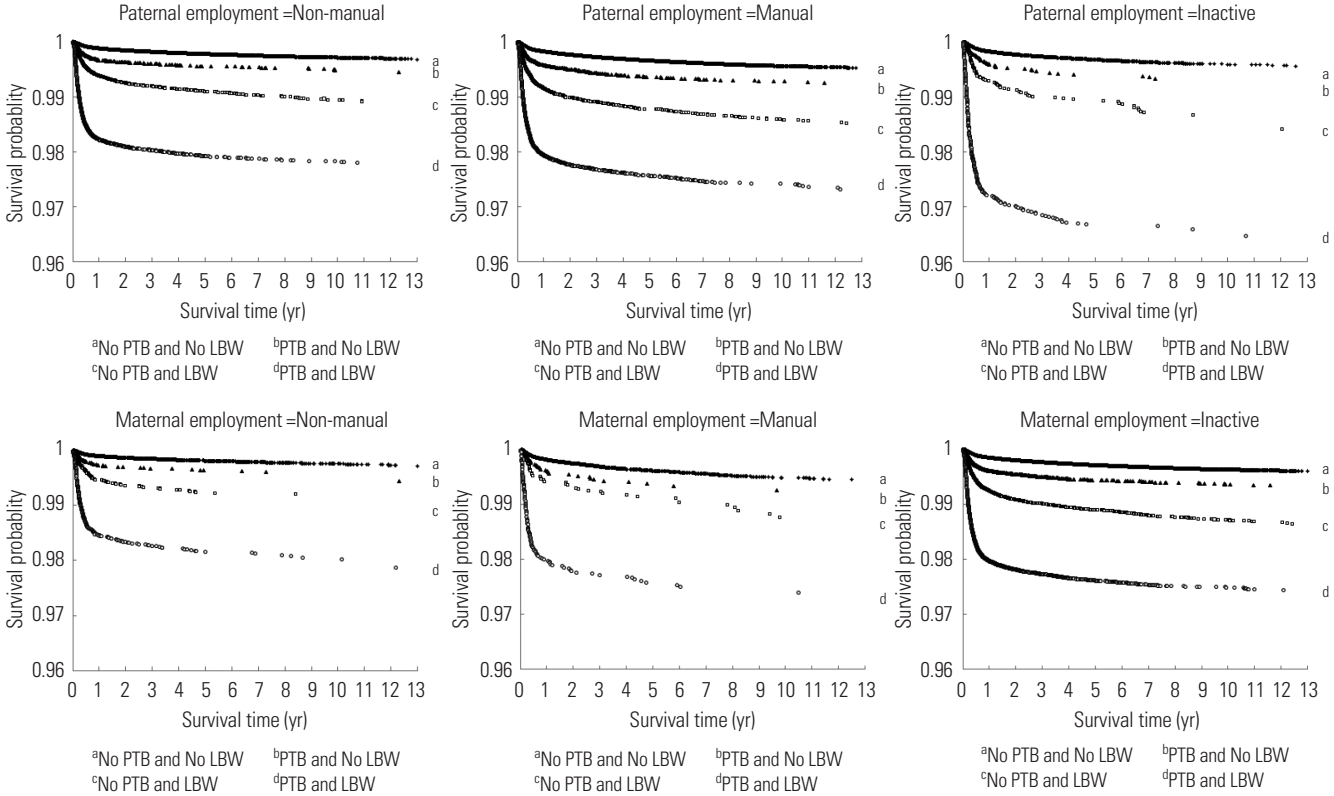

Fig. 2. Kaplan-Meier survival probabilities according to the combination of gestational age and LBW, stratified according to parental employment status. PTB, preterm birth; LBW, low birth weight.

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has a stronger effect on child mortality than adverse birth outcomes.

We found that parental social classes (parental education and employment) interactively affected child mortality. Child mortality was higher when both parents had lower educational levels and when the father was economically inactive and the mother performed manual labor. These results are consistent with those of a previous study,[14] wherein adverse birth outcomes were higher when both parents had lower education levels and when the father was economically inactive and the mother was employed in manual labor.[14] However, the strength of the relationship between social class and child mortality was greater in this study than adverse birth outcomes in the previous study.

