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Secular trends in the prevalence of low birthweight infants in Japan from 1980 to 2020: a joinpoint regression analysis

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ABSTRACT

Japan has a higher prevalence of low birthweight infants (LBW, < 2500 g) than other developed countries. In this study, we aimed to clarify the descriptive epidemiological characteristics of LBW prevalence in Japan from 1980 to 2020. LBW prevalence data were obtained from the Vital Statistics of Japan. Trends in crude and age-standardized LBW prevalence rates for total and singleton births separately and rates for full-term births, as well as age-specific prevalence rates by maternal age at delivery, were analyzed using joinpoint regression. The crude LBW rate increased slowly from 5.18 per 100 births in 1980, rose sharply from the late 1980s, peaked at 9.62 in 2007, and then declined slowly to 9.22 in 2020 for the total births. The annual percent changes were 1.35% (1980–1987), 3.37% (1987–2000), 1.81% (2000–2006), and –0.24% (2006–2020), with an average annual percent change (APC) of 1.51%. Age-standardized rates for the singleton and full-term births showed a similar trend. Age-specific rates showed a sharp increase for approximately 10 years after 1985, followed by a decline in the group > 35 years of age. The rate for the 15–19 age group increased gradually, with no change point (APC = 0.60). These findings likely reflect changes in maternal and socio-environmental factors—such as increased maternal age, undernutrition, lower body mass index (BMI), and expanded use of assisted reproductive technology and perinatal care—and emphasize the importance of preconception care and maternal health care, including nutrition and life-course approaches, to reduce low birthweight risk.

Keywords: low birthweight, Japan, joinpoint regression analysis

Abbreviations:
APC: annual percent change
LBW: low birthweight
BMI: body mass index

INTRODUCTION

Low birthweight (LBW, < 2500 g) in infants is a global public health concern. Birth weight is an essential indicator of the intrauterine environment, nutritional status, and lifestyle of

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the mother. In addition, pregnancy-related illnesses during pregnancy substantially affect the intrauterine environment.[1-3] LBW is closely associated with the health status of the newborn and long-term health conditions[4-6] such as hypertension,[7,8] type 2 diabetes,[9] and cardiovascular diseases.[10,11] Therefore, LBW is a primary outcome indicator of the Global Nutrition Monitoring Framework core indicator set[12] and is included in the World Health Organization (WHO) Global reference list of 100 core health indicators.[13]

According to United Nations Children Emergency Fund,[14] approximately 19.8 million neonates had LBW in 2020, accounting for 14.7% of the total births. Two perspectives are crucial when examining trends in LBW and when considering countermeasures. The first is the challenge in low- and low-middle-income regions, including South Asia and Sub-Saharan Africa, where 16.5 million infants were born with LBW, accounting for 83.3% of all neonates with LBW. The prevalence of LBW varies among countries; however, approximately 1 million infants with LBW were born in high-income areas. According to 2021 data published by the Organisation for Economic Co-operation and Development (OECD),[15] Greece (9.7%) and Japan (9.4%) had higher LBW prevalence rates than the United States (8.5%), France (7.3%), South Korea (7.2%), and the United Kingdom (6.4%). Annual trends show an increasing LBW prevalence in all countries except the United Kingdom. Japan, in particular, showed a rapid increase in the prevalence of neonates with LBW from 5.2% in 1980 to over 9% in 2002, which was faster than the increase in any other country. However, considering that Japan has a low neonatal mortality rate, the increasing prevalence of infants with LBW could lead to a considerable socioeconomic burden, including an increase in disease prevalence. Therefore, we aimed to clarify the descriptive epidemiological characteristics of infants with LBW in Japan and provide epidemiological knowledge that can serve as a foundation for preventive measures.

MATERIALS AND METHODS

Study design and data collection

This nationwide descriptive epidemiological study used the annual Vital Statistics published by the Japanese government and analyzed government statistical data from 1980 to 2020 to characterize the descriptive epidemiology of LBW prevalence. LBW birth data (1980–2020) were collected from the public database of the Japanese Ministry of Health, Labour and Welfare (MHLW), and the trends were analyzed using a joinpoint regression analysis.[16]

In Japan, obstetricians and midwives at hospitals and clinics issue birth certificates at the time of delivery, including birth weight and whether the birth is singleton or multiple. The parents of the child submit the birth certificate to the municipal office within 14 days of birth, and information on the certificate is stored in an electronic form. Annually, the MHLW publishes the number of births weighing < 2500 g according to the mother's 5-year age group. All data used in this study are open-access and publicly available. No personally identifiable information was recorded or used; therefore, ethical approval was not required based on Ethical Guidelines for Medical and Biological Research Involving Human Subjects that the Bioethics Review Committee of the Nagoya University Graduate School of Medicine adheres to.

Statistical analyses

The outcome variable was the prevalence of LBW in the total and singleton births. We considered that all births, including multiple births, should be targeted when examining the impact of infertility treatment. On the other hand, we considered it appropriate to target only singleton births in order to observe the effects of changes in the social environment other than infertility treatment.

Available data included the number of infants with LBW in seven age groups from 1980 to 2020: < 19, 20–24, 25–29, 30–34, 35–39, 40–44, and ≥ 45 years. Infants with LBW were divided into single and multiple birth groups. In addition, the number of infants with LBW by week of delivery was available, but not by maternal age group.

First, we examined the trend in crude LBW prevalence from 1980 to 2020. Then, we investigated the trend in age-adjusted LBW prevalence based on the number of births by age group in 2015 and determined the crude LBW prevalence in the seven age groups. Next, the trend in crude LBW prevalence was examined by targeting only full-term births. These examinations were conducted for the total and single births only.

