

Disability-Adjusted Life Years for Maternal, Neonatal, and Nutritional Disorders in Korea

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Received: 5 February 2016

Accepted: 26 June 2016

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Funding: This study was supported by a grant of the Korean Health Technology R&D Project, Ministry of Health and Welfare, Republic of Korea (Grant No. HI13C0729).

Maternal and child health is an important issue throughout the world. Given their impact on maternal and child health, nutritional issues need to be carefully addressed. Accordingly, the effect of maternal, child, and nutritional disorders on disability-adjusted life years (DALYs) should be calculated. The present study used DALYs to estimate the burden of disease of maternal, neonatal, and nutritional disorders in the Korean population in 2012. For this purpose, we used claim data of the Korean National Health Insurance Service, DisMod II, and death data of the Statistics Korea and adhered to incidence-based DALY estimation methodology. The total DALYs per 100,000 population were 376 in maternal disorders, 64 in neonatal disorders, and 58 in nutritional deficiencies. The leading causes of DALYs were abortion in maternal disorders, preterm birth complications in neonatal disorders, and iron-deficiency anemia in nutritional deficiencies. Our findings shed light on the considerable burden of maternal, neonatal, and nutritional conditions, emphasizing the need for health care policies that can reduce morbidity and mortality.

Keywords: Disability-Adjusted Life Year; DALYs; Incidence-based; Maternal Disorders; Neonatal Disorders; Nutritional Deficiencies

INTRODUCTION

Maternal health and child health are public health matters of the highest priorities in all countries throughout the world. Of the 8 Millennium Development Goals established by the United Nations in 2000, 2 of the 3 public health issues were maternal and child health issues, namely, as reducing child mortality and improving maternal health (1). One important reason for the adoption of these issues in the Millennium Development Goal initiative is that pregnancy and childbirth could considerably affect the physical, mental, emotional, and socioeconomic health of women and their families (2). Therefore, developed countries such as the United States have been trying to improve well-being of mothers, infants, and children as an important public health goal (3). It is an important public health issue to address the nutritional problems in company with maternal and neonatal health. Good nutrition and lifestyle improves health pregnancy outcomes (4), whereas maternal and child malnutrition is strongly associated with child mortality in many countries (5). Therefore, the essential nutrition activity of the

World Health Organization (WHO) has focused on improving the health and nutrition of mothers, newborns, infants, and young children (6). In addition, the prior Global Burden of Disease (GBD) Study also reported the burden of these disorders categorized as one group (7).

Developed countries are still interested in these maternal, neonatal, and nutritional issues as both domestic and international matters. As domestic matters, these issues could be related to health inequality, such as infant mortality differences according to race in the United States (8). In Korea, differences in infant and child mortality rates according to social class have also been reported (9).

From an international perspective, domestic experiences in improving these outcomes have been delivered to other developing countries. Canada developed the Canadian Network for Maternal, Newborn, and Child Health, which is a collaboration of more than 80 organizations working to save the lives of the most vulnerable women, newborns, and children in over 1,000 global communities (10). These organizations have tried to combine their knowledge and expertise to improve results, as well

as engage Canadians.

Disability-adjusted life year (DALY), introduced in the GBD 1990 Study (11), is a composite index combining mortality and morbidity, and has been widely used to estimate a measure of total disease burden of population by age, sex and region. DALYs make it possible to compare disease burdens of various causes so as to target healthcare policies or interventions toward minimizing burden of diseases in vulnerable populations (12). The GBD 2010 study provided the DALYs of maternal, neonatal, and nutritional disorders including 15 causes (13). The first study quantifying the Korean national burden of disease in 2002 (the KBoD 2002 study) (14) followed the protocol of the original GBD study using incidence-based DALY approach but made differences in methodology to reflect Korean context: the disease classification, epidemiological data estimation methods, and the disability weights. In Korea, many studies have been reported on the burden of disease such as cancer (15), asthma (16), and stroke (17), and burden of disease attributable to risk factors (18,19).

The maternal mortality ratio of Korea was 10 persons per 100,000 live births (20), much higher than the OECD average, 7 in 2012 (21). The rise in number of mothers age 35 or more is linked to increased risk of neonates in Korea (22). In addition, there are still nutritional problems such as high maternal iron deficiency anemia (IDA) (23). However, there are no studies on the burden of diseases due to maternal and neonatal disorders and nutritional deficiencies in Korea after the KBoD 2002 study.

The present study followed the methodology of the KBoD 2002 study using incidence-based approach to compare the results of two studies and tried to reflect Korean context. This study was conducted to estimate DALYs due to maternal, neonatal, and nutritional disorders as part of the Korean national burden of disease study in 2012 (the KBoD 2012 study).

