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ORIGINAL ARTICLE

The effect of sociodemographic factors on infant mortality according to cause of death: a birth cohort in Seoul, Korea, 1999–2003

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Abstract
Objectives The aim of this study was to examine the effect of socioeconomic status and demographic factors on infant mortality, classified by cause of death, in a group of children born in Seoul, Korea during 1999–2003.
Methods Linked infant birth and death data were collected from the Korea National Statistical Office. Logistic regression models were used to investigate the effect of socioeconomic and demographic factors on infant mortality. The results were adjusted to take into account the infants' length of gestation and birth weight.
Results Infant death rates from all causes tended to decrease as the parents' educational level increased. We observed a similar pattern for deaths from other specific causes. We also found higher mortality rates for mothers less than 20 years of age and over 35.
Conclusions Our analysis shows that socioeconomic and demographic factors affect infant mortality. In the case of postneonatal infant death, we confirmed that adequate follow-up care can reduce the risks of death from these acquired factors. This suggests that these are important factors to consider in reducing infant mortality.

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Keywords Infant death · Neonatal death · Postneonatal death · Socioeconomic status · Demographic factor · Cause of death

Introduction

Infant mortality is widely seen as an indicator of the public health status of broader society. An inverse relationship between infant mortality and socioeconomic status has been reported both within countries (Son et al. 2006) and between countries (Dummer and Parker 2005; Goza et al. 2004; Rene 1980). In recent years, although infant mortality has decreased (Machado and Hill 2005), the socioeconomic disparities in infant mortality have persisted and may even have increased (Arntzen et al. 1996a).

In one study of the socioeconomic disparities in infant mortality, Hosseinpoor et al. (2006) reported that the largest contributions to disparity in infant mortality arose from differences in household economic status and the mother's education. In Norway, Arntzen et al. (2004a) also reported an inverse relationship between parents' education and infant mortality rates.

Regardless of the economic status in both developed and developing countries, firstborn infants have a higher-than-average risk of infant death (Hobcraft et al. 1985). Miller (1993) has also reported that firstborns are consistently at a disadvantage in a variety of measures, including birth weight, height, length of gestation, weight versus gestational age, and weight versus height, when compared to infants of higher birth order.

Until now, most studies relating infant mortality to socioeconomic and demographic factors have considered total deaths from all causes, including different etiologies. Some researchers have examined the effects of

socioeconomic status and demographic factors on specific causes of infant mortality (Shaw et al. 2005), but to date there has been no study in Korea that has examined this issue.

Therefore, the purpose of this study was to examine the effects of socioeconomic status and demographic factors on postneonatal mortality by varying causes of death, specifically among firstborn children born in Seoul, Korea, during 1999–2003.

Methods

We obtained linked records of births and infant deaths that occurred in 1999–2003 from the Korea National Statistical Office. Any records that were missing data on one or more of the variables used in our analysis were excluded. We also used birth order information from the records to limit our study population to firstborn infants. To examine infant mortality by age, we divided the children who died into groups according to their age at death: neonates (less than 27 days), postneonates (more than 27 days and less than 1 year), and infants (all children less than 1-year old, including both neonates and postneonates).

There were 6,107 infant deaths in the study period; 5,341 of the infants died neonatally, while 766 died in the postneonatal period. Independent variables included marital status, parents' education level, parents' occupation, mother's age at delivery, gestational period, and the baby's weight at birth. The parents' education levels were divided into four categories: elementary school, middle school, high school, and university level. The parents' occupations were categorized as professional (0, manager; 1, expert; 2, engineer; 3, office worker; 4, service job; 5, salesman), manual (6, agriculture, fishery, and forestry; 7, technical service; 8, mechanics; 9, physical labor), or other (10, students less than 14 years old; 11, unemployed; 12, household; 13, military man). The mother's age at delivery was classified as $<$20, 20–24, 25–29, 30–34, or $\geq$35 years.

