

Early Neonatal Mortality, Low Birth Weight and Related Factors in Japan

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Abstract

Objectives: The author conducted an ecological study to examine prefectural differences in ENMR and the related factors in Japan, using two new indicators; birth weight (BW) adjusted ENMR and expected ENMR by BW distribution.

Method: Correlate analysis of data from national vital statistics and some indicators of medical care services among 47 prefectures edited by the Ministry of Health and Welfare, Japan were conducted. BW-adjusted ENMR and expected ENMR by BW, as well as other indicators, were prepared for statistical analysis.

Result: Crude and BW-adjusted ENMRs were significantly correlated with ENMRs for low birth weight (LBW) and very low birth weight (VLBW) early neonates ($p < 0.01$). The number of Obstetrics and Gynecology (OB/GYN) physicians was negatively correlated with BW adjusted ENMR.

Conclusion: Crude and BW-adjusted ENMRs were affected mainly by LBW and VLBW early neonate specific ENMR, but not by the rate of LBW. The variation of ENMR among prefectures in Japan is attributable to the number of OB/GYN physicians. The present findings suggest that emphasis should be laid upon enhancement of regional perinatal care systems.

Key words: early neonatal mortality rate, low birth weight, medical care system, perinatal care, Japan

Introduction

Vital statistics are a fundamental and important source of conformation used to plan efficient health programs¹. Maternal and child health (MCH) statistics are necessary to plan an effective (MCH) care system². They must be collected accurately, and published immediately.

Every MCH statistic, such as the infant mortality rate (IMR) or the neonatal mortality rate (NMR), has significantly improved in Japan, although maternal mortality is still relatively high compared with other advanced countries³. These marked improvements are mainly attributable to advances in medicine and the establishment of an effective health care system⁴. The improvement of NMR and IMR in Japan has been due to increases in the survival rate in low birth weight (LBW, birth weight of $< 2,500$ g) and very low birth weight (VLBW, birth weight of $< 1,500$ g) babies⁵. However, they have changed little in recent years, although, the rate of LBW has been rising⁶. Some studies have reported that neonates or infants with LBW have a higher mortality rate than those with normal birth weights^{7,8}. Whether the rate of LBW effects regional child health statistics and what factors can be re-

lated to differentials in those statistics remains to be determined.

The Committee on Maternal and Child Health in Japan, an expert committee in the Ministry of Health and Welfare (MHW) in Japan, proposed that we should attain further promotion of neonatal medical care in its report in 1992³. We need to clarify which factors have effects on neonatal mortality to cope with this problem. In Japan, there are differences in such health care providing circumstances as the number of physicians or the number of hospitals per population among prefectures³. There are differentials of establishing maternal and child health centers among prefectures⁶. Although a previous study examined the relationship between the maternal mortality rate and the perinatal mortality rate⁹, the effect of LBW on child health statistics has not been studied in Japan.

ENMR is defined as the rate of deaths less than 7 days of age in one year per 1,000 live births. ENMR is an informative indicator in the field of maternal and child health since deaths during the early neonatal period (between birth and 7 days of age) reflects maternal, fetal and neonatal factors². Previous studies have pointed out that the NMR and IMR are determined by both the distribution of birth weight among live births and the mortality at each birth weight^{10,11}. The maternal and fetal factors have been considered to be associated with the former; and the neonatal medical care system with the latter¹⁰. Namely, NMR and IMR can decrease when either the percentage of births with low weight or birth weight specific mortality rates decrease. The ENMR for a population may also be determined by both of these factors. It is

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necessary to consider each of these two factors separately to make regional comparisons of the ENMR.

This study reviewed ENMR that could be obtained for each of the 47 prefectures of Japan, and examined the relationship between crude and birth weight (BW)-adjusted ENMR and the distribution of LBW. This study also examined the determinant factors for BW-adjusted ENMR among prefectures in Japan.

Materials and Methods

Data source

The data regarding births and deaths were obtained from the Vital Statistics of Japan¹²⁾ published by the MHW, Japan. Since they only began to publish the number of birth weight specific early neonatal deaths by prefecture in 1996, the data between 1996 and 1998 are used. The rates of LBW and VLBW, the ENMR for those born with LBW and VLBW were also obtained from the same statistics. The number of pediatricians and Obstetrics and Gynecology (OB/GYN) physicians were obtained from the Physicians, Dentists and Pharmacist Statistics in Japan¹³⁾ published by MHW, Japan. The number of hospitals and the number of beds were obtained from Medical Care Providers Statistics in Japan¹⁴⁾ edited by the MHW, Japan. The number of public health nurses, nurses and midwives were obtained from The Official Report of Health Administration¹⁵⁾ edited by the MHW, Japan. Since all of these statistics can be obtained for 1996, the data from 1996 were analyzed.