MATERIALS AND METHODS

Disease classification of maternal, neonatal, and nutritional disorders

The causes of maternal disorders, neonatal disorders, and nutritional deficiencies were based on the hierarchical disease cause list from the GBD 2010 Study (24). The claim data of Korean National Health Insurance Service and Medical Aid Program were used. Each disease had an operational definition, obtained from the International Classification of Diseases-10th Revision (ICD-10) (25), frequencies of hospitalization and ambulatory medical services in each year, and washout period with expert consultations (Table 1).

DALYs calculation

To measure the burden of disease of maternal, neonatal, and nutritional disorders, we estimated incidence-based DALYs which incorporate years of life lost (YLL) and years lived with disability (YLD). The basic formula for DALYs is as follows (26):

$$\begin{aligned} \text{DALY} &= \text{YLL} + \text{YLD} \\ &= N \times L + I \times DW \times L \end{aligned}$$

N = number of deaths; L = standard life expectancy at age of death in years; I = number of incident cases; DW = disability weight; L = average duration of the case until remission or death.

For the YLL, mortality rate was calculated by using the cause of death data of the Statistics Korea. In the case of causes which cannot or should not be considered as an underlying cause of death, we followed the GBD's redistribution algorithm for garbage codes. Years lost due to premature death were derived from the standard expected years of life lost (SEYLL). Life expectancy was based on the general population's life expectancy by age, using life tables of the Statistics Korea in 2012. We used 4% age weighting and 3% time discount rate.

Table 1. Categories of causes and their operational definitions

Causes	ICD-10 codes	Hospitalization	Ambulatory medical service	Washout period, yr
Maternal disorders				
Abortion	000, 001, 002, 003, 004, 005, 006, 007, 008	1	1	0
Maternal hemorrhage	020, 044, 045, 046, 067, 072	1	1	0
Hypertensive disorders of pregnancy	010, 011, 012, 013, 014, 015, 016	1	1	0
Obstructed labor	064, 065, 066	1	1	0
Maternal sepsis	085, 075.3	1	1	0
Neonatal disorders				
Preterm birth complications	P07, P22, P25, P26, P27, P28, P61.2, P77, P52, H35.1	1	3	3
Sepsis and other infectious disorders of the newborn	P36, P38, P39	1	1	0
Neonatal encephalopathy (birth asphyxia and birth trauma)	P11.0, P11.1, P11.2, P11.4, P11.5, P11.9, P21, P91	1	1	3
Sudden infant death syndrome	R95	1	1	0
Nutritional deficiencies				
Iron deficiency anemia	D50	1	2	3
Vitamin A deficiency	E50, E64.1	1	3	3
Protein-energy malnutrition	E40, E41, E42, E43, E44, E45, E46, E64.0	1	3	3
Iodine deficiency	E01	1	3	3

The YLD was calculated by using the incidence rate, age at onset, disease duration, and disability weight. Estimates of incidence were based on the prevalence cases from the claim data and washout periods. The fatality rate was calculated using the prevalence data, cause of death data of the Statistics Korea, and garbage code redistribution like prior incidence-based burden of disease study. To calculate the age at onset and disease duration, we used the DisMod II (27) with appropriate input parameters (incidence rate, prevalence rate, mortality rate, and fatality rate). Disability weights were generated from a self-administered web-based survey of physicians and medical college students, using paired comparison for valuation method. The frame of the KBoD 2012 study (28), estimating mortality (29), and calculating disability weights (30) was described in more detail elsewhere in this issue.

Ethics statement

This study was approved by the Korea University institutional review board, No. 1040548-KU-IRB-13-164-A-1(E-A-1). Informed consent was waived by the board.

RESULTS

The results for the burdens of maternal disorders, neonatal disorders, and nutritional deficiencies are presented in Fig. 1. In maternal disorders, the total DALYs were 376 per 100,000 population. The total YLDs were 374 per 100,000 population, accounting for 99% of the total DALYs. Abortion was the leading cause

of YLDs, followed by maternal hemorrhage, hypertensive disorders of pregnancy, obstructed labor, and maternal sepsis. All maternal disorders presented similarly low YLLs.

In neonatal disorders, the total DALYs were 64 per 100,000 population. The total YLLs were 56 per 100,000 population, 88% of the total DALYs. Preterm birth complications were the most common cause of YLLs, followed by neonatal encephalopathy, sudden infant death syndrome, and sepsis/infectious disorders of the newborn.