We separated the causes of death into respiratory and cardiovascular disorders specific to the perinatal period (ICD-10, P20-P29) and congenital malformations, deformations, and chromosomal abnormalities (ICD-10, Q00-Q99). We analyzed the associations of infant mortality with socioeconomic level and demographic factor by calculating the odds ratio (OR) and associated 95% confidence interval (CI), controlling for the period of gestation and weight at birth using logistic regression analysis. The reference group for all risk factors was selected to be the group that hypothetically had the lowest risk. All analyses were performed with SAS 8.1 (SAS Institute, Inc., Cary, NC).

Results

Descriptive analysis

A total of 297,613 firstborn infants were born during the period 1999–2003 (Table 1). The pattern of mortality in males versus females is similar in each of the three age ranges (infant, neonate, and postneonate). A large majority of the mothers in each of the groups were married. In terms of the level of education attained, the largest group among the mothers was the group with a high school education, while the largest group among the fathers consisted of males with a university education. In the occupational groupings, the largest percentage of fathers was in the professional group, while the largest percentage of mothers was in the household group. For the mother's age at the time of infant death, the highest percentage was in the 25–29 age group.

Table 2 shows the number of infant, neonatal, and postneonatal deaths divided according to cause of death, including deaths from all causes, respiratory and cardiovascular disorders, or congenital malformations.

The estimated odds ratios for neonatal mortality from all causes, controlling for gestational period and weight at birth, indicate that a lower parental education level is related to a higher risk of neonatal death in their firstborn (Table 3).

Table 3 also indicates that the highest risk (OR 7.31, 95% CI 6.24–8.56) of neonatal death was for mothers who were teenagers. When broken down according to specific diseases, the risk distribution of mortality had a similar pattern.

In analyzing postneonatal mortality, we combined mothers with an elementary school education and mothers with a middle school education because of the limited number of cases in the elementary school group. Controlling for the gestational period and weight at birth, the odds ratios for postneonatal mortality from all causes were 1.47 (95% CI 1.27–1.70) for mothers with a high school education and 3.03 (95% CI 2.19–4.18) for mothers with a middle or elementary school education as compared to mothers with a university education (Table 3). In other words, the less education a mother had, the higher the risk of neonatal death. Looking at the father's level of education, we had similar results to those in the mother's education category; this indicated that the risk of postneonatal death had an inverse relationship with both the father's and the mother's educational achievement.

After controlling for the gestational period and weight at birth, in the category of the mother's age at the time of her firstborn's birth, the odds ratios for postneonatal death indicate that the risk of postneonatal death was higher

Table 1 Characteristics of the birth cohort in Seoul, Korea, 1999–2003

Characteristics [*n*, (%)]	Deaths			All subjects ($n = 297,613$)
	Infant ($n = 6,107$)	Neonatal ($n = 5,341$)	Postneonatal ($n = 766$)	
Sex				
Male	3,335 (54.6)	2,901 (54.3)	434 (56.7)	152,505 (51.2)
Female	2,772 (45.4)	2,440 (45.7)	332 (43.3)	145,108 (48.8)
Marital status				
Married	5,726 (93.9)	4,994 (93.6)	732 (95.7)	293,554 (98.7)
Unmarried	373 (6.1)	340 (6.4)	33 (4.3)	3,999 (1.3)
Paternal education				
Upper or equal university level	3,119 (52.6)	2,734 (52.8)	385 (51.2)	183,540 (62.0)
High school	2,448 (41.3)	2,130 (41.2)	318 (42.3)	103,648 (35.0)
Middle school	276 (4.7)	236 (4.6)	40 (5.3)	7,097 (2.4)
Lower or equal elementary school	84 (1.4)	75 (1.4)	9 (1.2)	1,755 (0.6)
Maternal education				
Upper or equal university level	2,777 (46.1)	2,446 (46.5)	331 (43.4)	160,660 (54.1)
High school	2,921 (48.5)	2,532 (48.2)	389 (51.1)	129,467 (43.6)
Middle school	254 (4.2)	221 (4.2)	33 (4.3)	5,685 (1.9)
Lower or equal elementary school	69 (1.2)	60 (1.1)	9 (1.2)	1,143 (0.4)
Paternal occupation				
Non-manual	4,341 (78.7)	3,778 (78.5)	563 (80.0)	232,823 (85.3)
Manual	454 (8.2)	386 (8.0)	68 (9.6)	20,684 (7.6)
Unemployed, housework, students	725 (13.1)	652 (13.5)	73 (10.4)	19,269 (7.1)
Maternal occupation				
Non-manual	1,082 (18.7)	945 (18.7)	137 (18.7)	64,073 (21.9)
Manual	29 (0.5)	25 (0.5)	4 (0.5)	1,342 (0.5)
Unemployed, housework, students	4,671 (80.8)	4,079 (80.8)	592 (80.8)	226,475 (77.6)
Age of mother (years)				
<20	200 (3.3)	182 (3.4)	18 (2.3)	1,861 (0.6)
20–24	1,044 (17.2)	925 (17.5)	119 (15.6)	34,143 (11.5)
25–29	3,025 (49.9)	2,606 (49.2)	419 (54.8)	176,614 (59.4)
30–34	1,336 (22.0)	1,172 (22.1)	164 (21.4)	71,828 (24.2)
≥35	461 (7.6)	416 (7.8)	45 (5.9)	12,821 (4.3)