Preparation of indicators

In this study, two indicators were prepared for statistical analysis, as well as crude ENMR. First, birth weight (BW) adjusted ENMR was calculated for each prefecture using the direct method (see Appendix 1). The birth weight distribution of live births in all of Japan between 1996 and 1998 was used as the standard. Second, the expected ENMR by BW was calculated as an indicator of the contribution of BW on ENMR in a certain prefecture (see Appendix 2). The birth weight-specific ENMR in all of Japan between 1996 and 1998 was used as the standard. In each prefecture, the expected ENMR was calculated as a summary product of the all- Japan birth weight specific ENMR and BW distribution. This indicator was prepared since it may represent a reflection of the BW distribution on ENMR in a prefecture, possibly better than the use of simple average BW.

Statistical analysis

First, the distribution of crude and BW-adjusted ENMR and the expected ENMR by BW for all prefectures in Japan were examined.

Spearman's correlation coefficients were calculated between crude or BW-adjusted ENMR and the rate of LBW, the rate of VLBW, LBW specific ENMR or VLBW specific ENMR.

Spearman's correlation coefficients were calculated between the BW adjusted ENMR and the number of pediatricians, OB/GYN physicians, public health nurses, nurses, midwives, general hospitals, OB/GYN hospitals, pediatric hospitals, hospitals with a newborn intensive care unit (NICU), or NICU beds. BW adjusted ENMR was used to assess the post-delivery factors, which have effects on ENMR accuracy. Multiple linear regression analysis was used to examine the unique association of these indicators of the medical care service with BW-adjusted ENMR. SPSS is used

Table 1 Distribution of Crude and Birth weight (BW)-adjusted Early Neonatal Mortality Rate (ENMR) and Expected ENMR by BW among 47 prefectures in Japan (1996–1998)

	Crude ENMR	BW adjusted ENMR	Expected ENMR by BW
N	47	47	47
Mean	1.48	1.48	1.39
Standard Deviation	0.28	0.28	0.11
Maximum	2.10	2.32	1.85
Minimum	1.34	1.56	1.23

for statistical analysis¹⁶⁾.

Results

Distribution of crude ENMR and adjusted ENMR

The descriptive analyses regarding crude and adjusted ENMR by prefecture are presented in Table 1 and Figure 1. The mean of crude ENMR was 1.48, and the standard deviation (SD) was 0.28. The mean of BW adjusted ENMR was 1.48 and the SD was 0.28. The mean of expected ENMR by BW was 1.39 and the SD was 0.11. (Table 1)

Correlation between ENMR and BW indicators

Crude ENMR was significantly correlated with BW-adjusted ENMR by BW and Expected ENMR by BW ($r=0.901$ and

