Maternal, infant, and perinatal mortality statistics and trends in Korea between 2009 and 2017

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Objective

To provide updates on maternal, infant, and perinatal mortality using the national population data of South Korea between 2009 and 2017 and describe the mortality rate by target groups, timing, or causes of events to provide a basis for detecting vulnerable populations and ensuring timely medical and political interventions.

Methods

Pregnancy-related mortality in women, as well as deaths of infants, in South Korea was identified using population data from Statistics Korea. Records from death certificates, cremation reports on infant and fetal deaths, and the complementary cause-of-death investigation system were reviewed for the 2009–2017 period.

Results

A total of 461 maternal deaths, 11,717 infant deaths, and 12,249 perinatal deaths, including fetal deaths over 28 gestational weeks, were identified from 3,945,159 live births between 2009 and 2017. The maternal mortality ratio was 13.5 deaths per 100,000 live births in 2009 and decreased to 7.8 in 2017. Only the rate of deaths related to hypertensive disorders showed an increasing tendency. Both the infant and perinatal mortality rates improved (from 3.2 deaths per 1,000 live births in 2009 to 2.8 in 2017 and from 3.5 to 2.7, respectively). Among the external causes of infant mortality, assaults including homicides accounted for 25% (n=150), and this proportion was constant throughout the study period.

Conclusion

Overall improvements were observed in all maternal, infant, and perinatal mortality measures. In-depth analysis and interventions with respect to certain causes, such as hypertensive disorders in mothers or assaults in infants, should be considered priority issues.

Keywords: Maternal mortality; Infant mortality; Perinatal mortality; Cause of death; South Korea

Introduction

Maternal, infant, and perinatal mortality are surrogate measures of the national health status and indicators of social development, for which cross-country comparisons are frequently conducted. The maternal mortality ratio and infant mortality ratio in South Korea decreased from 14 deaths per 100,000 live births in 2005 to 8.4 in 2016 and from 4.7 to

2.8, respectively [1]. Although the changes are meaningful, the maternal mortality ratio is still higher than the average in Organization for Economic Cooperation and Development (OECD) countries, and the indices seem to have been stagnant in recent years. A detailed epidemiological description is necessary to develop and implement proper public health interventions for improving mortality measures. However, few reports are available on this issue thus far [2].

Previously, Statistics Korea reported an overview of infant, maternal, and perinatal mortality statistics in South Korea, with a focus on the number of deaths, the crude death rate, and the ranking of causes of death. We reinterpreted the mortality rate from the point of view of the obstetrician with researchers of the vital statistics division in Statistics Korea because of a rapid diminution in the number of births in South Korea.

The primary purpose of this study was to provide updates on maternal, infant, and perinatal mortality in South Korea. Specifically, we aimed to describe the mortality rates by target groups, timing, or causes of events to provide a basis for detecting vulnerable populations and ensuring timely medical and political interventions.

Materials and methods

A retrospective investigation of mortality events recorded in 2017 was conducted. The data were compared with previous records in the 2009–2016 period.

1. Sources of data
Mortality events were aggregated from 3 different data sources: death certificates, cremation reports on infant and fetal deaths, and the complementary cause-of-death (COD) investigation system (Supplementary Data 1).

The death certificate data, based on the Act on the Registration, etc. of Family Relationships, are ascertained in real time to follow the population dynamics at the national level [3]. When an event occurs, a family member or local community officer submits the death certificate to the population dynamics system. The collected data are forwarded to the county level and province level, sequentially, and finally entered into the Statistics Korea database.

Cremation reports on infant and fetal deaths are described based on the Act on Funeral Services, etc. [4]. The reports first collected at each crematorium are forwarded to the provincial office and finally entered into the Statistics Korea database.

The COD system serves as a retrospective reconfirming process of mortalities detected from death certificates, cremation reports, or the National Health Insurance Service (NHIS). Maternal death that occurred during pregnancy or within 6 months of delivery, infant death within 1 year of birth, and fetal death over 16 weeks of gestation are first screened by Statistics Korea. The health-care institutions where the deceased was born, died, or had any experience of pregnancy- or delivery-related medical care are then requested to complete the complementary investigation on medical history.