Joinpoint regression analysis

Trends in the LBW prevalence were analyzed using a joinpoint regression model.[16] The basic concept of joinpoint regression analysis is to divide the long-term trend line into several segments and describe each segment with continuous linearity. Seven joint points were set up for the estimation, and the model was tested and confirmed to be the best fit. In the joinpoint regression analysis, the years in which significant changes in prevalence occurred during the study period were identified, along with the annual percent change (APC) in each segment and the average APC for the entire period. Joinpoint regression analysis was performed using the Joinpoint Regression Program (v. 5.0.0; US National Cancer Institute, Bethesda, MD, USA).[17]

RESULTS

Figure 1 shows the crude and age-standardized prevalence rates of neonates with LBW per 100 births for the total and singleton births from 1980 to 2020. It also displays the respective modeled annual trends. Figure 1 and Table 1 present the joinpoint regression analysis results

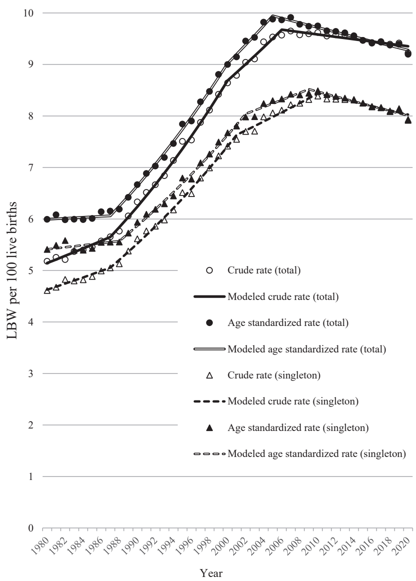

Fig. 1 Crude and age-standardized prevalence rates per 100 births of low birthweight by overall and singleton births from 1980 to 2020, and the respective modeled annual trends

LBW: low birthweight

Table 1 Trends analysis of crude and age-standardized prevalence rate of low birthweight per 100 births according to total and singleton births, 1980–2020

Age	Number of joinpoints	Segment Start	End	APC (95% CI, lower, upper)	Average APC (95% CI, lower, upper)
Total (singleton and multiple live birth)					
15–49					
Crude	3	1980	1987	1.35* (0.95, 1.65)	
		1987	2000	3.37* (3.24, 3.52)	
		2000	2006	1.81* (1.35, 2.25)	
		2006	2020	–0.24* (–0.35, –0.14)	1.51* (1.47, 1.54)
ASR	3	1980	1987	0.16 (–0.42, 0.58)	
		1987	2000	3.11* (2.99, 3.30)	
		2000	2005	1.97* (1.33, 2.32)	
		2005	2020	–0.46* (–0.54, –0.39)	1.10* (1.06, 1.15)
Singleton live birth					
15–49					
Crude	3	1980	1987	1.28* (0.81, 1.62)	
		1987	2001	2.99* (2.86, 3.16)	
		2001	2010	1.12* (0.86, 1.40)	
		2010	2020	–0.50* (–0.73, –0.31)	1.39* (1.34, 1.43)
ASR	3	1980	1988	0.37 (–0.10, 0.74)	
		1988	2002	2.66* (2.52, 2.82)	
		2002	2009	0.83* (0.50, 1.20)	
		2009	2020	–0.56* (–0.72, –0.43)	0.99* (0.94, 1.04)

APC: annual percent change
ASR: age-standardized rate
CI: confidence interval
*statistical significance

for the trends. The crude rate of infants with LBW increased slowly from 5.18 in 1980, rose sharply from the late 1980s, peaked at 9.62 in 2007, and declined slowly to 9.22 in 2020 for all births. The APCs were as follows: +1.35% (95% confidence interval [CI], 0.95, 1.65) from 1980 to 1987, +3.37% (95% CI, 3.24, 3.52) from 1987 to 2000, +1.81% (95% CI, 1.35, 2.25) from 2000 to 2006, and –0.24% (95% CI, –0.35, –0.14) from 2006 to 2020, with an average APC of +1.51 (95% CI, 1.47, 1.54). The trends in the crude and age-standardized rates were similar. Crude and age-standardized rate trends in singleton births were similar to those of all births; however, the corresponding APCs for the four segments and the average APCs were lower for singleton births than for all births.

The crude and modeled prevalence rates per 100 births of neonates with LBW from 1980 to 2020 according to maternal age group are presented in Figures 2A and B, respectively. Table 2 shows the APCs obtained by the joinpoint analysis. The crude rates in 1980 were 8.67, 5.70, 4.77, 5.00, 7.71, 11.13, 17.05 for the 15–19, 20–24, 25–29, 30–34, 35–39, 40–44, and 45–49 age groups, respectively. Women in the 15–19 years old group showed the highest crude rate, followed by those in their 40's. The crude rate remained high in the 40s group, whereas it increased in women in the 10s, 20s, and 30s age groups. The APC showed a rapid increase for each age group of ≥ 20 years. The periods were 1985–1999 (APC = 2.49), 1985–2000 (APC = 3.41), 1987–1995 (APC = 4.23), 1995–2002 (APC = 3.21), 1988–2004 (APC = 2.94), 1993–2004 (APC = 2.24), and 2001–2004 (APC = 14.78) for the 20–24, 25–29, 30–34, 35–39, 40–44, and 45–49 age groups, respectively. The onset of this rapid increase occurred with age. The crude rate decreased from the mid-2000s after this rapid increase, which was particularly pronounced for women aged ≥ 40 years. Interestingly, the crude rate for the 15–19 age group increased steadily, with no change point (APC = 0.60).

