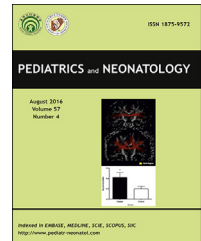




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ORIGINAL ARTICLE

International Ranking of Infant Mortality Rates: Taiwan Compared with European Countries



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Key Words

infant mortality;
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Taiwan

Background: Rankings of infant mortality rates are commonly cited international comparisons to assess the health status of individual countries. We compared the infant mortality rate of Taiwan with those of European countries for 2004 according to two definitions.

Methods: First, the countries were ranked on the basis of crude infant, neonatal, and postneonatal mortality rates. The countries were then ranked according to the mortality rates calculated after exclusion of live births with a known birth weight of <1000 g, which is the definition set by the World Health Organization.

Results: Taiwan was ranked 11th, 12th, and 15th among 26 high-income countries for crude infant, neonatal, and postneonatal mortality rates, respectively. The ranks were 12th, 16th, and 15th, respectively, for mortality rates, excluding live births with a birth weight of <1000 g. However, in only seven, four, and 10 countries were the mortality rate ratios statistically significantly lower than Taiwan in infant, neonatal, and postneonatal mortality, respectively, according to the second definition.

Conclusion: The ranking of Taiwan was similar (11th vs. 12th) according to the two definitions. However, after consideration of the confidence interval, only six countries (Sweden, Finland,

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Czech Republic, Belgium, Austria, and Germany) had infant mortality rates statistically significantly lower than those of Taiwan in 2004.

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1. Introduction

Rankings of infant mortality rates are the most commonly cited international comparisons used to assess the health status of individual countries. International organizations, such as the United Nations Children's Fund (UNICEF) and the Organization for Economic Cooperation and Development (OECD), routinely publish international rankings of perinatal, infant, or child mortality rates among countries.^{1,2} Furthermore, the aim of United Nations Millennium Development Goal 4 is to reduce mortality of children younger than 5 years by two thirds between 1990 and 2015. Therefore, a series of studies comparing the neonatal, postnatal, infant, and under-5 years mortality across countries have been published.^{3–9}

A previous study indicated that the infant mortality rate of Taiwan ranked 20th among 21 countries.¹⁰ A recent study suggested that the survival rate of very low birth weight infants was higher than that observed in the USA, but lower than Canada and Japan.¹¹ However, many scholars indicated the presence of bias, such as the variation in registration of live births and stillbirths among countries, in comparisons of infant mortality rates among countries.^{12–25} Therefore, the World Health Organization (WHO) recommended restricting international comparisons of infant mortality rates to comparing live births with a known birth weight of at least 1000 g.²⁶ Despite this suggestion, information on the number of live births with a birth weight < 1000 g is not readily available for many countries, which hinders valid international comparisons. Recently, Joseph et al²³ studied the number of live births and neonatal and infant deaths of infants <1000 g in 23 European countries, Canada, and the United States. We used the information from Joseph et al²³ to compare the infant mortality rate of Taiwan with those of the aforementioned European countries.

2. Methods

2.1. Data sources

Information on the number of live births, neonatal, post-neonatal, and infant deaths according to the birth weights (particularly those < 500 g and <1000 g) of 23 European countries, Canada, and the United States was obtained from Joseph et al,²³ with most of the data from 2004. The corresponding information for Taiwan for 2004 was obtained by linking data from the birth registry, birth reporting, and cause of death, sourced through the processes established by the collaboration center for health

information application, Ministry of Health and Welfare, Taiwan.²⁷

2.2. Measures

First, the reported proportions of live births and neonatal deaths with a birth weight of <500 g or <1000 g for each country were compared. Second, the countries were ranked based on the crude infant (<1 year), neonatal (0–27 days), and postneonatal (28–364 days) mortality rates (deaths per 1000 live births). Third, the countries were ranked again according to the mortality rates in which the live births with a known birth weight of <1000 g were excluded. Finally, the mortality rate ratios (RR) and 95% confidence intervals (95% CI) were computed using Taiwan as the reference in order to assess the magnitude and statistical significance of the observed differences in the mortality rates between Taiwan and the other countries. The formula for estimation of 95% CI is as follows²⁸:

$$RR_{L,U} = e^{\ln RR \pm 1.96 \sqrt{\frac{1}{A1} + \frac{1}{A2}}}$$

where *L* is the lower limit and *U* is the upper limit of 95% CI. *A1* is the number of deaths in the compared country, and *A2* is the number of deaths in Taiwan.