$P \leq 0.001$ for all comparisons (except maternal job category in postneonatal mortality)

Table 2 Number of infant, neonatal, and postneonatal deaths by cause of death in Seoul, Korea, 1999–2003

	Number of deaths (%)		
	Infant	Neonatal	Postneonatal
All causes	6,107 (100)	5,341 (100)	766 (100)
RC	1,847 (30.2)	1,710 (32.0)	137 (17.9)
CM	1,342 (22.0)	1,159 (21.7)	183 (23.9)

RC respiratory and cardiovascular disorders specific to the perinatal period (ICD-10, P20-P29), *CM* congenital malformations, deformations, and chromosomal abnormalities (ICD-10, Q00-Q99)

among mothers who were teenagers and for those who were over 35 (Table 3).

When postneonatal mortality was further divided into respiratory and cardiovascular disorders specific to the perinatal period and deaths from congenital malformations, deformations, and chromosomal abnormalities, the pattern of postneonatal morality and its relationship to the parents' education level was similar to what was seen for all causes of death. However, the data for mother's age at delivery had some differences. The risk of postneonatal death from these disorders was actually lower for women over 30, although the difference was not statistically significant. Otherwise, the risk of postneonatal death from congenital malformations, deformations, and chromosomal abnormalities according to age had a very similar pattern as that seen for all causes of death, although the effect size was small (Table 3; Fig. 1).

The less education either a mother or a father had, the higher the risk of infant death (Table 3). The estimated odds ratios for infant death, after controlling for gestational

Table 3 Adjusted odds ratios and 95% confidence intervals of neonatal, postneonatal, and infant mortality from specific causes by socioeconomic and demographic factors using logistic regression in Seoul, Korea, 1999–2003