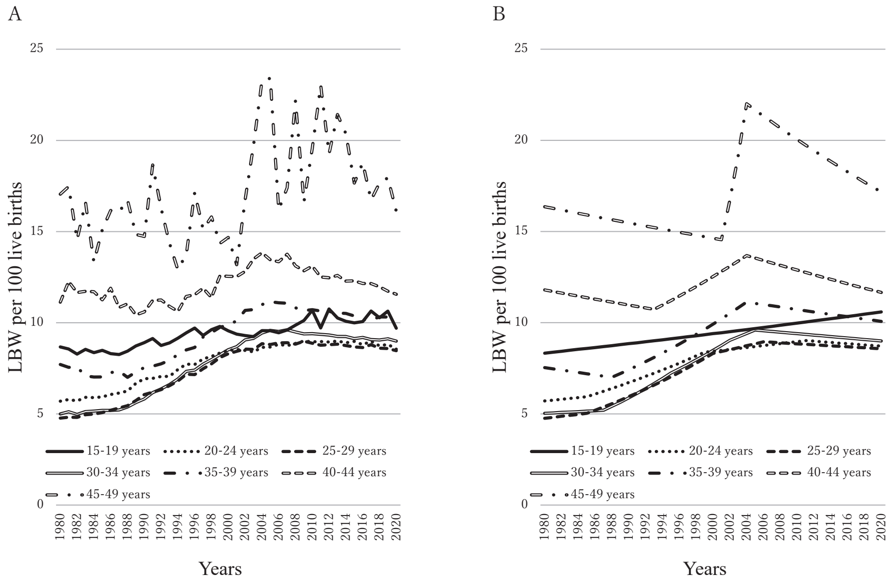

Fig. 2 Crude and modeled prevalence rates per 100 births with low birthweight from 1980 to 2020 by maternal age group among overall births

Fig. 2A: Crude prevalence rates per 100 births with low birthweight from 1980 to 2020 by maternal age group among overall births

Fig. 2B: Modeled prevalence rates per 100 births with low birthweight from 1980 to 2020 by maternal age group among overall births

LBW: low birthweight

Table 2 Trends analysis of crude low birthweight prevalence rate per 100 births by age group according to total and singleton births, 1980–2020

Age	Number of joinpoints	Segment Start	Segment End	APC (95% CI, lower, upper)	Average APC (95% CI, lower, upper)
Total (singleton and multiple live birth)					
15–19	0	1980	2020	0.60* (0.50, 0.70)	0.60* (0.50, 0.70)

20–24	3	1980	1985	0.81 (–0.23, 1.42)	
		1985	1999	2.49* (2.33, 2.73)	
		1999	2011	0.62* (0.38, 1.02)	
		2011	2020	–0.38 (–1.23, 0.00)	1.07* (0.98, 1.13)
25–29	3	1980	1985	1.10* (0.41, 1.61)	
		1985	2000	3.41* (3.30, 3.55)	
		2000	2006	1.24* (0.68, 1.84)	
		2006	2020	–0.31* (–0.48, –0.18)	1.48* (1.43, 1.52)
30–34	4	1980	1987	0.46* (0.13, 0.76)	
		1987	1995	4.23* (3.75, 4.71)	
		1995	2002	3.21* (2.85, 4.04)	
		2002	2005	2.07 (–0.51, 2.89)	
		2005	2020	–0.43* (–0.53, –0.34)	1.47* (1.43, 1.50)
35–39	2	1980	1988	–0.91* (–1.97, –0.13)	
		1988	2004	2.94* (2.70, 3.20)	
		2004	2020	–0.62* (–0.77, –0.47)	0.73* (0.64, 0.84)
40–44	2	1980	1993	–0.73* (–1.38, –0.23)	
		1993	2004	2.24* (1.73, 3.15)	
		2004	2020	–1.00* (–1.18, –0.81)	–0.03 (–0.12, 0.08)
45–49	2	1980	2001	–0.56 (–2.39, 0.39)	
		2001	2004	14.78* (3.35, 19.8)	
		2004	2020	–1.54* (–2.52, –0.81)	0.12 (–0.26, 0.51)
Singleton live birth					
15–19	0	1980	2020	0.56* (0.47, 0.66)	0.56* (0.47, 0.66)
20–24	3	1980	1985	0.89 (–0.34, 1.54)	
		1985	1999	2.42* (2.25, 2.73)	
		1999	2013	0.57* (0.36, 0.90)	
		2013	2020	–0.69* (–2.17, –0.09)	1.03* (0.93, 1.11)
25–29	3	1980	1986	1.33* (0.67, 1.80)	
		1986	2000	3.31* (3.16, 3.51)	
		2000	2009	0.96* (0.63, 1.35)	
		2009	2020	–0.55* (–0.86, –0.32)	1.41* (1.35, 1.46)
30–34	4	1980	1987	0.42* (0.01, 0.82)	
		1987	2000	3.38* (3.13, 3.62)	
		2000	2005	2.13* (1.49, 3.32)	
		2005	2010	0.43 (–0.17, 1.55)	
		2010	2020	–0.52* (–0.87, –0.36)	1.35* (1.31, 1.39)
35–39	4	1980	1984	–2.67* (–5.53, –0.99)	
		1984	1992	0.79 (–0.17, 2.02)	

		1992	2005	2.26* (0.30, 3.48)	
		2005	2011	0.10 (–0.40, 2.26)	
		2011	2020	–0.72* (–1.53, –0.43)	0.47* (0.37, 0.58)
40–44	2	1980	1990	–1.38* (–2.55, –0.68)	
		1990	2007	0.99* (0.75, 1.41)	
		2007	2020	–1.17* (–1.41, –0.94)	–0.31* (–0.41, –0.19)
45–49	2	1980	2001	–0.89 (–4.64, 0.04)	
		2001	2008	2.76* (0.004, 9.79)	
		2008	2020	–1.62* (–3.66, –0.53)	–0.48* (–0.85, –0.11)

APC: annual percent change
CI: confidence interval
*statistical significance

The crude and modeled prevalence rates per 100 births of neonates with LBW from 1980 to 2020 according to maternal age among singleton births are presented in Figures 3A and B, respectively. Table 2 shows the APCs obtained by the joinpoint analysis. The change in each age group for singleton births was similar to that of all births; however, the fluctuations were smaller.