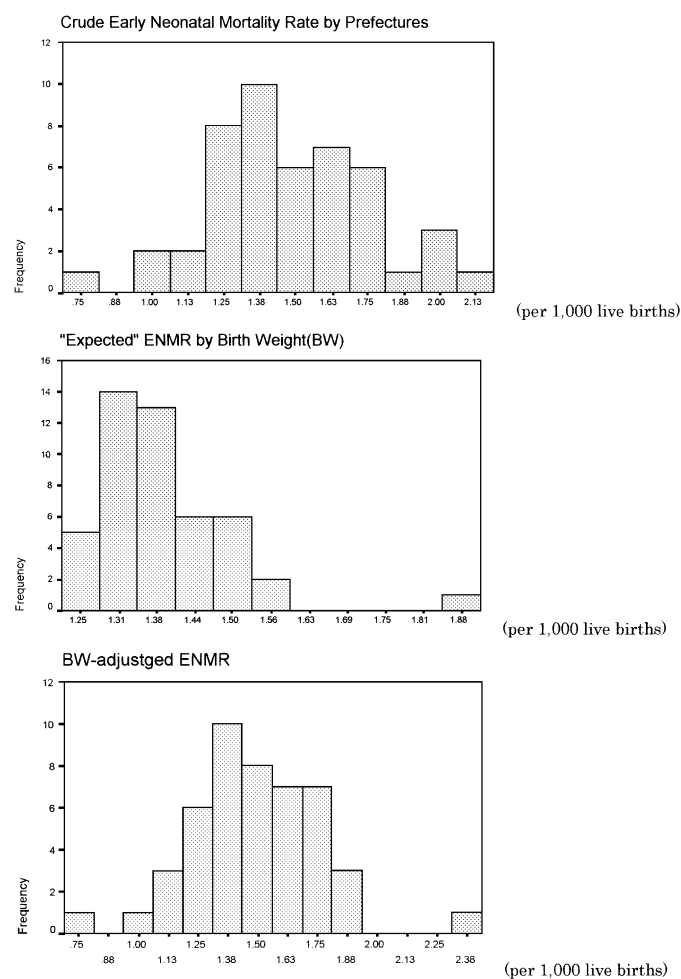


Fig. 1 Histogram of Crude Early Neonatal Mortality Rate, Birth Weight (BW) adjusted ENMR and "Expected" ENMR by BW.

Table 2 Association of Distribution of Birth Weight (BW) and BW-specific Early Neonatal Mortality Rate (ENMR) with crude and BW-adjusted ENMR and Expected ENMR by BW in Japan (1996–1998): Spearman's Correlation Coefficients (47 Prefectures)

		Crude ENMR	BW-adjusted ENMR	Expected ENMR by BW
Distribution of BW	Incidence of LBW*	-0.004	-0.226	0.600**
	Incidence of VLBW*	0.176	-0.140	0.898**
BW specific ENMR	ENMR for LBW	0.901**	0.834**	0.081
	ENMR for VLBW	0.708**	0.686**	-0.089

*: LBW=Low Birth Weight; VLBW=Very Low Birth Weight, **: Correlation is significant at the 0.01 level.

Table 3 Correlations between ENMR and Neonatal Medical Care Circumstances: Spearman's Correlation Coefficients (47 Prefectures)

	BW adjusted ENMR
Physicians (No. per 100,000 population)	0.065
Pediatricians (No. per 1,000 live births)	0.157
OB/GYN Physicians (No. per 1,000 live births)	-0.248*
Nurses (No. per 100,000 population)	0.045
Public Health Nurses (No. per 100,000 population)	0.225
Midwives (No. per 1,000 live births)	0.056
OB/GYN Hospitals (No. per 1,000 live births)	-0.223
Pediatric Hospitals (No. per 1,000 live births)	0.168
General Hospital (No. per 100,000 population)	0.006
Hospitals with NICU (No. per 1,000 live births)	0.034
NICU beds (No. per 1,000 live births)	0.069

*: Correlation is significant at the 0.05 level.

$r=0.254$, respectively $p<0.05$). The BW-adjusted ENMR and “Expected” ENMR by BW was also significantly correlated ($r=0.385$, $p<0.05$). Crude ENMR was significantly correlated with LBW early neonate specific ENMR and VLBW early neonate specific ENMR ($p<0.01$) (Table 2). BW adjusted ENMR was significantly correlated with LBW early neonate specific ENMR and VLBW early neonate specific ENMR ($p<0.01$). There was no significant correlation between BW adjusted ENMR and the incidence of LBW or that of VLBW, which was expected from the definition of this indicator.

Expected ENMR by BW was significantly correlated with the incidence of LBW and that of VLBW, which was also expected.

Correlation between BW-adjusted ENMR and indicators of neonatal care services

Number of OB/GYN physicians per given live birth was negatively correlated with BW adjusted ENMR (Table 3). No indicators other than this were correlated with BW adjusted ENMR.

Discussion

In this study, the crude and BW-adjusted ENMRs were strongly associated with the ENMRs for those born with LBW and VLBW. However, the rates of LBW or VLBW did not explain the variation in ENMR among prefectures; we observed almost no association between the rates of LBW or VLBW and the BW-adjusted ENMR. The NMR and IMR are determined by both the distribution of birth weight and the mortality for each birth weight group¹⁰. The findings of present study suggested that the regional difference in the ENMR was attributable to ENMRs among those born with lower birth weight, but not to the rate of low birth weight neonates. Early mortality within 7 days after birth may be determined more by a severe neonatal problem or a maternal prob-