This study was reviewed by the Institutional Review Board (IRB) of the National Cheng Kung University Hospital, Tainan, Taiwan with IRB Number B-ER-102-120-t.

3. Results

The reported proportion of live births with a birth weight <500 g varied widely among countries in 2004. In eight countries, the live birth rates were less than one per 10,000 live births (Table 1). The rate was 3.8 per 10,000 live births for Taiwan, which ranked 20th among 26 countries. However, the proportion of live births with a birth weight <1000 g in Taiwan was 30.8 per 10,000 live births, which ranked 7th among 26 countries (Table 1).

When ranking was based on crude infant mortality rates, Taiwan ranked 11th among 19 high-income countries. When infant mortality rates were calculated after live births with a birth weight <1000 g were excluded, Taiwan ranked 12th (Table 2). Of the 11 countries that ranked ahead of Taiwan for infant mortality, excluding live births with a birth weight <1000 g, only seven countries had infant mortality rates statistically significantly lower than those of Taiwan (Figure 1A).

We further categorized infant mortality into neonatal and postneonatal mortality. Taiwan ranked 12th for the crude neonatal mortality rate; however, when the neonatal mortality rate excluding birth weights <1000 g was

Table 1 Reported number of live births, proportion (per 10,000) of live births with birth weight <500 g or <1000 g, and rank in each studied country.

Country	Number of live births	Live births <500 g		Live births <1000 g	
		Proportion	Rank	Proportion	Rank
Malta	3887	0.0	1	25.7	2
Luxembourg	5469	0.0	2	1.9	1
Latvia	20,355	0.0	3	28.5	5
Ireland	62,066	0.0	4	32.6	8
Poland	356,697	0.0	5	38.9	18
Belgium	76,872	0.4	6	33.2	11
Portugal	109,356	0.6	7	35.7	13
Slovak Republic	52,388	0.8	8	32.8	9
Lithuania	29,480	1.0	9	28.2	4
Czech Republic	97,664	1.4	10	37.9	16
Sweden	100,158	1.5	11	27.4	3
Northern Ireland	22,362	1.8	12	40.7	21
Norway	57,111	1.9	13	33.4	12
Estonia	13,990	2.1	14	40.1	20
Denmark	64,521	2.2	15	33.1	10
Netherlands	181,006	2.7	16	36.8	14
Austria	78,934	2.8	17	37.8	15
Slovenia	17,846	3.4	18	38.1	17
Finland	57,569	3.8	19	30.4	6
Taiwan	217,404	3.8	20	30.8	7
Scotland	52,911	4.2	21	39.5	19
Germany	646,599	4.8	22	50.1	24
Hungary	95,118	6.1	24	61.0	25
England & Wales	639,721	6.1	23	49.4	23
Canada	204,521	10.8	25	45.2	22
United States	4,118,951	16.9	26	75.2	26

Table 2 Crude infant mortality rates (deaths per 1000 live births), infant mortality rates excluding live births with birth weight <1000 g, ranks, and comparative RR by country, with Taiwan as the reference.