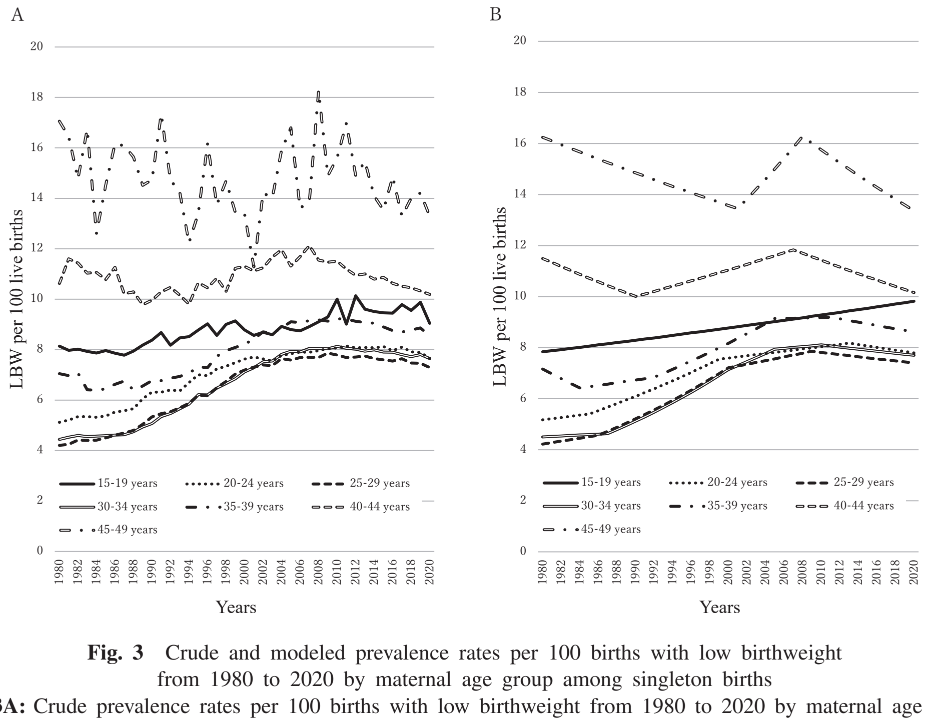

Fig. 3 Crude and modeled prevalence rates per 100 births with low birthweight from 1980 to 2020 by maternal age group among singleton births
Fig. 3A: Crude prevalence rates per 100 births with low birthweight from 1980 to 2020 by maternal age group among singleton births
Fig. 3B: Modeled prevalence rates per 100 births with low birthweight from 1980 to 2020 by maternal age group among singleton births
LBW: low birthweight

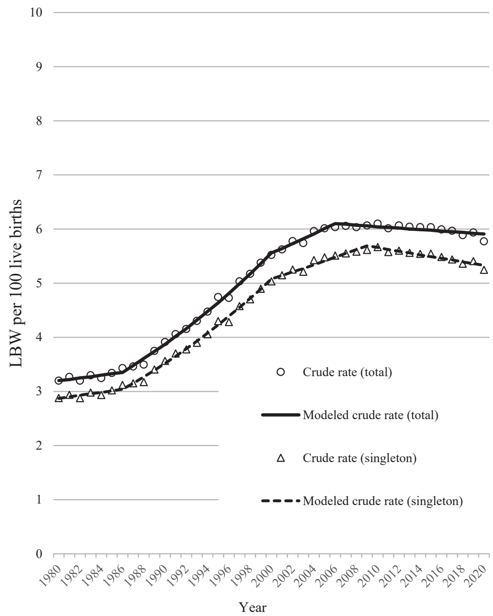

Fig. 4 Crude and modeled prevalence rates per 100 births of neonates with LBW from 1980 to 2020 among only full-term births

LBW: low birthweight

Table 3 Trends analysis of crude prevalence rate of low birthweight per 100 births according to total and singleton births among full–term births, 1980–2020

Age	Number of joinpoints	Segment Start	Segment End	APC (95% CI, lower, upper)	Average APC (95% CI, lower, upper)
Total (singleton and multiple live birth)					
15–49					
Crude	3	1980	1986	0.81* (0.04, 1.36)	
		1986	2000	3.67* (3.51, 3.89)	
		2000	2006	1.56* (0.94, 2.20)	
		2006	2020	–0.23* (–0.40, –0.09)	1.55* (1.49, 1.60)
Singleton live birth					
15–49					
Crude	3	1980	1986	0.96* (0.14, 1.56)	
		1986	2000	3.73* (3.55, 3.96)	
		2000	2009	1.28* (0.95, 1.65)	
		2009	2020	–0.59* (–0.84, –0.38)	1.56* (1.50, 1.62)

APC: annual percent change
ASR: age–standardized rate
CI: confidence interval
*statistical significance

The crude and modeled prevalence rates per 100 births of neonates with LBW from 1980 to 2020 among only full-term births are shown in Figure 4. Table 3 presents the APCs obtained by the joinpoint analysis. The trends for all full-term births and full-term singleton births were similar to the results in Figure 1 obtained for all weeks of delivery. There was a sharp increase starting in 1986, with negative values starting in 2006 for total births and in 2009 for singleton births.

DISCUSSION

To the best of our knowledge, this is the first study to quantitatively analyze long-term data from 1980 to 2020 using joinpoint regression analysis to clarify the descriptive epidemiological characteristics of neonates with LBW according to maternal age in Japan. Three previous studies examined LBW prevalence using Vital Statistics. Morisaki et al[18] conducted an ecological study that examined the association between LBW and adult height using data from 1969 to 2014; however, they did not analyze trends in LBW. Takemoto et al[19] investigated the descriptive epidemiological characteristics of neonates with LBW using singleton birth data from 1979 to 2010 but did not use a descriptive epidemiology-specific statistical model. Mine et al[20] analyzed singleton and full-term birth data from 2000 to 2019 using joinpoint regression analysis; however, they did not examine the data according to maternal age.