lem. Low birth weight may be associated with mortality during the period of 7 days or later (NMRs and IMRs) through a deteriorated growth or a possible moderate complication. The strong correlation coefficients ($r=0.68-0.90$) suggest that a regional difference in crude or BW-adjusted ENMR reflects a variation in ENMRs for LBW or VLBW neonates, or that it is determined by common factors may underlie these indicators. An improvement in ENMRs for LBW or VLBW neonates may be a good strategy to decrease ENMRs in Japan. However, we observed a significant and moderate correlation between the BW-adjusted ENMR and the expected ENMR by BW. Not LBW or VLBW, but an average level of birth weight may still have some association with BW-adjusted ENMRs, which might reflect the socioeconomic background of the prefecture. This remains to be addressed in future research.

Low or almost no correlation between the ENMRs and the rates of LBW or VLBW suggests that factors for early neonatal mortality among LBW neonates are different from factors for the occurrence of LBW/VLBW. Previous studies have reported that neonatal medical care contributes to a decrease in NMR and IMR¹⁷. However, several maternal factors have been associated with low birth weight¹⁸: maternal smoking¹⁹⁻²³, history of live born LBW infants²⁰, having diabetes²¹, low maternal weight gain^{22,23}, and mothers educational level²⁴. This also appeared to be the case for ENMRs.

The mortality of neonates or infants with LBW has a close association with the medical care system after birth. Since newborn infants with LBW are subject to develop respiratory tract insufficiency, they have respiratory distress syndrome (RDS)²⁵. Surfactant therapy can reduce morbidity and mortality among premature infants with RDS^{26,27}. These advances in neonatal medical care contributed to the decrease in ENMR. The Center for Disease Control and Prevention (CDC) in the United States reported that the key reason for the decline in neonatal mortality has been the improved rates of survival among LBW babies, not the reduction in the incidence of LBW²⁸. Neonatal mortality with LBW is significantly lower for births that occurred in higher-level hospitals^{29,30}, LBW infants should be delivered in higher-level medical centers³¹. Obstetric and pediatric care providers should have the ability to partner with the community, public health officials and other organizations participating in the perinatal health system to ensure the best possible outcomes for LBW infants by maintaining the links to risk-appropriate medical care³².

The present study suggests that OB/GYN physicians have a key role to reduce ENMR. Pediatricians and pediatric hospitals may contribute to neonatal medical care. Hospitals with NICU are essential for medical care of neonates with high risk. However, perinatal care provided by the OB/GYN might have a greater effect on the regional differentials in ENMR. Sakamoto et al. reported that the aim of perinatal medicine was to assist fetal and neonatal adaptation to secure healthy growth during infancy and

thereafter, primarily by an appropriate obstetric practice⁴). The concept of the perinatal period emerged in the late 1940s as physicians and researchers became increasingly aware of the relatively large number of deaths that occurred in the period immediately before or after delivery. It was suggested that conditions established before delivery or from the stresses introduced by the birth process were responsible for the majority of neonatal deaths³³). Improvement of the perinatal care system may be important for decrease of ENMR in a community.

There are some limitations of this study. First, the ENMRs of prefectures in Japan are relatively low. In addition, there is only a small difference in ENMRs among prefectures. These might result in a low power of the analysis; i.e. failure to detect relevant factors. When the correlation between BW-adjusted ENMR and indicators of health care services were examined, no significant correlation between ENMR and indicators regarding pediatrician or NICU could be found. This may be due to the small difference in ENMRs. Second, in this study, the data between 1996 and 1998 published by Japanese government was used and analyzed and there may be unknown confounding factors. In this type of study, the interpretation of correlation is often difficult. It should be careful to conclude a direct causal relationship from these correlations, although they often provide useful insights. Third, there were limitations due to regional comparison analysis. The indicators were examined at the prefecture level. Although it is difficult, it might be better to use data from smaller region such as a city to assess the differences in mortality or medical care service more accurately. Fourth, as the source of information for the correlation analysis between ENMR and the indicators of neonatal care service were used only published and easily accessible data for indicators of neonatal care. More factors, which are subject to effects on neonatal mortality, should be examined in further studies.