In nutritional deficiencies, the total DALYs were 58 per 100,000 population. The total YLDs were 54 per 100,000 population, 93% of the total DALYs. IDA showed the greatest burden in terms of the highest YLDs, followed by vitamin A deficiency, protein-energy malnutrition, and iodine deficiency.

In maternal disorders, the 30-34 years age group accounted for the highest burden (41%) of the total DALYs. The DALYs of maternal disorders except maternal sepsis were highest in the 30-34 years age group, whereas the DALYs of maternal sepsis were highest in the 35-39 years age group (Table 2).

In neonatal disorders, 98% of the total DALYs were attributed to the group under the age of 1 year. For all causes, the DALYs of males were slightly higher than those of females (Table 3).

In nutritional deficiencies, the highest proportion of the total DALYs (28%) was attributed to the 40-49 years age group. The DALYs of IDA and protein-energy malnutrition were highest in the 40-49 years age group. In the case of vitamin A deficiency, the 50-59 years age group presented higher DALYs than any other age group. The DALYs of iodine deficiency were highest in

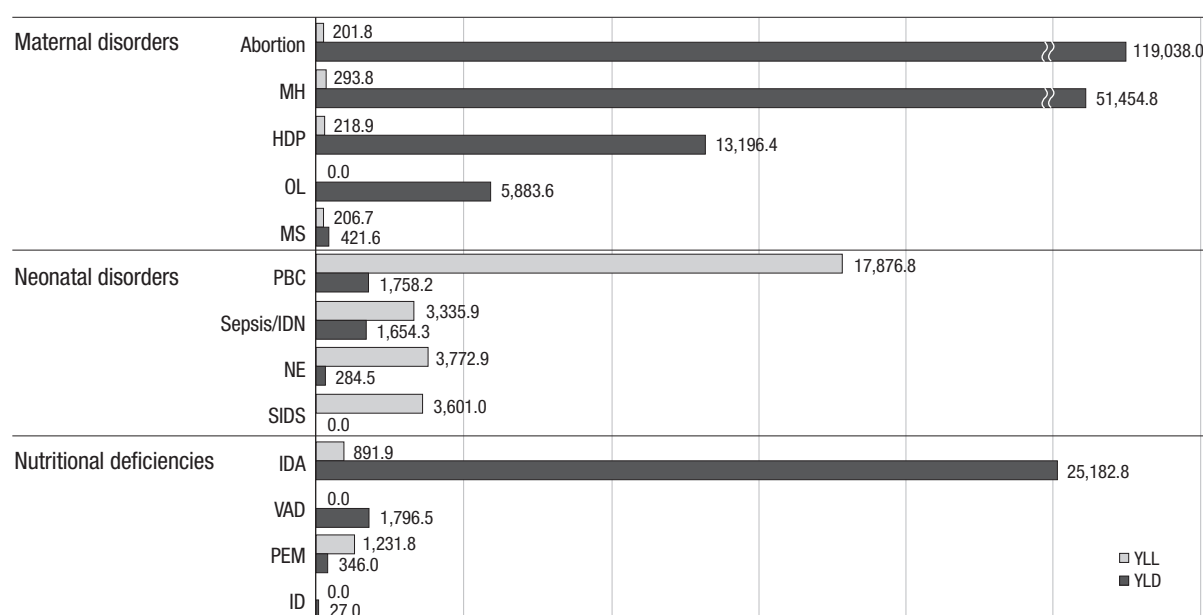


Fig. 1. Incidence-based DALYs for maternal, neonatal, and nutritional diseases.

MH, maternal hemorrhage; HDP, hypertensive disorders of pregnancy; OL, obstructed labor; MS, maternal sepsis; PBC, preterm birth complications; IDN, infectious disorders of the newborn; NE, neonatal encephalopathy (birth asphyxia and birth trauma); SIDS, sudden infant death syndrome; IDA, iron-deficiency anemia; VAD, vitamin A deficiency; PEM, protein-energy malnutrition; ID, iodine deficiency.

Table 2. Incidence-based DALYs for maternal disorders by age

Age, yr	Abortion	Maternal hemorrhage	Hypertensive disorders of pregnancy	Obstructed labor	Maternal sepsis	Total
10-14	21.6	2.0	7.3	1.7	0.0	32.6
15-19	2,482.1	436.4	118.0	80.6	2.7	3,119.8
20-24	11,665.2	4,350.7	1,103.2	675.0	28.4	17,822.5
25-29	27,375.8	16,226.4	4,096.4	1,836.9	179.2	49,714.7
30-34	46,614.3	22,488.2	5,664.9	2,521.3	163.9	77,452.6
35-39	22,686.3	7,015.9	2,049.6	656.8	248.5	32,657.1
40-44	7,478.6	1,167.4	340.5	105.1	4.1	9,095.7
45-49	874.5	57.2	19.9	3.9	1.5	957.0
50-54	39.6	2.7	10.9	2.4	0.0	55.6
55-59	1.8	1.4	4.6	0.0	0.0	7.8