The factors associated with LBW include maternal age,[21] maternal pre-pregnancy underweight,[22,23] poor weight gain during pregnancy,[24,25] smoking,[26] and pregnancy complications such as hypertensive disorders of pregnancy.[27] In addition, Erasun et al[28] conducted ecological research that analyzed the OECD database from 2000 to 2015 with a random effects model. The findings show that investment in health care, health care coverage, public health care system coverage, the number of hospitals per million population, and the ratio of health care workers were associated with a lower rate of LBW. In Japan, prefectural data from Vital Statistics and the Survey of Medical Institutions in 2020 showed that the percentage of low birthweight infants was negatively associated with the number of hospitals per 100,000 population (Spearman's correlation coefficient = –0.027) and the number of health care workers per 100 beds (Spearman's correlation coefficient = –0.042), although these associations were not statistically significant.[29,30] Therefore, it is necessary to consider maternal and socio-environmental factors to speculate on the characteristics of the trends in LBW prevalence and the affecting factors.

The rapid increase in LBW prevalence in Japan from 1987 to 2000 (total, APC = 3.37; singleton, APC = 2.29) is mainly due to the development of perinatal and neonatal care, including the spread of neonatal intensive care units and the establishment of perinatal medical centers.[31,32] The improvement in the prognosis of infants with LBW infants seems to have influenced the decision on the timing of delivery in clinical obstetric practice. In contrast, the slowdown in the increase since 2000 (APC = 1.81) may represent a transition from a period of development to maturity in related medical care. Another factor contributing to the increase in LBW prevalence is the development of assisted reproductive technologies (ARTs). Advancements in treatment have expanded the population eligible for treatment, resulting in a sharp increase in LBW prevalence in the 20s since 1985 (APC = 2.49 and 3.34 in the 20–24 and 25–29 age groups, respectively), in the 30–34 age group since 1987 (APC = 4.23), in the 35–39 age group since 1998 (APC = 2.94), 40–44 age group since 1993 (APC = 2.24), and 45–49 age group since 2001 (APC = 14.78), appearing in the older age groups with increasing year. Infection, uterine myoma, and endometriosis are the most common causes of infertility and can lead to fetal growth retardation and preterm delivery.[33,34] Mothers who conceived through ART are also more likely to have gestational hypertension[35,36] and placenta previa,[37,38] which are known to cause LBW, than women who conceived naturally.[39,40] In addition, the increase in multiple pregnancies because of excessive ovarian stimulation and numerous embryo transfers also increased LBW prevalence. As a countermeasure, in 1996, the Japanese Society of Obstetrics and Gynecology recommended that the number of transferred embryos be limited to three.[41] In 2007, the Japanese Society for Reproductive Medicine issued a guideline stating, "In the first treatment cycle for patients < 35 years, the number of embryos transferred should be one in principle, and in treatment cycles for patients < 40 years, the number of embryos transferred should be ≤ 2 in principle."[42] Today, selective single embryo transfer is the standard practice.[43] These changes in treatment policy may have led to a decrease in LBW prevalence from 2000 to mid-2000. The decrease in LBW prevalence was particularly pronounced in the 35 and older age group. Other changes related to embryo transfer include the change from fresh embryo transfer to frozen embryo transfer[44-49] and that from cleavage-stage embryo transfer to blastocyst transfer due to the development of ART.[50] Frozen embryo and blastocyst transfers have been reported to reduce the risk of low birth weight.[51-53]

Notably, the analysis examining only full-term births showed similar trends to those for all births. This finding indicates that the rise in LBW is not solely attributable to an increase in preterm births, which are often associated with high-risk pregnancies such as those involving advanced maternal age or ART conception. Therefore, factors affecting fetal growth during full-term pregnancies—such as maternal nutrition, body mass index (BMI), and other socio-environmental factors—must be carefully considered. According to the joinpoint analysis of the 1980s, in the 35-year-old age group, APCs were initially negative but turned positive in the mid-1980s due to the development of ART. In contrast, APCs have been positive since 1980 in the group < 35 years of age. In particular, APCs in teens who are unaffected by ART have continually increased without showing a transition point. The suspected causes of these problems include reduced nutritional intake during pregnancy and increased slenderness in women. This trend continues throughout pregnancy. Therefore, in 2006, the MHLW recommended that pregnant women with a pre-pregnancy BMI of < 18.5 gain 9–12 kg and those with a BMI of 18.5–25 gain 7–12 kg as the appropriate weight gain during pregnancy.[54] Furthermore, in 2021, the MHLW[55] revised the recommendation to 12–15 kg for pregnant women with a pre-pregnancy BMI of < 18.5 and 10–13 kg for pregnant women with a BMI of 18.5–25.

Measures must be taken before conception to resolve the discussed issues. In 2013, preconception care was defined by the WHO (2013) as "the provision of biomedical, behavioral, and social health interventions to women and couples before conception occurs."[56] Preconception care is important for the health of all women, including the prevention of unintended teenage pregnancies. It is the top public health priority for addressing maternal and child health issues including measures for LBW infants in Japan. In Japan, a system for preconception care is being developed to support safe, secure, and healthy pregnancy and delivery and postpartum healthcare, as well as to provide information on healthcare for future pregnancies. This system is based on The Basic Law for Child and Maternal Health and Child Development promulgated in 2018. Midwives, public health nurses, and other nurses play crucial roles in all these areas.