Country	Crude infant mortality				Infant mortality excluding live births with birth weight <1000 g			
	Rate	Rank	RR	95% CI	Rate	Rank	RR	95% CI
Sweden	2.99	1	0.61	*0.51–0.73	2.38	3	0.68	*0.55–0.83
Norway	3.01	2	0.61	*0.50–0.75	3.02	11	0.86	0.68–1.09
Finland	3.39	3	0.69	*0.57–0.83	2.17	2	0.62	*0.51–0.75
Czech Republic	3.75	4	0.76	*0.63–0.92	2.13	1	0.61	*0.50–0.75
Belgium	3.94	5	0.80	*0.68–0.94	2.80	8	0.80	*0.67–0.95
Northern Ireland	4.02	6	0.82	0.63–1.05	2.61	6	0.75	0.55–1.00
Austria	4.05	7	0.82	*0.70–0.96	2.49	4	0.71	*0.61–0.83
Germany	4.14	8	0.84	0.70–1.01	2.66	7	0.76	*0.62–0.93
Denmark	4.43	9	0.90	0.74–1.09	2.89	9	0.83	0.67–1.02
England & Wales	4.93	10	1.00	0.86–1.17	3.01	10	0.86	0.74–1.01
Taiwan	4.93	11	1.00	Reference	3.50	12	1.00	Reference
Scotland	4.93	12	1.00	0.85–1.17	3.52	13	1.01	0.85–1.19
Canada	5.05	13	1.02	0.84–1.24	2.50	5	0.71	*0.58–0.88
Malta	5.92	14	1.20	1.03–1.40	4.65	18	1.33	1.14–1.54
Estonia	6.29	15	1.28	1.08–1.51	4.40	16	1.26	1.05–1.51
Hungary	6.60	16	1.34	1.04–1.73	3.69	15	1.05	0.79–1.41
United States	6.70	17	1.36	1.16–1.59	3.53	14	1.01	0.86–1.18
Poland	6.77	18	1.37	0.89–2.12	4.62	17	1.32	0.81–2.14
Latvia	9.38	19	1.90	1.55–2.34	7.76	19	2.22	1.79–2.75

CI = confidence interval; RR = rate ratio.

*P < 0.05.