Table 3. Incidence-based DALYs for neonatal disorders by gender and age

Age, yr	Preterm birth complications		Sepsis and other infectious disorders of the newborn		Neonatal encephalopathy (birth asphyxia and birth trauma)		Sudden infant death syndrome		Total
	Male	Female	Male	Female	Male	Female	Male	Female	
0	10,983.1	8,472.6	2,740.9	2,046.8	2,051.5	1,736.7	2,040.1	1,560.9	31,632.6
1	78.4	10.8	93.4	83.2	29.1	130.6	0.0	0.0	425.5
2	1.4	0.8	4.4	3.7	13.2	11.3	0.0	0.0	34.8
3	35.8	0.8	1.8	2.4	7.3	41.7	0.0	0.0	89.8
4	2.7	2.4	1.6	1.1	6.0	1.0	0.0	0.0	14.8
5	2.0	2.6	2.6	2.3	3.2	3.5	0.0	0.0	16.2
6	4.3	6.0	1.1	1.1	2.6	2.8	0.0	0.0	17.9
7	7.6	3.1	0.0	0.0	3.0	4.8	0.0	0.0	18.5
8	2.2	1.9	0.0	1.1	1.7	3.6	0.0	0.0	10.5
9	12.2	4.2	0.0	2.7	3.9	0.0	0.0	0.0	23.0

Table 4. Incidence-based DALYs for nutritional deficiencies by gender and age

Age, yr	Iron deficiency anemia		Vitamin A deficiency		Protein-energy malnutrition		Iodine deficiency		Total
	Male	Female	Male	Female	Male	Female	Male	Female	
0-9	1,034.9	763.5	12.0	8.9	6.5	7.6	0.1	0.0	1,833.5
10-19	448.0	2,308.6	42.2	94.0	12.6	13.5	0.0	1.0	2,919.9
20-29	261.6	2,612.2	69.3	214.5	1.1	109.2	0.4	2.7	3,271.0
30-39	310.1	4,987.1	82.5	176.3	104.4	105.1	0.5	6.1	5,772.1
40-49	441.2	7,206.6	92.6	213.6	225.1	152.9	2.0	3.6	8,337.6
50-59	641.9	2,035.6	101.3	239.4	80.8	33.2	1.2	4.6	3,138.0
60-69	503.0	727.8	81.1	164.7	129.1	112.8	0.4	3.2	1,722.1
70-79	445.8	743.3	59.8	118.4	119.7	80.2	0.0	0.7	1,567.9
80+	159.7	443.8	7.1	18.9	123.4	160.8	0.1	0.2	914.0

the 30-39 years age group. Female showed higher DALYs in IDA, vitamin A deficiency, and iodine deficiency than men (Table 4). An exception was protein-energy malnutrition.

DISCUSSION

In the present study, we used DALYs to estimate the burden of disease of maternal, neonatal, and nutritional disorders for Koreans in 2012. At the aggregate level, the burdens of maternal, neonatal, and nutritional disorders were 376, 64, and 58 DALYs per 100,000 persons, respectively. Abortion was the largest specific cause of burden among maternity-related disorders and

most DALYs due to maternal disorders were found in the women aged 20-39 years. Among neonatal disorders, preterm birth complications were the most common specific cause of disease burden. Neonatal disorders led to death early in life. Almost all neonatal mortality and morbidity occurred under 1 year of age. The highest ranking cause in nutritional deficiencies was IDA and females were affected much more than males by IDA. Especially, almost 60% of the DALYs due to IDA were derived from the female group aged 20-49 years.

The burdens of maternal, neonatal, and nutritional disorders in 2012 increased from 34 DALYs per 100,000 to 376, 58 to 64, and 3 to 58, respectively, compared to the KBoD 2002 study