The strengths of this study include the use of statistical models to quantify trends in LBW prevalence and joinpoint analysis, which determined the timing and extent of changes in LBW prevalence. However, this study also has several limitations in interpreting the results. As this study used annual aggregate data published by the government, individual-level risk factors—such as pre-pregnancy BMI, weight changes during pregnancy, smoking history, and socioeconomic background—could not be assessed. Therefore, our discussion relies on prior studies and ecological interpretations, given the multifactorial nature of LBW. Moreover, since this is a descriptive epidemiological study, we cannot directly establish causal relationships between LBW prevalence and socio-environmental factors. The opposing influences of medical advances and maternal risk factors on LBW prevalence cannot be separated. These limitations should be carefully considered when interpreting our findings.

CONCLUSIONS

This study quantitatively clarified the trends in LBW prevalence in Japan from 1980 to 2020 using a joinpoint regression analysis. The prevalence of LBW showed an inverted J-shaped curve with a peak in 2007. Trends by maternal age differed markedly, probably reflecting the influence of changes in various social and environmental factors, including the development of perinatal and neonatal care and ART, changes in the associated system, advanced maternal age, a decline in nutritional intake, and thinness of women in their reproductive years. Addressing LBW requires comprehensive care, including appropriate maternal care, nutritional support, and social and environmental interventions during pregnancy. In addition, enhanced preconception care is recommended as a key strategy in Japan.

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Author contributions

Eri Nonoyama: Data curation, statistical analysis, methodology, writing-original draft, writing-review and editing. Koji Tamakoshi: Data curation, statistical analysis, methodology, supervision, validation, writing-original draft, writing-review and editing. Yuki Takahashi: Supervision, writing-review and editing. Akiko Yamada: Supervision, writing-review and editing. All authors have read and approved the final manuscript.

Conflict of interest

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Data availability

The data used in this study were obtained from the publicly available Vital Statistics of Japan, published by the Ministry of Health, Labour and Welfare (MHLW). https://www.e-stat.go.jp/

REFERENCES

1 Fitzgerald E, Hor K, Drake AJ. Maternal influences on fetal brain development: the role of nutrition, infection and stress, and the potential for intergenerational consequences. *Early Hum Dev*. 2020;150:105190. doi:10.1016/j.earlhumdev.2020.105190

2 Dessie ZB, Fentie M, Abebe Z, Ayele TA, Muchie KF. Maternal characteristics and nutritional status among 6–59 months of children in Ethiopia: further analysis of demographic and health survey. *BMC Pediatr*. 2019;19(1):83. doi:10.1186/s12887-019-1459-x

3 Naik VD, Lee J, Wu G, Washburn S, Ramadoss J. Effects of nutrition and gestational alcohol consumption

on fetal growth and development. *Nutr Rev*. 2022;80(6):1568–1579. doi:10.1093/nutrit/nuab119

4 Buklijas T, Al-Gailani S. A fetus in the world: physiology, epidemiology, and the making of fetal origins of adult disease. *Hist Philos Life Sci*. 2023;45(4):44. doi:10.1007/s40656-023-00598-z

5 de Mendonça ELSS, de Lima Macêna M, Bueno NB, de Oliveira ACM, Mello CS. Premature birth, low birth weight, small for gestational age and chronic non-communicable diseases in adult life: A systematic review with meta-analysis. *Early Hum Dev*. 2020;149:105154. doi:10.1016/j.earlhumdev.2020.105154

6 Martín-Calvo N, Goni L, Tur JA, Martínez JA. Low birth weight and small for gestational age are associated with complications of childhood and adolescence obesity: systematic review and meta-analysis. *Obes Rev*. 2022;23(Suppl 1):e13380. doi:10.1111/obr.13380

7 Kanda T, Murai-Takeda A, Kawabe H, Itoh H. Low birth weight trends: possible impacts on the prevalences of hypertension and chronic kidney disease. *Hypertens Res*. 2020;43(9):859–868. doi:10.1038/s41440-020-0451-z

8 Tamakoshi K, Yatsuya H, Wada K, et al. Birth weight and adult hypertension: cross-sectional study in a Japanese workplace population. *Circ J*. 2006;70(3):262–267. doi:10.1253/circj.70.262

9 Whincup PH, Kaye SJ, Owen CG, et al. Birth weight and risk of type 2 diabetes: a systematic review. *JAMA*. 2008;300(24):2886–2897. doi:10.1001/jama.2008.886

10 Ardissino M, Morley AP, Slob EAW, et al. Birth weight influences cardiac structure, function, and disease risk: evidence of a causal association. *Eur Heart J*. 2024;45(6):443–454. doi:10.1093/eurheartj/ehad631

11 Barker DJ, Winter PD, Osmond C, Margetts B, Simmonds SJ. Weight in infancy and death from ischaemic heart disease. *Lancet*. 1989;2(8663):577–580. doi:10.1016/s0140-6736(89)90710-1

12 World Health Organization. Global Nutrition Monitoring Framework: operational guidance for tracking progress in meeting targets for 2025. December 20, 2017. Accessed May 29, 2024. https://www.who.int/publications/i/item/9789241513609

13 World Health Organization. 2018 Global reference list of 100 core health indicators (plus health-related SDGs). 2018. Accessed May 29, 2024. https://iris.who.int/handle/10665/259951

14 United Nations International Children's Emergency Fund. Low birthweight. 2020. Accessed May 29, 2024. https://data.unicef.org/topic/nutrition/low-birthweight/

15 Organization for Economic Co-operation and Development. Infant health: low birthweight. 2023. Accessed May 29, 2024. https://stats.oecd.org/Index.aspx?ThemeTreeId=9

16 Kim HJ, Fay MP, Feuer EJ, Midthune DN. Permutation tests for joinpoint regression with applications to cancer rates. *Stat Med*. 2000;19(3):335–351. doi:10.1002/(sici)1097-0258(20000215)19:3<335::aid-sim336>3.0.co;2-z

17 National Cancer Institute. Joinpoint trend analysis software. 2023. Accessed October 6, 2023. https://surveillance.cancer.gov/joinpoint/