2. Data validation
All event records ascertained from different sources are submitted to Statistics Korea, which reviews the completeness of the data and integrates them into a unified national mortality database based on personal identification codes. Multiple data sources not only enable crosschecking for quality assurance but also reduce the burden on respondents. To minimize bias from missing data, substituting values were calculated based on relevant records and variables.

3. Coding principles
The cause of death was defined as (a) the disease or injury that initiated the train of morbid events leading directly to death or (b) the circumstances of the accident or violence that produced the fatal injury [5] and coded according to the 10th revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10) [5].

In cases where the cause of death was unclear, additional administrative data from the NHIS, National Cancer Center, National Forensic Service, National Police Agency, or Centers for Disease Control and Prevention were referenced for completion.

The causes of maternal mortality and infant, fetal, and neonatal mortality were classified based on the World Health Organization (WHO) recommendations of the general mortality condensed list and infant and child mortality condensed list, respectively [5].

4. Statistics
Maternal death was defined as "the death of a woman while pregnant or within 42 days of termination of pregnancy, irre-

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spective of the duration and the site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management, but not from accidental or incidental causes" [5]. It was subdivided into direct obstetric deaths ("those resulting from obstetric complications of the pregnant state [pregnancy, labor, and puerperium]; from interventions, omissions, or incorrect treatment; or from a chain of events resulting from any of the above") and indirect obstetric deaths ("those resulting from previous existing disease or disease that developed during pregnancy and that was not due to direct obstetric causes, but that was aggravated by physiologic effects of pregnancy") [5]. The maternal mortality ratio and rate were calculated based on these definitions.

The infant mortality rate was calculated from deaths that occurred before 1 year after birth. Among those, neonatal mortality was classified as deaths that occurred before 28 days after birth. Fetal death was defined as the death of the fetus over 16 gestational weeks or "death prior to the complete expulsion or extraction from its mother of a product of conception, indicated by the absence of evidence of life after such separation" [5]. Meanwhile, perinatal death was calculated as the sum of fetal deaths that occurred after 28 gestational weeks and neonatal deaths that occurred before 7 days after birth.

The detailed definitions and equations for the indices used in this study are summarized in the technical note.

5. Technical note

The terms used in this study are based on the ICD-10 by the WHO.

Maternal death: the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the duration and the site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management, but not from accidental or incidental causes.

Direct obstetric death: maternal death resulting from obstetric complications of the pregnant state (pregnancy, labor, and puerperium); from interventions, omissions, or incorrect treatment; or from a chain of events resulting from any of the above.

Indirect obstetric death: maternal death resulting from previous existing disease or disease that developed during pregnancy and that was not due to direct obstetric causes, but that was aggravated by physiologic effects of pregnancy.

Maternal mortality ratio = (yearly number of maternal deaths [direct and indirect]/yearly number of live births) × k

k may be 1,000, 10,000 or 100,000, as preferred and indicated by the country.

Infant death: death of a newborn that occurred <365 days after birth.

Infant mortality rate = (yearly number of infant deaths/yearly number of live births) × 1,000

Neonatal death: death of a newborn that occurred <28 days after birth.

Neonatal mortality rate = (yearly number of neonatal deaths/yearly number of live births) × 1,000

Fetal death: death prior to the complete expulsion or extraction from its mother of a product of conception, indicat-

Table 1. Maternal mortality by year and maternal age: Korea, 2009–2017

Year	No. of maternal deaths	Maternal mortality ratio[a]	Age-specific ratio					No. of births
			Maternal age (yr)					
			≤24	25–29	30–34	35–39	≥40	
2009	60	13.5	18.0	9.6	9.4	26.4	78.3	444,849
2010	74	15.7	14.6	8.2	13.0	29.6	96.9	470,171
2011	81	17.2	0.0	12.4	14.5	33.7	65.8	471,265
2012	48	9.9	7.3	7.9	7.1	20.3	26.0	484,550
2013	50	11.5	0.0	8.8	7.7	23.3	54.4	436,455
2014	48	11.0	4.2	9.4	9.0	19.5	16.9	435,435
2015	38	8.7	0.0	5.3	8.8	14.1	8.0	438,420
2016	34	8.4	9.5	5.9	7.3	11.7	15.7	406,243
2017	28	7.8	0.0	4.1	6.2	14.0	15.9	357,771

[a]Deaths per 100,000 live births.

ed by the absence of evidence of life after such separation.