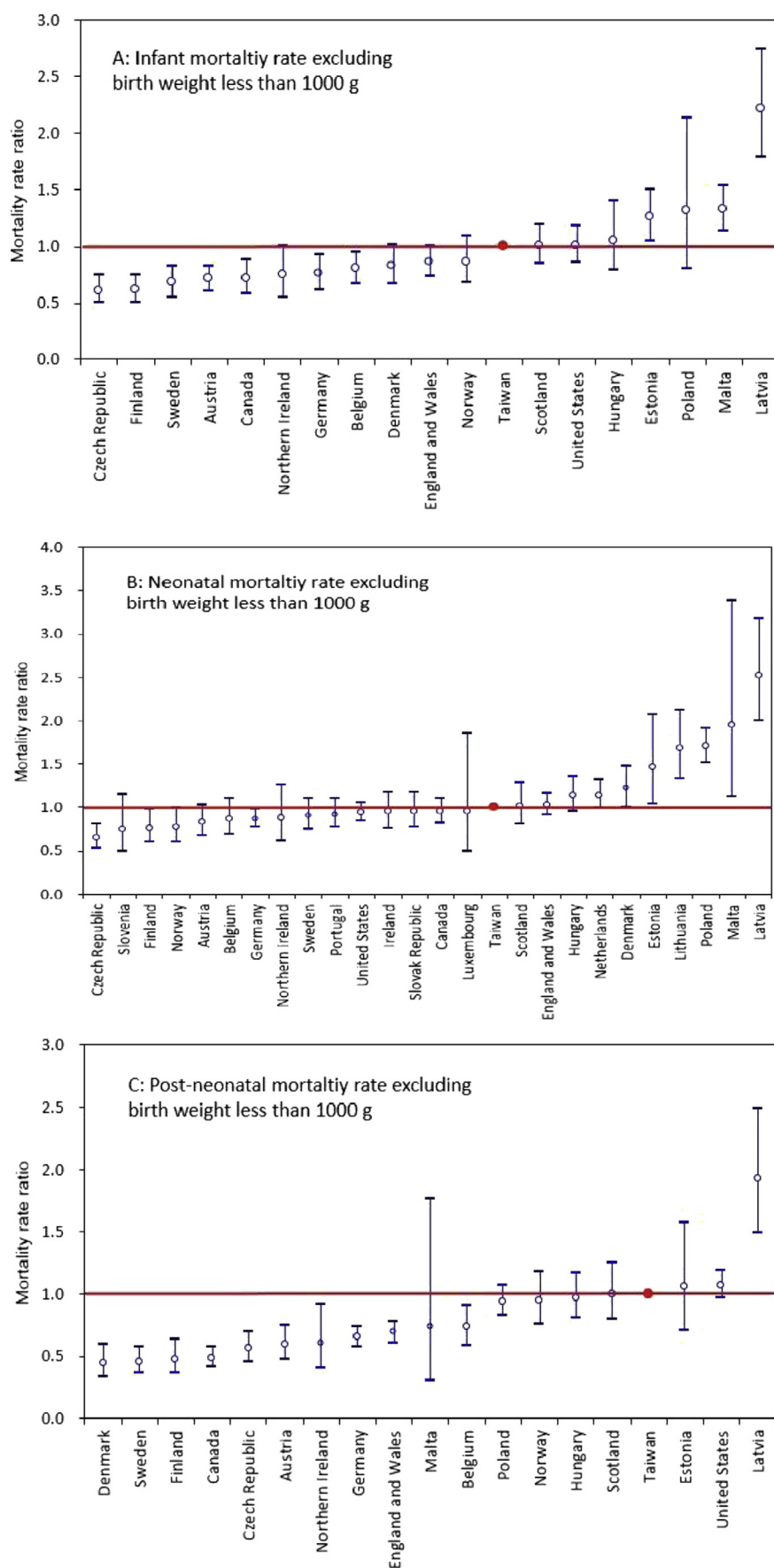


Figure 1 Infant (A), neonatal (B), and postnatal (C) mortality rate ratios excluding live births under 1000 g by country with Taiwan as the reference.

Table 3 Crude neonatal mortality rates (deaths per 1000 live births), neonatal mortality rates excluding live births with birth weight <1000 g, ranks, and comparative RR by country, with Taiwan as the reference.

Country	Crude neonatal mortality				Neonatal mortality excluding live births with birth weight <1000 g			
	Rate	Rank	RR	95% CI	Rate	Rank	RR	95% CI
Luxembourg	2.01	1	0.70	0.39–1.27	1.64	15	0.95	0.49–1.85
Norway	2.07	2	0.72	*0.59–0.88	1.33	4	0.78	*0.61–0.99
Sweden	2.10	3	0.73	*0.63–0.86	1.56	9	0.91	0.75–1.10
Czech Republic	2.29	4	0.80	*0.68–0.93	1.12	1	0.65	*0.53–0.81
Finland	2.45	5	0.85	0.71–1.02	1.31	3	0.76	*0.60–0.98
Slovak Republic	2.56	6	0.89	0.76–1.05	1.64	6	0.95	0.77–1.17
Portugal	2.56	7	0.89	0.77–1.03	1.59	10	0.92	0.77–1.10
Belgium	2.56	8	0.89	0.74–1.07	1.49	13	0.87	0.69–1.10
Slovenia	2.63	9	0.92	0.68–1.23	1.29	2	0.75	0.49–1.15
Ireland	2.69	10	0.94	0.79–1.11	1.64	12	0.95	0.76–1.18
Austria	2.72	11	0.95	0.81–1.11	1.44	5	0.83	0.68–1.03
Taiwan	2.87	12	1.00	Reference	1.72	16	1.00	Reference
Germany	2.93	13	1.02	0.93–1.12	1.50	7	0.87	*0.77–0.98
Northern Ireland	2.95	14	1.03	0.80–1.32	1.53	8	0.89	0.62–1.26
Scotland	3.04	15	1.06	0.89–1.26	1.75	17	1.02	0.81–1.28
England & Wales	3.42	16	1.19	1.09–1.30	1.78	18	1.03	0.92–1.16
Netherlands	3.49	17	1.22	1.09–1.36	1.97	20	1.14	0.99–1.32
Denmark	3.56	18	1.24	1.07–1.44	2.10	21	1.22	1.00–1.48
Canada	3.75	19	1.31	1.18–1.45	1.64	14	0.95	0.82–1.10
Estonia	4.22	20	1.47	1.13–1.92	2.52	22	1.46	1.04–2.07
Malta	4.37	21	1.52	0.94–2.47	3.35	25	1.95	1.12–3.38
Hungary	4.45	22	1.55	1.37–1.75	1.96	19	1.14	0.96–1.36
United States	4.47	23	1.56	1.44–1.69	1.62	11	0.94	0.85–1.05
Lithuania	4.61	24	1.61	1.33–1.93	2.89	23	1.68	1.33–2.12
Poland	4.85	25	1.69	1.54–1.85	2.94	24	1.71	1.52–1.92
Latvia	5.70	26	1.99	1.63–2.42	4.33	26	2.52	2.00–3.18