(31). The increases could be not only due to methodological differences but also due to substantive changes in the disease burdens. The differences of methods between two studies were disease classifications, their operational definitions, and disability weights. Disability weights of maternal, neonatal, and nutritional disorders in the KBoD 2012 study were higher than in the KBoD 2002 study. For example, the disability weights of abortion and IDA in the KBoD 2012 study were two and three times higher than in the KBoD 2002 study, respectively (31). These higher disability weights could affect these increases. In addition, there have been epidemiological changes between periods of two KBoD studies. All causes' epidemiologic parameters including both incidence and prevalence from the Korean claim data and disease duration from the DisMod II had been increased. Especially, IDA prevalence in this study was three times higher than in the KBoD 2002 study. However, DALYs estimates due to abortion could be still underestimated. The number of abortions could thus be underreported because health providers do not claim insurance coverage for illegal abortion. One study estimated 168,738 abortions in women aged 14 to 44 based on a survey of women and 108,679 abortions based on a health provider survey (32). In the present study, only 92,919 abortions were observed in the same age group. In addition, burden of neonatal disorders also might be underestimated because stillbirth was not counted in our DALYs estimates. More than 2,000 babies per year die during pregnancy in Korea (33). These results emphasize the considerable burden of neonatal conditions in Korea. Therefore, in future studies, these real epidemiologic data could be considered to estimate DALYs rather than the claim data.

Compared with incidence-based DALYs of other countries grouped into western-pacific high-income countries by WHO, the burden due to maternal disorders of Korea was much higher than Japan, Singapore, Austria, and New Zealand in 2004 (34). The burden due to neonatal conditions of Korea was slightly higher than Japan and Singapore, and much lower than Austria and New Zealand. In the case of nutritional deficiencies, the burden of Korea was lower than Japan, Singapore, and Austria, and higher than New Zealand. In spite of comparing results calculated from incidence-based approach, international comparisons of burden of disease should be made cautiously because the availability and quality of morbidity and mortality data strongly differ among countries (35).

From the GBD 2010 study, burdens of diseases due to maternal, neonatal, and nutritional disorders in Korea were 9 DALYs per 100,000, 241, and 523, respectively (36). These results are sharply different from those of the present study. Those differences are attributable to several differences between two studies. First, the GBD 2010 study used a prevalence-based approach, while this study adopted an incidence-based approach. The number of DALYs will be affected by the approaches, yielding

different results (37). WHO presented that incidence-based YLDs were more than three times as high as prevalence-based YLDs at group aged 0-4 years (38). One study reported that the prevalence-based approach resulted in 29%-38% less YLDs, compared to incidence-based approach (39). In maternal disorder such abortion or maternal hemorrhage and neonatal disorder like preterm birth complication, annual incidence might be similar with periodic prevalence for one year. Therefore disease durations and disability weights on disorders might affect these differences. Second, the GBD 2010 study substituted data of other countries for sparse data which were not available to calculate parameters for each country (40), but the present study used the epidemiologic data to reflect Korean context. Therefore, authors thought results from this study could be more valid in Korea and prevalence-based approach using Korean data will be needed within near future. Third, the GBD 2010 used the same disability weights for every country, but the present study generated disability weights for Korean people. For these reasons direct comparison between the GBD 2010 and the KBoD 2012 study could be inappropriate.

The present study has some limitations. First, we used the primary diagnostic code and cause of death from health insurance claims data instead of medical records. Because there are variations across hospitals and physicians in the coding of morbidity and mortality, some degree of uncertainty could be associated with the epidemiologic data, such as the incidence rate, prevalence rate, and duration of disease. However, to ensure the accuracy of the diagnostic coding, we additionally used the number of hospitalizations and the frequency of outpatient visits according to expert consultation. Second, there was limitation concerning disease duration estimated from prevalence rate, incidence rate, case fatality, and mortality using DisMod II. However, the present study did not include the validation for the estimates, so there was possibility that the epidemiological estimates from DisMod II might be inappropriate.

In conclusion, our findings indicate that maternal and neonatal conditions are a substantial burden requiring improvements to reduce morbidity and mortality. National health policies should pay increased attention to maternal and neonatal healthcare. In addition to a robust health system to improve maternal health, improvements in social awareness and support for unwed mothers are essential. Improvements in newborn healthcare services, including universal coverage of neonatal intensive care, are needed. Investigation of birth outcomes and changes in the burden of neonatal disorders over time is also required. Although the present study focused on malnutrition or undernutrition according the GBD classification, further studies are necessary in order to obtain the burdens of diseases due to overnutrition, such as gestational diabetes mellitus and fetal macrosomia.

DISCLOSURE

The authors have no potential conflicts of interest to disclose.

AUTHOR CONTRIBUTION

Conception and design of this study: Jo MW, Ock M. Interpretation of results and drafting of the manuscript: Kim SH, Jo MW, Lee HJ. Analysis and interpretation of data: Go DS, Lee HJ, Kim SH. Acquisition of data: Jo MW, Ock M, Lee JY, Kim HJ. Critical revision of the manuscript: Jo MW, Lee HJ, Kim SH. Manuscript approval: all authors.

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