Our results imply that the lower the parents' social class, the higher the child mortality. A lower social class might influence material conditions, as well as social relationships, resulting in adverse birth outcomes and child mortality. Therefore, social status differences may be an area to address with respect to child mortality, specifically the lowest social class (lower education as well as lower employment status, such as economically inactive and manual employment).[22-26]

In this study, significant interactions were noted between parental social class factors associated with adverse births (PTB and LBW) and child mortality. The findings of the present study imply that parents from a lower social class could be a factor in fetal undernutrition, resulting in disproportionate fetal growth, leading to LBW and PTB and, thus, increasing child mortality associated with social status differences in child mortality. The risk factors for LBW or PTB were socioeconomic situations, maternal nutrition, maternal disease, pre-pregnancy testing, lifestyle, and drinking/smoking, which are all closely related to parental social class.[27-32] Thus, socioeconomic cultural conditions, to some degree, may underlie the risks of adverse birth outcomes.[29,33] Therefore, these conditions could also affect the association between the parents' social class and adverse birth outcomes resulting in child mortality.

An interesting finding of our study was that child mortality for adverse births was predominantly influenced by one parent with lower social status, regardless of the spouse's social class. The disparity in child mortality between normal births and adverse births was greater when one parent had a lower social class, middle school level or lower education, and economically inactive or manual work. This suggests that one of the parents might influence the entire family's social class. In particular, the father's social class can be a social class determinant for the family, the dominant risk factor for child mortality.

Another important finding in this study is that when fathers are in an economically inactive state, the disparity in child mortality between normal births and adverse births became higher when the mothers were engaged in manual work. When the father was economically inactive, the mother might be employed in order to maintain the household income (the added-worker effect) or she might recognize that the labor market and the economy are in a difficult state and stop looking for work, thus falling into an economically inactive state (the discouraged-work effect).[22-25] Ultimately, the spouse's economically inactive status forces the mother to either search for a job or to be unemployed, which are detrimental to maternal health and thus, also to a newborn's health. Economically inactive fathers also push the family into a lower social class, and the mother is more likely to enter the labor market in the areas of wholesale and retail, foodservice work, or accommodations,[22-25] which are usually physically strenuous and include long working hours, night shifts, and heavy lifting. Mothers who are involved in physically strenuous work are more likely to have LBW and PTB infants, which are associated with higher levels of child mortality.[26]

This study found that LBW was associated with the highest child mortality, followed by PTB. In this study, the causes of death among PTB or LBW infants were bacterial sepsis of the newborn, unspecified (International Classification of Disease, ICD 10, P369), respiratory distress syndrome of the newborn (P220), Necrotizing Enterocolitis of the fetus and newborn (P77), congenital malformation of the heart, unspecified (Q249), and less than 28 weeks of gestation completed (P072), which are positively correlated with prematurity due to the short gestational age.

The principal strength of this study is that it included national births from a 13-year period (1995–2007) in Korea, producing a nationwide retrospective cohort that constituted 99.43% of the total population. However, the findings of this study should be considered in light of its limitations. First, the national birth registration data, with which we employed in this study, have some omissions of cases of stillborn or neonatal deaths in the process of self-reporting of new births to the National Statistics Office, as the birth's parents might be reluctant to report the death cases to the national birth registration system.[34-38] Second, misclassification could have occurred, thus underestimating the actual mortality levels. Third, parental education level and employment status may not accurately represent real social class differentials. These limitations could have underestimated the actual mortality levels and non-differential or differential misclassification might have occurred.

In conclusion, this study showed that social class intensified the relationship between adverse birth outcomes and child mortality. The differences in child mortality between normal births and adverse births were greatest for parents with lower education (middle school of education or lower) and when the fathers were economically inactive and the mothers were in manual employment. Child mortality for adverse births was predominantly influenced by one parent in a lower social class, regardless of the spouse's social class. A father's economic inactive status, as well as maternal manual work, increased the risk of child mortality.

This study suggests that child mortality should be reduced

by considering adverse birth outcomes among parents in lower social classes. The parental social class should be considered to prevent child death due to adverse birth outcomes. The widening social inequalities might not be reduced by only focusing on social welfare policies and social welfare services without considering class relationships in a society.

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