CI = confidence interval; RR = rate ratio.

*P < 0.05.

considered, the ranking changed to 16th (Table 3). Furthermore, of the 15 countries ranked above Taiwan, only four countries (the Czech Republic, Finland, Norway, and Germany) exhibited neonatal mortality rates statistically significantly lower than the ratio of Taiwan (Figure 1B).

Regarding postneonatal mortality, Taiwan ranked 15th for both crude postneonatal and postneonatal mortality rates excluding birth weights <1000 g (Table 4). Of the 14 countries ranked above Taiwan, 10 had postneonatal mortality rates significantly lower than those of Taiwan (Figure 1C).

4. Discussion

The findings of this study indicated that the rankings of infant, neonatal, and postneonatal mortality in Taiwan when compared with European countries were similar according to the two supplied definitions. Despite Taiwan ranking 12th in infant mortality rate according to the WHO definition (i.e., excluding birth weights < 1000 g), only seven countries (Sweden, Finland, Czech, Belgium, Austria, Germany, and Canada) had significantly lower rates than those of Taiwan when the CIs were considered.

According to the WHO, live birth is defined as any product of conception that shows signs of life at birth with no consideration for birth weight or gestational age criteria. However, some countries have different regulations for the registration of such births. Countries, such as the Czech Republic, France, and the Netherlands, specify live-birth registration limits by combining the gestational age of at least 22 weeks, a birth weight of at least 500 g, and survival for the first 24 hours after birth.²¹ The variation in the proportion of live births with extremely low birth weights among countries, as indicated in Table 1, may result from the variation in birth registration practices in these countries.

In 2004, the reported proportion of live births with a birth weight <500 g in Taiwan (3.8 per 10,000 live births) was relatively high (ranked 20th) compared with 26 countries. However, the reported proportion of live births with a birth weight <1000 g in Taiwan (30.8 per 10,000 live births) was relatively low (ranked 7th). In other words, there were more live births with a birth weight <500 g in Taiwan than in other European countries. One possible explanation for this finding is that the Taiwan National Health Insurance program covers the medical expenditures of neonatal intensive care units; hence, the number of newborns with an extremely low birth weight who receive treatment would be high.

Table 4 Crude postneonatal mortality rates (deaths per 1000 live births), postneonatal mortality rates excluding live births with birth weight <1000 g, ranks, and comparative RR by country, with Taiwan as the reference.