Characteristics	OR (95% CI)		
	All causes	RC	CM
Neonatal mortality			
Maternal education			
Upper or equal university level	1.00	1.00	1.00
High school	1.30 (1.23, 1.38)	1.34 (1.21, 1.48)	1.32 (1.17, 1.49)
Middle school	2.69 (2.34, 3.10)	2.68 (2.09, 3.43)	2.73 (2.04, 3.67)
Lower or equal elementary school	3.54 (2.71, 4.63)	3.62 (2.28, 5.72)	4.17 (2.49, 7.00)
Paternal education			
Upper or equal university level	1.00	1.00	1.00
High school	1.41 (1.33, 1.49)	1.46 (1.32, 1.62)	1.31 (1.16, 1.49)
Middle school	2.32 (2.03, 2.66)	2.42 (1.91, 3.06)	2.26 (1.69, 3.01)
Lower or equal elementary school	3.03 (2.40, 3.83)	3.17 (2.13, 4.74)	2.68 (1.60, 4.49)
Age of mother (years)			
<20	7.31 (6.24, 8.56)	7.40 (5.68, 9.64)	5.62 (3.94, 8.00)
20–24	1.86 (1.72, 2.01)	1.85 (1.61, 2.11)	1.94 (1.65, 2.27)
25–29	1.00	1.00	1.00
30–34	1.10 (1.02, 1.18)	1.15 (1.02, 1.31)	1.01 (0.87, 1.18)
≥35	2.24 (2.02, 2.50)	2.33 (1.94, 2.81)	2.18 (1.73, 2.74)
Postneonatal mortality			
Maternal education			
Upper or equal university level	1.00	1.00	1.00
High school	1.47 (1.27, 1.70)	1.61 (1.12, 2.30)	1.71 (1.26, 2.32)
Lower or equal middle school	3.03 (2.19, 4.18)	2.64 (1.13, 6.13)	3.52 (1.87, 6.64)
Paternal education			
Upper or equal university level	1.00	1.00	1.00
High school	1.44 (1.24, 1.68)	1.60 (1.12, 2.28)	1.36 (1.00, 1.85)
Lower or equal middle school	2.65 (1.97, 3.57)	1.60 (0.64, 3.98)	2.59 (1.42, 4.73)
Age of mother (years)			
<20	4.08 (2.54, 6.55)	1.16 (0.16, 8.37)	1.94 (0.48, 7.86)
20–24	1.44 (1.17, 1.77)	1.35 (0.84, 2.19)	1.52 (1.00, 2.32)
25–29	1.00	1.00	1.00
30–34	0.95 (0.79, 1.14)	0.71 (0.45, 1.14)	1.08 (0.75, 1.56)
≥35	1.49 (1.09, 2.02)	0.52 (0.17, 1.66)	2.09 (1.21, 3.61)
Infant mortality			
Maternal education			
Upper or equal university level	1.00	1.00	1.00
High school	1.32 (1.25, 1.39)	1.36 (1.24, 1.50)	1.37 (1.22, 1.53)
Middle school	2.73 (2.40, 3.12)	2.72 (2.14, 3.44)	2.73 (2.08, 3.60)
Lower or equal elementary school	3.61 (2.82, 4.64)	3.37 (2.13, 5.33)	4.62 (2.91, 7.32)
Paternal education			
Upper or equal university level	1.00	1.00	1.00
High school	1.42 (1.34, 1.49)	1.47 (1.33, 1.62)	1.32 (1.18, 1.48)
Middle school	2.39 (2.10, 2.71)	2.39 (1.90, 3.00)	2.17 (1.65, 2.84)
Lower or equal elementary school	2.97 (2.38, 3.71)	2.94 (1.97, 4.39)	3.23 (2.09, 5.00)
Age of mother (years)			
<20	6.97 (5.99, 8.11)	6.83 (5.26, 8.88)	5.08 (3.60, 7.16)
20–24	1.81 (1.68, 1.94)	1.80 (1.58, 2.05)	1.88 (1.62, 2.18)
25–29	1.00	1.00	1.00
30–34	1.08 (1.01, 1.15)	1.11 (0.99, 1.26)	1.02 (0.89, 1.18)
≥35	2.14 (1.93, 2.37)	2.17 (1.80, 2.60)	2.17 (1.76, 2.68)

The model was adjusted by gestation and weight at birth

RC respiratory and cardiovascular disorders specific to the perinatal period (ICD-10, P20-P29), *CM* congenital malformations, deformations, and chromosomal abnormalities (ICD-10, Q00-Q99)