18 Morisaki N, Urayama KY, Yoshii K, Subramanian SV, Yokoya S. Ecological analysis of secular trends in low birth weight births and adult height in Japan. *J Epidemiol Community Health*. 2017;71(10):1014–1018. doi:10.1136/jech-2017-209266

19 Takemoto Y, Ota E, Yoneoka D, Mori R, Takeda S. Japanese secular trends in birthweight and the prevalence of low birthweight infants during the last three decades: A population-based study. *Sci Rep*. 2016;6:31396. doi:10.1038/srep31396

20 Mine T, Tsuboi S, Fukushima F. Twenty-year trends of low birth weight in Japan: A joinpoint regression analysis of data from 2000 to 2019. *Front Reprod Health*. 2021;3:772575. doi:10.3389/frph.2021.772575

21 Kyozuka H, Fujimori K, Hosoya M, et al. The effect of maternal age at the first childbirth on gestational age and birth weight: the Japan Environment and Children's Study (JECS). *J Epidemiol*. 2019;29(5):187–191. doi:10.2188/jea.JE20170283

22 Fukui K, Suto M, Kaneko K, Isayama T, Ito Y, Takehara K. Pre-pregnancy body mass index and low birthweight: secondary data analysis using health insurance claims data in Japan. *J Obstet Gynaecol Res*. 2024;50(8):1295–1301. doi:10.1111/jog.15973

23 Uchinuma H, Tsuchiya K, Sekine T, et al. Gestational body weight gain and risk of low birth weight or macrosomia in women of Japan: a nationwide cohort study. *Int J Obes (Lond)*. 2021;45(12):2666–2674. doi:10.1038/s41366-021-00947-7

24 Goldstein RF, Abell SK, Ranasinha S, et al. Association of gestational weight gain with maternal and infant outcomes: A systematic review and meta-analysis. *JAMA*. 2017;317(21):2207–2225. doi:10.1001/jama.2017.3635

25 Dalfra' MG, Burlina S, Lapolla A. Weight gain during pregnancy: A narrative review on the recent evidences. *Diabetes Res Clin Pract*. 2022;188:109913. doi:10.1016/j.diabres.2022.109913

26 Hamadneh S, Hamadneh J. Active and passive maternal smoking during pregnancy and birth outcomes: A

study from a developing country. *Ann Glob Health*. 2021;87(1):122. doi:10.5334/aogh.3384

27 Nishihama Y, Nakayama SF, Tabuchi T; Japan Environment and Children's Study Group. Population attributable fraction of risk factors for low birth weight in the Japan Environment and Children's Study. *Environ Int*. 2022;170:107560. doi:10.1016/j.envint.2022.107560

28 Erasun D, Alonso-Molero J, Gómez-Acebo I, Dierssen-Sotos T, Llorca J, Schneider J. Low birth weight trends in Organisation for Economic Co-operation and Development countries, 2000–2015: economic, health system and demographic conditionings. *BMC Pregnancy Childbirth*. 2021;21(1):13. doi:10.1186/s12884-020-03484-9

29 Ministry of Health, Labour and Welfare. Vital Statistics of Japan 2020. Published in Japanese. February 25, 2022. Accessed June 9, 2025. https://www.mhlw.go.jp/toukei/saikin/hw/jinkou/kakutei20/index.html

30 Ministry of Health, Labour and Welfare. Survey of Medical Institutions 2020. Published in Japanese. April 27, 2022. Accessed June 9, 2025. https://www.mhlw.go.jp/toukei/saikin/hw/iryosd/20/index.html

31 Ministry of Health, Labour and Welfare. Table 39 Annual trends in the number of medical facilities, beds, and total number of patients in facilities with NICU and MFICU. In: Ministry of Health, Labour and Welfare. *2009 Regional Public Health and Medical Care Statistics*. Published in Japanese. Accessed June 9, 2025. https://www.mhlw.go.jp/toukei/saikin/hw/hoken/kiso/21.html

32 Ishizuka Y, Komiya H, Hashimoto T, et al. Nationwide Survey Results on the Current State of Neonatal Care in Japan, Focusing on NICUs. In: Ministry of Health and Welfare, Research Group on the Development of a Management System for Maternal and Child Health Care ed. *Research report on the development of a management system for maternal and child health care.* Ministry of Health and Welfare; 1981. Article in Japanese. Accessed June 9, 2025. https://www.niph.go.jp/wadai/mhlw/1980/s5503037.pdf

33 Vercellini P, Viganò P, Bandini V, Buggio L, Berlanda N, Somigliana E. Association of endometriosis and adenomyosis with pregnancy and infertility. *Fertil Steril*. 2023;119(5):727–740. doi:10.1016/j.fertnstert.2023.03.018

34 Weckman AM, Ngai M, Wright J, McDonald CR, Kain KC. The impact of infection in pregnancy on placental vascular development and adverse birth outcomes. *Front Microbiol*. 2019;10:1924. doi:10.3389/fmicb.2019.01924

35 Chih HJ, Elias FTS, Gaudet L, Velez MP. Assisted reproductive technology and hypertensive disorders of pregnancy: systematic review and meta-analyses. *BMC Pregnancy Childbirth*. 2021;21(1):449. doi:10.1186/s12884-021-03938-8

36 Thomopoulos C, Salamalekis G, Kintis K, et al. Risk of hypertensive disorders in pregnancy following assisted reproductive technology: overview and meta-analysis. *J Clin Hypertens (Greenwich)*. 2017;19(2):173–183. doi:10.1111/jch.12945

37 Karami M, Jenabi E, Fereidooni B. The association of placenta previa and assisted reproductive techniques: a meta-analysis. *J Matern Fetal Neonatal Med*. 2018;31(14):1940–1947. doi:10.1080/14767058.2017.1332035