Perinatal death: fetal death and neonatal death occurring during the perinatal period. This study defines the perinatal period as from the 28th gestational week to before 7 days after birth, which corresponds to the definition of the United Nations and the OECD. Note, however, that the WHO uses the 22nd gestational week as the origin.

Perinatal mortality rate = (yearly number of perinatal deaths/yearly number of births[*]) × 1,000

[*]Number of births = number of live births + number of fetal deaths that occurred during the 28th gestational week or later.

Results

A total of 461 maternal, 11,717 infant, and 12,249 perinatal deaths with relevant baseline profile were identified between 2009 and 2017. All mortality indices showed a decreasing trend, although with some fluctuations, during the period.

The maternal mortality ratio decreased from 13.5 deaths per 100,000 live births in 2009 to 7.8 in 2017 (Table 1). In 2009 and 2010, the age-specific ratio showed a J-shaped pattern with a decrease in the age group less than 25 through 30–34 years followed by an increase with age in those older than 35 years. Since 2011, however, the ratios have been proportionated with age in pregnant women aged 25 years and older with no or the lowest records of deaths in those aged less than 25 years, except in 2016.

Of the 28 total maternal deaths in 2017, 79% (n=22) had direct obstetric causes (Table 2). While the mortality ratio from both direct and indirect causes decreased from 10.1 deaths per 100,000 live births and 3.4 in 2009 to 6.1 and 1.7 in 2017, respectively, the ratio of direct to indirect causes increased from 3.0 to 3.7. Specifically, complications predominantly related to the puerperium (e.g., infections or embolisms) were the most common, followed by complications of labor and delivery (e.g., postpartum hemorrhage). The proportion of these 2 entities constituted more than 70% of all direct causes across the years, except in 2009 (68.9%), 2011 (66.4%), and 2016 (64.3%). Meanwhile, the mortality ratio of hypertensive disorders, which was as low as 0.4 in 2009, increased more than 2-fold, at 1.1, in 2017 (Pearson's correlation coefficient, r=0.6), whereas all other causes showed a decrease or at least remained relatively constant

Table 2. Maternal mortality by groups of cause of death: Korea, 2009–2017

| Year | Total | | Direct causes | | | | | | | | | | | | | | Indirect causes | |
| | | | Pregnancy with abortive outcome | | Hypertensive disorders | | Other maternal disorders | | Maternal care-related problems | | Complications of labor and delivery[a] | | Complications related to the puerperium[b] | | Other obstetric conditions | | Total | |
	No. of deaths	MM ratio[c]	No. of deaths	MM ratio	No. of deaths	MM ratio	No. of deaths	MM ratio	No. of deaths	MM ratio	No. of deaths	MM ratio	No. of deaths	MM ratio	No. of deaths	MM ratio	No. of deaths	MM ratio
2009	45	10.1	2	0.4	2	0.4	2	0.4	4	0.9	17	3.8	14	3.1	4	0.9	15	3.4
2010	45	9.6	1	0.2	3	0.6	0	-	3	0.6	17	3.6	20	4.3	1	0.2	29	6.2
2011	56	11.9	4	0.8	5	1.1	1	0.2	4	0.8	13	2.8	24	5.1	5	1.1	25	5.3
2012	31	6.4	3	0.6	4	0.8	1	0.2	1	0.2	7	1.4	15	3.1	0	0.0	17	3.5
2013	38	8.7	2	0.5	2	0.5	0	-	6	1.4	11	2.5	16	3.7	0	0.0	12	2.8
2014	39	9.0	2	0.5	4	0.9	2	0.5	1	0.2	17	3.9	13	3.0	0	0.0	9	2.1
2015	36	8.2	0	0.0	3	0.7	0	0.0	3	0.7	12	2.7	17	3.9	1	0.2	2	0.5
2016	28	6.9	2	0.5	4	1.0	0	0.0	4	1.0	4	1.0	14	3.4	0	0.0	6	1.5
2017	22	6.1	0	0.0	4	1.1	1	0.3	1	0.3	8	2.2	8	2.2	0	0.0	6	1.7

MM, maternal mortality.
[a]Including abnormalities of forces of labor (e.g., uterine inertia) and postpartum hemorrhage; [b]Including obstetric embolism; [c]Deaths per 100,000 live births.