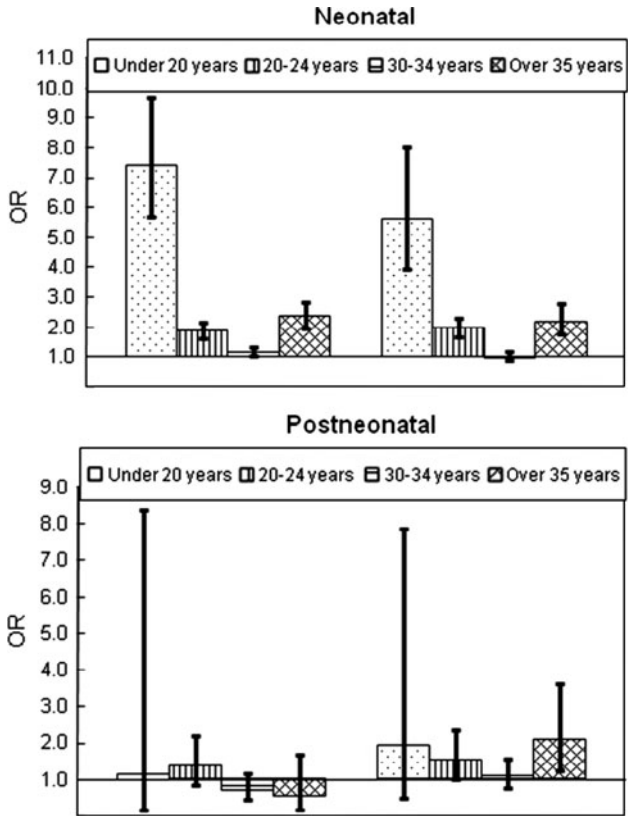

Fig. 1 Odds ratios and 95% confidence intervals of neonatal and postneonatal mortality according to maternal age by cause of death compared to the 25–29 maternal age group [*RC* respiratory and cardiovascular disorders specific to the perinatal period (ICD-10, P20-P29), *CM* congenital malformations, deformations, and chromosomal abnormalities (ICD-10, Q00-Q99)]

period and weight at birth, as related to the mother's age were 6.97 (95% CI 5.99–8.11) for mothers less than 20 years old, 1.81 (95% CI 1.68–1.94) for mothers 20–24, 1.08 (95% CI 1.01–1.15) for mothers in the 30–34 age group, and 2.14 (95% CI 1.93–2.37) for mothers over 35, all compared to mothers in the 25–29 age range. For specific diseases, the pattern of risk was very similar to the pattern of deaths from all causes. Also, in analyzing according to marital status (results not shown), we found that the mortality risks were higher for unmarried mother than for married mothers in all age groups.

Discussion

In this study, we found that the risk of infant death is highest among parents with the lowest socioeconomic status, teenaged mothers, and mothers over 35. In particular, we analyzed the effect of socioeconomic status and demographic factors on infant mortality among firstborns, as broken down by cause of death.

For parents with a low level of education, which can be an indicator of low socioeconomic status, the risk of neonatal, postneonatal, and infant death was increased. This finding is consistent with the results of previous studies. Arntzen et al. (2004b) found, for example, that the risk of infant death was lower in groups with higher educational achievements. Gnavi and Costa (2002) reported that postneonatal mortality is strongly related to a mother's education level, with lower educational achievements related to higher mortality rates. Our study confirmed that the risk of infant death increases with the parents' decreasing education levels. Except in the case of the high school education level and neonatal and infant mortality, the size effect of the mother's education level was larger than that of the father's education. A previous analysis by Pena et al. (2000) of the protective effect of the mother's education level on infant mortality found that social inequality may be an independent risk factor for infant mortality in low-income countries, and female education may contribute to preventing infant mortality in poor households.

Our finding also shows that the mortality risk was higher for unmarried mothers than for married mothers in all age groups. This is consistent with a previous finding that the rates of stillbirth and neonatal and postneonatal mortality were higher among the offspring of unmarried mothers (Arntzen et al. 1996b). Marital status may be a marker for the presence or absence of social, emotional, and financial resources (Bennett et al. 1994; Gaudino et al. 1999). We believe that unmarried mothers are generally more vulnerable to rearing or health care issues because of their tendency to have a lower socioeconomic status; they may be less educated or younger in age than married mothers. In our analysis of mortality risk versus the mother's age, our findings were consistent with those of previous studies. The risk of neonatal, postneonatal, and infant deaths was higher for mothers under 20 and over 35 than it was in mothers in the 25–29 age group. Onayade et al. (2006) reported that teenage pregnancy is one of the major factors increasing the risk of neonatal death. Furthermore, the study of Nabukera et al. (2006) found that infants born to women aged 30 and above were at increased risk for prematurity and low birth weight; there is also a higher risk of fetal and infant mortality in this age group. In particular, mothers who were under 20 were at the highest risk in this study. Comparing adolescent (12–17 years) mothers to older (20–34 years) mothers, Markovitz et al. (2005) found that the younger group had an increased risk of infant (OR 1.95, 95% CI 1.54–2.48), neonatal (OR 1.69, 95% CI 1.24–2.31) and postneonatal mortality (OR 2.47, 95% CI 1.70–3.59).