Country	Crude post-neonatal mortality				Post-neonatal mortality excluding live births with birth weight <1000 g			
	Rate	Rank	RR	95% CI	Rate	Rank	RR	95% CI
Denmark	0.87	1	0.42	*0.32–0.56	0.79	1	0.45	*0.33–0.60
Sweden	0.89	2	0.43	*0.34–0.54	0.81	2	0.46	*0.36–0.58
Finland	0.94	3	0.46	*0.34–0.61	0.85	3	0.48	*0.36–0.64
Norway	0.94	4	0.46	*0.34–0.61	1.69	13	0.95	0.76–1.18
Northern Ireland	1.07	5	0.52	0.34–0.78	1.08	7	0.61	*0.40–0.92
Germany	1.21	6	0.59	*0.52–0.66	1.17	8	0.66	*0.58–0.74
Canada	1.30	7	0.63	*0.54–0.73	0.86	4	0.49	*0.41–0.58
Austria	1.33	8	0.65	*0.52–0.80	1.05	6	0.59	*0.47–0.75
Belgium	1.38	9	0.67	*0.54–0.83	1.30	10	0.73	*0.59–0.91
Czech Republic	1.46	10	0.71	*0.59–0.86	1.00	5	0.56	*0.45–0.70
England & Wales	1.51	11	0.73	*0.66–0.82	1.24	9	0.69	*0.61–0.78
Malta	1.55	12	0.75	0.34–1.68	1.30	10	0.73	0.30–1.76
Scotland	1.89	13	0.92	0.74–1.14	1.78	15	1.00	0.80–1.25
Poland	1.92	14	0.93	0.83–1.05	1.68	12	0.94	0.83–1.07
Taiwan	2.06	15	1.00	Reference	1.78	15	1.00	Reference
Estonia	2.07	16	1.00	0.69–1.46	1.88	17	1.05	0.71–1.57
Hungary	2.15	17	1.04	0.88–1.23	1.73	14	0.97	0.81–1.17
United States	2.23	18	1.08	0.98–1.19	1.90	18	1.07	0.97–1.19
Latvia	3.68	19	1.79	1.40–2.28	3.43	19	1.93	1.49–2.49

CI = confidence interval; RR = rate ratio.

*P < 0.05.

As the reported proportion of live births with a birth weight <1000 g in Taiwan was relatively low compared with most European countries, the Taiwanese ranking for infant, neonatal, and postneonatal mortality rates did not differ substantially before or after exclusion of birth weights <1000 g. Many countries with a lower neonatal mortality rate than that of Taiwan did not reveal significantly lower mortality rate ratios when we considered the 95% CIs that were due to the low number of neonatal deaths. For example, there were only nine neonatal deaths in Luxembourg and 23 neonatal deaths in Slovenia, excluding birth weights <1000 g, whereas 373 neonatal deaths were reported in Taiwan in 2004.

Neonatal mortality rates varied greatly by birth weight categories, and showed drastic fluctuations in Taiwan during the past decade.²⁹ Therefore, the use of weight-specific neonatal or infant mortality rates in international comparison studies was appropriate, as in the study conducted by Su et al,¹¹ who compared gestational age-specific survival rates of very low birth weight infants between Taiwan and Canada, Japan, and the United States.¹¹ Another significant contribution of this study was the use of the identical indicators in the same time period, which allowed a direct comparison of countries.

There were several limitations in this study, and results should be interpreted in light of these limitations. First, the data from European countries, Canada, and the United States were based on the study of Joseph et al,²³ which was gathered 10 years ago. Recent data may yield somewhat different results. For future research, emphasis should also be placed on collecting recent data for a more updated comparison. Second, the study focused solely on birth

weight without considering gestational age, which may also be related to mortality. Given that gestational age and birth weight were highly related, the results would likely lead to similar conclusions when considering gestational age. Finally, since the birth weight composition varied greatly between countries, future international comparison studies should compare neonatal and infant mortality rates stratified by birth-weight or gestational-age categories.

In conclusion, based on the corrected rates recommended by WHO and statistical examination, Taiwan ranked moderately compared with European countries when the infant, neonatal, and postneonatal mortality rates were calculated. Further analyses are necessary to determine the causes of infant, neonatal, and postneonatal deaths, which would provide relevant information in designing preventive programs for reducing infant, neonatal, and postneonatal mortality.

Conflicts of interest

There are no conflicts of interest to disclose.

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