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(–0.7≤r≤–0.2) during the same period.

The infant mortality rate gradually improved from 3.2 deaths per 1,000 live births yearly in 2009 to 2.8 in 2017 (Table 3). The rate was higher in boys, regardless of year; there was a 23.1% decrease in the mortality rate in girls (3.1 in 2009 and 2.5 in 2017), the decrease remained only 6.8% in boys (3.3 in 2009 to 3.1 in 2017). When the infantile period was specifically analyzed, the mortality rate was higher in newborns younger than 28 days after birth than in those 28 days or older, with the ratio of neonatal to postneonatal deaths ranging between 1.1 and 1.4.

Across the age groups of mothers, the infant mortality rate was the lowest in mothers aged 25–29 years and increased with age thereafter (Fig. 1). Especially, the rate peaked in teenage pregnancies, although there was a decreasing trend in the recent 3 years. However, the mortality rate increased in late labors in mothers older than 40 years of age during the same period and remained similar (6.7 deaths per 1,000 live births yearly in 2009 and 6.5 in 2017).

The risk of both infant mortality and perinatal mortality was overwhelming during the first and second trimesters (Table 4). The mortality rate then decreased with gestational week until the term, followed by a rebound in the post-term period.

Of the 1,000 infant mortality events in 2017, 51.7% (n=517) were due to conditions originating in the perinatal period, followed by congenital malformations, deformations, and chromosomal abnormalities (16.8%, n=168), which were the 2 major categories throughout the observation period (Supplementary Table 1). Infantile respiratory distress

was the single most common cause among the perinatal conditions, along with sepsis and asphyxia. In 2017, the mortality rates were 0.3, 0.1, and 0.1 from these 3 causes,
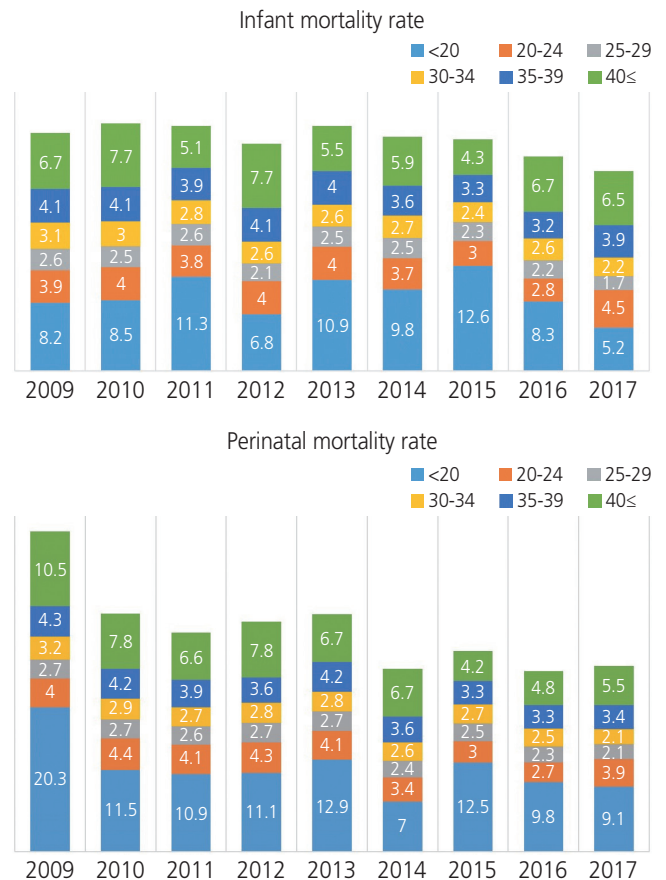

Fig. 1. Infant mortality by condensed list of cause of death: Korea, 2009–2017.