In this study, we confirmed that there are differences in the effect of parents' socioeconomic status estimated by the level of education on infant mortality. Previous studies had

reported that a low socioeconomic level was the most important risk factor for low birth weight (Mathews et al. 2003), and low-birth weight infants were at higher risk for infant death (Adair and Popkin 1988). We conducted an additional analysis on the risk of low birth weight versus the parents' socioeconomic status using the data from this study (results not shown). We found that for parents with a lower socioeconomic status, the risk of low birth weight is higher, and the effect is statistically significant.

We restricted our study population to firstborn infants. Infant mortality rates are generally higher for first births than for second births, but after the second child they generally increase as birth order increases (Kramer 1987). The national vital statistics report (2006) shows that the infant mortality rate for first births is 14% higher than the rate for second births. Furthermore, firstborn children have consistently been shown to have a higher-than-average risk of low birth weight, premature birth, intrauterine growth retardation, and infant death (Miller 1993). The size effect found in this study was larger than that of other previous studies carried out on all infants regardless of birth order, although there were differences in the study period, region, method of analysis, etc.

In this study, we examined the effect of socioeconomic status and demographic factors on infant mortality, broken down by cause of death. The risk of postneonatal death from respiratory and cardiovascular disorders specific to the perinatal period was reduced in mothers aged 30 and over and was unlike the risk patterns seen for other causes of death, although this effect was not statistically significant. Otherwise, the risk of postneonatal death from congenital malformations, deformations, and chromosomal abnormalities showed a similar pattern to what was seen for all deaths, with the risks increased for mothers under 20 and over 35, although the size effect was small. These results can be explained as follows. Although genetic factors can have a similar effect on neonatal mortality, the risk of death from acquired factors, in contrast to congenital abnormalities, can be reduced through follow-up health care visits and improved nutrition in the postneonatal period, even if the mother was in the older group when she became pregnant.

We analyzed the parents' occupations as one of the indicators of socioeconomic status. We divided the occupations into three categories (professional, manual, and other), but we did not see a significant difference in infant mortality among the groups (results not shown). A variety of indicators, including educational level and occupation, of the socioeconomic status of parents exist, but the use of occupation has certain weaknesses. One weakness is a misclassification bias that stems from getting the information from the birth and death certificates. Another is that current occupation may not properly reflect past history. Thus, information on the parental occupation reported in the birth certificate is of limited use as one of the socioeconomic indicators.

The limitation of this study population was the use of surrogate indicators for the socioeconomic status of the family. The indicators taken from the birth certificate were parental education level, occupation, and marital status. It was not possible for us to evaluate whether these variables in this study could work well as surrogate indicators for socioeconomic status. One reason we can guess why we found no significant association between mortality and occupation is because occupation was poorly categorized. This misclassification of parental occupation would be non-differential, therefore made our estimation biased toward the null.

One strength of the study is that we were able to use birth information about the infants who died, because the data we used were linked birth and infant death records. Thus, although the study has various limitations as described above, it has an advantage over previous studies that used only mortality data. Additionally, our analysis showed that socioeconomic and demographic factors affect infant mortality. For postneonatal infant death, in particular, we confirmed that it is possible to reduce the risk of death from acquired factors by offering adequate follow-up care.

In conclusion, we investigated the effect of socioeconomic status and demographic factors on infant mortality among firstborn infants, broken down by cause of death, in a birth cohort from Seoul, Korea for the years 1999–2003. We described the different effects of socioeconomic status (parental education and occupation levels) and demographic factors on infant mortality by age group and cause of death. The risk of infant death was increased for parents with lower education level or for mothers who were younger than 20 or older than 35 when they gave birth. Also, for postneonatal infant deaths, we confirmed that it is possible to reduce the risk of death from acquired factors by providing adequate follow-up care. Thus, to lower mortality rates among infants, this study suggests that it is important to take into account such factors as socioeconomic status, demographic characteristics, and the age of the mother. Especially, the public health resources should be distributed more to expectant mothers with lower education level in order to make lower mortality among infants.

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Conflict of interest The authors declare that they have no competing interests.

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