In this study, two indicators were proposed regarding ENMR. The first was a BW-adjusted ENMR. This study is unique since it used the adjusting technique to examine the ENMR. The second was an expected ENMR by BW, which was correlated with the ENMRs more than the rates of LBW or VLBW did. These indicators appear useful for comparing the ENMR taking into account the birth weight distribution and birth weight specific mortality

rate. This study is unique since the BW adjusted ENMR was used to examine the effect of neonatal care service on early neonatal mortality. Since NMR and IMR are also determined by both the distribution of birth weight among live births and the mortality at each birth weight¹⁷), it was pointed out that the international comparison of NMR or IMR could contribute to planning the MCH program in each country³⁴). However, the differences in the definitions and measures in vital statistics among countries make it difficult to compare the MCH statistics internationally³⁵). This is also the case with ENMR. It was found that adjusting methods were useful to compare ENMR. When these methods were used, however, both standard birth weight distribution among live births and standard birth weight specific mortality were needed. To make international comparisons, each country needs to register the number of births by birth weight and the number of early neonatal deaths. Few countries have published this information. They also cannot be found in the Demographic Year Book edited by the United Nations or The State of the Worlds Children edited by UNICEF, which publishes international vital statistics^{35,36}). International organizations should help to improve the vital statistics system in each country to make international comparisons possible.

The maternal and child health act in Japan, which was innovated in 1994, obligates local governments to be responsible for promoting sequential MCH services by conducting regular health examinations for infants and pregnant women, distributing adequate perinatal medical knowledge and arranging for home visit education³). Each regional government needs to have more responsibility for establishing the MCH program based on regional circumstances. In conclusion, LBW or VLBW specific ENMR is associated with the regional differences in crude ENMR. The care system should be enhanced in each region in order to reduce ENMR.

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Appendix 1

Standardization of Prefectural ENMR using Standard Birth Weight Distribution (Sample Calculation for Tokyo Prefecture)

Birth Weight	Standard BW Distribution (*) (%) (a)	Tokyo Prefecture Observed			Tokyo Prefecture expected		Birth Weight Adjusted ENMR (**)
		Live Births (No.) (b)	Early neonatal deaths (No.) (c)	ENMR (No. Per 1,000 Live Births) (d)	Live Births (No.) (e)	Early Neonatal Deaths (No.) (f)	
<1,000 (1)	0.22 (a ₁)	644	106	164.60 (d ₁)	657.1 (e ₁)	108.16 (f ₁)	
1,000–1,499 (2)	0.38	1,105	41	37.10	1,134.7	42.10	414.09/
1,500–1,999 (3)	1.03	2,981	49	16.44	3,039.3	49.96	294,820*1,000
2,000–2,499 (4)	6.20	18,511	65	3.51	18,281.4	64.19	=1.40455
>=2,500 (5)	92.14	271,522	147	0.54	271,658.1	147.07	(per 1,000 live births)
Unknown (6)	0.02	57	3	52.63	49.4	2.60	
Total (T)	100.0 (a _T)	294,820 (b _T)	411	1.39	294,820.0 (e _T)	414.09 (f _T)	

(*) Obtained from population birth weight distribution between 1996 and 1998 in Japan.

(**) Calculation formula for BW adjusted ENMR.

$$e_i = S(b_i * a_i / 100).$$

$$f_i = S(e_i * d_i / 1000).$$

$$\text{BW adjusted ENMR} = f_i / e_i * 1000.$$

Appendix 2

Standardization of Prefectural ENMR using Standard Birth Weight Specific ENMR (Sample Calculation for Tokyo Prefecture)

Birth Weight	Standard ENMR (*) (No. Per 1,000 live births) (a)	Tokyo Prefecture		Expected ENMR by Birth Weight (**)
		Actual Live Births (No.) (b)	Expected Early Neonatal Death (No.) (c)	
<1,000 (1)	173.91 (a ₁)	644 (b ₁)	112.00 (c ₁)	
1,000–1,499 (2)	41.84	1,105	46.24	
1,500–1,999 (3)	16.94	2,981	50.50	406.87/294,820*1000
2,000–2,499 (4)	3.24	18,511	59.93	=1.38006
>=2,500 (5)	0.48	271,522	130.92	(per 1,000 live births)
Unknown (6)	127.69	57	7.29	
Total (T)		294,820 (b _T)	406.87 (c _T)	

(*) Obtained from population birth weight specific ENMR between 1996 and 1998 in Japan.

(**) Calculation formula for Expected ENMR by Birth Weight.

$$c_i = \Sigma(b_i * a_i / 1,000).$$

$$\text{Expected ENMR by Birth Weight} = c_i / b_i * 1,000.$$