Table 3. Infant mortality rate[a] by year, sex, and period of death: Korea, 2009–2017

Year	No. of infant deaths	Infant mortality rate	Rate by sex		Rate by period	
			Boys	**Girls**	**Neonatal (<28 day)**	**Postneonatal (≥28 day)**
2009	1,415	3.2	3.3	3.1	1.7	1.5
2010	1,508	3.2	3.7	2.7	1.8	1.4
2011	1,435	3.0	3.4	2.7	1.7	1.3
2012	1,405	2.9	3.1	2.7	1.7	1.2
2013	1,305	3.0	3.1	2.9	1.7	1.3
2014	1,305	3.0	3.2	2.8	1.7	1.3
2015	1,190	2.7	2.9	2.5	1.5	1.2
2016	1,154	2.8	3.1	2.6	1.6	1.2
2017	1,000	2.8	3.1	2.5	1.5	1.3

[a]Deaths per 1,000 live births.

Table 4. Infant and perinatal mortality rate[a)] by gestational age: Korea, 2009–2017

Year	Infant mortality rate					Perinatal mortality rate				
	Gestational age (wk)					Gestational age (wk)				
	<28	28–31	32–36	37–41	≥42	<28	28–31	32–36	37–41	≥42
2009	464.0	75.7	9.1	1.5	2.4	251.7	180.8	18.4	1.0	3.0
2010	440.0	76.7	9.1	1.4	3.4	242.8	145.3	17.9	1.0	3.4
2011	405.0	65.1	8.5	1.4	3.2	209.0	137.8	16.7	1.0	2.4
2012	411.2	58.6	6.9	1.2	1.7	215.3	137.1	15.1	1.0	2.6
2013	374.0	66.5	7.7	1.3	1.1	195.9	134.7	17.3	1.0	2.3
2014	397.2	63.7	7.5	1.3	-	198.6	144.6	14.4	1.0	4.2
2015	367.5	47.8	6.4	1.1	3.1	190.9	115.2	14.3	0.9	-
2016	443.3	58.7	7.2	1.0	-	200.8	121.2	12.0	0.8	2.0
2017	378.1	55.0	6.2	1.2	2.9	177.7	107.5	11.4	0.8	2.9

[a)]Deaths per 1,000 live births.

accounting for 23.2% (n=120), 8.3% (n=43), and 4.4% (n=23) of all deaths due to perinatal conditions (n=517), respectively. In congenital abnormalities, most events were due to heart conditions or Down's syndrome. There were 33.3% (n=56) of deaths due to heart conditions and 17.3% (n=29) of deaths due to other circulatory anomalies, as well as 10.1% (n=17) due to Down's syndrome or other chromosomal disorders in this entity (n=168). Unfortunately, >20% of the external causes were assaults, and this proportion remained this high across the years, ranging between 24.2% (n=15) and 35.6% (n=21), except in 2012 and in 2014 when there were 12 (15.6%) and 6 (11.5%) deaths, respectively.

The perinatal mortality rate, including fetal deaths at 28 gestational weeks or more and neonatal deaths before 7 days after birth, gradually decreased during the past 9 years (Supplementary Table 2). Similar to infant mortality, the perinatal rate was slightly higher in boys than in girls, with the ratio of rates ranging from 1.0 to 1.2. Specifically, the fetal mortality rate was higher than the neonatal mortality rate before 7 days after birth, with 1.7 and 1.0 deaths per 1,000 live births yearly, respectively. However, compared with 2009, the fetal mortality rate decreased by 26.1% in 2017, whereas the decrease was 16.7% in the neonatal mortality rate during the same period. The rate distribution by maternal age and gestational week was similar to that observed in infant mortality (Table 4, Fig.1). The increasing trend of mortality rate in the recent 3 years among those whose mothers were 40 years or older was also comparable.