38 Vermey BG, Buchanan A, Chambers GM, et al. Are singleton pregnancies after assisted reproduction technology (ART) associated with a higher risk of placental anomalies compared with non-art singleton pregnancies? A systematic review and meta-analysis. *BJOG*. 2019;126(2):209–218. doi:10.1111/1471-0528.15227

39 Qin J, Liu X, Sheng X, Wang H, Gao S. Assisted reproductive technology and the risk of pregnancy-related complications and adverse pregnancy outcomes in singleton pregnancies: a meta-analysis of cohort studies. *Fertil Steril*. 2016;105(1):73–85.e1-e6. doi:10.1016/j.fertnstert.2015.09.007

40 Woo I, Hindoyan R, Landay M, et al. Perinatal outcomes after natural conception versus in vitro fertilization (IVF) in gestational surrogates: a model to evaluate IVF treatment versus maternal effects. *Fertil Steril*. 2017;108(6):993–998. doi:10.1016/j.fertnstert.2017.09.014

41 Ministry of Health, Labour and Welfare. Japanese Society of Obstetrics and Gynaecology bulletin: Opinion on 'multiple pregnancies'. Published in Japanese. February 1996. Accessed May 29, 2024. https://www.mhlw.go.jp/shingi/2006/10/s1018-7i05.html

42 Japan Society for Reproductive Medicine. Report of the Ethics Committee. Guidelines on the number of embryos transferred to prevent multiple pregnancies. Published in Japanese. March 16, 2007. Accessed May 29, 2024. http://www.jsrm.or.jp/guideline-statem/guideline_2007_01.html

43 Takeshima K, Jwa SC, Saito H, et al. Impact of single embryo transfer policy on perinatal outcomes in fresh and frozen cycles—analysis of the Japanese Assisted Reproduction Technology registry between 2007 and 2012. *Fertil Steril*. 2016;105(2):337–346.e3. doi:10.1016/j.fertnstert.2015.10.002

44 Saito H, Jwa SC, Kuwahara A, et al. Assisted reproductive technology in Japan: a summary report for 2015 by the Ethics Committee of the Japan Society of Obstetrics and Gynecology. *Reprod Med Biol*. 2018;17(1):20–28. doi:10.1002/rmb2.12074

45 Ishihara O, Jwa SC, Kuwahara A, et al. Assisted reproductive technology in Japan: A summary report for 2016 by the Ethics Committee of the Japan Society of Obstetrics and Gynecology. *Reprod Med Biol*. 2019;18(1):7–16. doi:10.1002/rmb2.12258
46 Ishihara O, Jwa SC, Kuwahara A, et al. Assisted reproductive technology in Japan: A summary report for 2017 by the Ethics Committee of the Japan Society of Obstetrics and Gynecology. *Reprod Med Biol*. 2020;19(1):3–12. doi:10.1002/rmb2.12307
47 Ishihara O, Jwa SC, Kuwahara A, et al. Assisted reproductive technology in Japan: A summary report for 2018 by the Ethics Committee of the Japan Society of Obstetrics and Gynecology. *Reprod Med Biol*. 2021;20(1):3–12. doi:10.1002/rmb2.12358
48 Katagiri Y, Jwa SC, Kuwahara A, et al. Assisted reproductive technology in Japan: A summary report for 2019 by the Ethics Committee of the Japan Society of Obstetrics and Gynecology. *Reprod Med Biol*. 2022;21(1):e12434. doi:10.1002/rmb2.12434
49 Katagiri Y, Jwa SC, Kuwahara A, et al. Assisted reproductive technology in Japan: A summary report for 2020 by the Ethics Committee of the Japan Society of Obstetrics and Gynecology. *Reprod Med Biol*. 2023;22(1):e12494. doi:10.1002/rmb2.12494
50 Ishihara O, Araki R, Kuwahara A, Itakura A, Saito H, Adamson GD. Impact of frozen-thawed single-blastocyst transfer on maternal and neonatal outcome: an analysis of 277,042 single-embryo transfer cycles from 2008 to 2010 in Japan. *Fertil Steril*. 2014;101(1):128–133. doi:10.1016/j.fertnstert.2013.09.025
51 Melville J, Stringer A, Black N, et al. The impact of assisted reproductive technology treatments on maternal and offspring outcomes in singleton pregnancies: a review of systematic reviews. *F S Rev*. 2021;2(4):287–301. doi:10.1016/j.xfnr.2021.09.003
52 Nakashima A, Araki R, Tani H, et al. Implications of assisted reproductive technologies on term singleton birth weight: an analysis of 25,777 children in the national assisted reproduction registry of Japan. *Fertil Steril*. 2013;99(2):450–455. doi:10.1016/j.fertnstert.2012.09.027
53 Matsuo S, Ushida T, Tano S, et al. Sex-specific differences in head circumference of term singletons after assisted reproductive technology: a multicentre study in Japan. *Reprod Biomed Online*. 2023;47(6):103331. doi:10.1016/j.rbmo.2023.103331
54 Ministry of Health, Labour and Welfare. Dietary guidelines for pregnant and lactating women. Published in Japanese. February 2006. Accessed May 29, 2024. https://www.mhlw.go.jp/houdou/2006/02/h0201-3a.html
55 Ministry of Health, Labour and Welfare. Dietary guidelines for pregnant and lactating women starting before pregnancy. Published in Japanese. 2021. Accessed May 29, 2024. https://warp.da.ndl.go.jp/info:ndljp/pid/12366627/www.mhlw.go.jp/seisakunitsuite/bunya/kodomo/kodomo_kosodate/boshi-hoken/ninpu-02.html
56 World Health Organization. Preconception care: maximizing the gains for maternal and child health – policy brief. 2013. Accessed May 29, 2024. https://iris.who.int/bitstream/handle/10665/340533/WHO-FWC-MCA-13.02-eng.pdf?sequence=1