Discussion

Pregnancy-related mortality and perinatal mortality have gradually improved during the 2009–2017 period. The maternal mortality ratio has dropped by 42.2% to reach 7.8 deaths per 100,000 live births, and it has been continuously decreasing in the recent 3 years. Although the rate of decrease has recently slowed down, both infant mortality and perinatal mortality have improved to 12.5% and 22.9%, respectively.

In South Korea in 2009, the maternal mortality ratio was among the highest in OECD countries, with 13.5 deaths, and was still increasing in contrast to the overall decreasing trend observed in high-income states [6,7]. For this reason, the Ministry of Health and Welfare has initiated a "Supporting Policy for Underserved Area of Obstetric Care" since 2011, especially for underdeveloped small cities and towns, which include administrative and financial support as well as organizing transfer and referral systems [8]. Although a single policy may not fully explain the changes, the improvement in maternal mortality since 1 year after its implementation is, at least partly, attributable to such a societal approach.

It should be noted that maternal deaths due to hypertensive disorders are increasing while those due to all other specific causes are decreasing. Robust risk factors such as advanced maternal age, obesity, or working during pregnancy have been extensively discussed to date [9-11]. Although the prevalence of overweight or preexisting hypertension is low and stable at present in South Korea [12,13], increasing age

at delivery is inevitable in high-income countries, which will eventually lead to relevant maternity characteristics in undesirable directions [14,15]. As chronic morbidities are hardly reversible when symptomatic, preventive measures should not only focus on a specific age group but should also be devised as a lifelong modification.

Complications at delivery or puerperium were decreasing but remain the 2 most significant causes of deaths. As our data only provide grouping variables, it is difficult to identify specific reasons. However, a previous study in South Korea suggested that amniotic fluid embolism (ICD-10: O88.1), obstetric blood-clot embolism (O88.2), uterine inertia (O62.2), and immediate postpartum hemorrhage (O72.1) were common causes in each group, respectively. While such embolic and hemorrhagic events are among the frequent causes of maternal mortality in high-income and aging countries [16,17], it is also suggested that a significant portion of these causes are preventable by establishing a patient referral or proper transfer system [16].

Teenage pregnancy is a continuous threat to infant and, especially, perinatal mortality. However, as the absolute number of mortality events in teenage mothers is relatively small for both infant and perinatal mortality (8 cases [0.8%] and 14 cases [1.5%] in 2017, respectively), this has been less likely to be considered a priority issue. Unlike common beliefs that socioeconomic factors may influence the outcome of teenage pregnancies, studies have shown that merely young age, independent of other factors, is a risk for undesirable results [18]. Thus, an approach should focus on avoiding pregnancy itself in younger age through proper education [19], rather than trying to support teenage mothers.

The fact that both the number of mortality events (22, 22, 20, 12, 15, 6, 21, 15, and 17 cases between 2009 and 2017) as well as the proportion (27.5%, 28.2%, 26.3%, 15.6%, 24.6%, 11.5%, 35.6%, 24.2%, and 30.9%) out of the total external causes of infant deaths are due to child assault including homicide, and that these numbers are actually constant or rather increasing especially in proportion despite the overall decreasing mortality, is not only a tragedy but a disgrace for any developed country. Immediate interventions beginning from scrutinized descriptive epidemiology to surveillance systems and integrated medical, social, and political resolutions are required.

This study evaluated all available data sources with respect to maternal and perinatal deaths in South Korea at present.

We sought to ensure the completeness and reliability of the data by incorporating a complementary COD process. However, as the data are originally based on death certificates with diagnosis based on ICD, possible explanatory information such as education level or socioeconomic status is lacking. Nevertheless, our study represents the most up-to-date vital status information at the country level, and we are positive that it can serve as evidence for further scrutiny.

Acknowledgements

Conflict of interest

No potential conflict of interest relevant to this article was reported.

Ethical approval

No institutional approval was required because this was an analysis of publicly available data that were produced by Statistics Korea according to the Bioethics and Safety Act (IRB-2019-0270).

Patient consent

Informed consent was not required because this was an analysis of publicly available data.

Supplementary materials

Supplementary materials associated with this article can be found online at https://doi.org/10.5468/ogs.20081.

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