Open Journal of Preventive Medicine, 2014, 4, 751-759
Published Online October 2014 in SciRes. http://www.scirp.org/journal/ojpm
http://dx.doi.org/10.4236/ojpm.2014.410085

Scientific Research

Maternal Mortality Correlates by Nation

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Received 24 August 2014; revised 22 September 2014; accepted 3 October 2014

Abstract

***Background*: This study reports the results of a secondary analysis of data provided by the World Health Organization to determine the correlates of maternal mortality among all reporting nations worldwide. Historically, maternal mortality ratios have declined in nations that provided a system for access to skilled care for the majority of its women. Currently, maternal mortality ratios are associated with access to skilled care as well as economic indicators, literacy, education, access to contraceptives, transportation and HIV prevalence. *Methods*: Descriptive statistics, bi-variate correlations and multiple linear regression analyses are reported using maternal mortality ratios as the dependent variable. In addition, an examination of countries that are exceptions to the regression is also reported. *Results*: Strong positive Pearson two-tailed correlations were found between MMR and infant mortality rate (0.866), total fertility rate (0.854), poverty rate (0.756), and adolescent fertility rate (0.710). Strong negative correlations were found between MMR and percentage of births attended by a skilled attendant (−0.786), percentage of women using contraceptives (−0.786), and adult literacy rate (−0.710). Eighty-one percent of the variation in MMR can be explained by differences in IMR, percent of births attended by a skilled provider, percent of women using contraceptive, total fertility rate, adolescent fertility rate, adult literacy rate and poverty. *Discussion*: Examination of the correlates of maternal mortality gives direction to the effort to achieve the WHO's Millennium Development Goal of reducing maternal mortality by two-thirds from 1995-2015.**

Keywords

Maternal Mortality, Millennium Development Goals, Women's Health

1. Background

1.1. Maternal Mortality

Maternal death is defined as "the death of a woman while pregnant or within 42 days of termination of preg-

nancy, irrespective of the duration and site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management but not from accidental or incidental causes" [1].

A Millennium Development Goal set by the World Health Organization is to reduce the current worldwide rate of maternal mortality of 400 per 100,000 live births by 75% by the year 2015 [2]. In order to achieve this goal, it will be necessary to dramatically reduce the rates in nations where the rates of women dying in childbirth are the highest in the world. Maternal mortality rates in the western world are stable and low; however, this has not always been true.

1.2. Historic Correlates

Maternal mortality rates were consistently high in the western world until they made a sharp decline in the 1930s [3]. The rates experienced today in sub-Saharan Africa averaging 684 deaths per 100,000 live births [4] have not been seen in the western world since the nineteenth century. During the last decade of the nineteenth century there was initially a dramatic decline in maternal mortality in northwestern Europe. Sharp declines in maternal mortality subsequently occurred in Great Britain, Ireland and the United States in the early twentieth century. Malaysia and Sri Lanka are the most recent nations to have experienced significant drops in maternal mortality toward the end of the twentieth century [3].

In Sweden from 1890 to 1895, the maternal mortality rate dropped from approximately 350 deaths per 100,000 live births to less than 200 [5]. This decline has been attributed to the widespread use of Listerian antisepsis in home deliveries. The same low levels occurred throughout northwestern Europe in Norway, Denmark and the Netherlands where midwives were traditionally well-trained and well-supervised. They consistently used antiseptic techniques since they were first introduced [6]. Sweden taught and trained professional midwives since early in the eighteenth century [7].

It wasn't until three decades later that a dramatic decline in maternal mortality occurred in England and Wales in the 1930s where the rate finally converged with Sweden's low rate of nearly 300 down from nearly 500 per 100,000 live births at the turn of the twentieth century. Loudon (2000) attributes the improved rates to the introduction of sulfonamides for treating streptococcus, "ergometrine, blood transfusions, penicillin, better training, better anesthesia, improved organization of obstetric services, less interference in normal labors and the decline in virulence of the streptococcus" [3]. A similar decline is documented in Ireland where the rate fell from 516 per 100,000 live births in 1933 to 257 in 1943 [8]. At this time Ireland was experiencing a widespread famine.

At the same time in the United States at the beginning of the twentieth century between 600 and 900 women died of pregnancy-related complications for every 100,000 live births [9]. By 1940 the rate had declined to less than 300. The Centers for Disease Control and Prevention [9] recognized that most of the maternal deaths were preventable because they were due to poor obstetric education and delivery practices. Inappropriate and excessive surgical and obstetrical interventions resulted in sepsis causing 40% of maternal deaths [10]. It is interesting to note that the United States at this time was experiencing the most devastating economic depression of its history.

Prior to the 1930s most deliveries were in homes. The training of midwives was not uniform. Some states had a history of training midwives since the mid nineteenth century while other states actually banned midwifery practice [11]. In the 1930s a call for action by the federal government for practice guidelines for hospital deliveries coincided with a shift from home births to hospital births. "During 1938-1948, the proportion of infants born in hospitals increased from 55% to 90%" [12]. Safer deliveries in hospital under aseptic conditions and provision of maternal care for the poor hastened the decline in maternal mortality after the 1930s. However, remarkable achievements were also made in rural areas. In rural Kentucky a group of midwives who traveled on horseback to assist deliveries achieved maternal mortality rates ten times lower than in the nearby city of Lexington and in the United States as a whole, despite the high level of poverty [3].

A third wave of improved maternal care occurred in Sri Lanka and Malaysia in the latter half of the twentieth century. In Sri Lanka maternal mortality rates dropped from 2000 per 100,000 live births in the 1930s to nearly 20 per 100,000 in the year 2000 [13]. Similarly, the rates in Malaysia declined from 550 in 1950 to less than 20 in 2000 [13]. The improvements are attributed to monitoring and analysis of levels and causes of maternal mortality, provision of integrated obstetric care by professional midwives, malaria control and family planning. A key element to their successes was removing financial barriers so that skilled attendance could reach more than 80% of the women giving birth.

Historically, maternal mortality has been resistant to reduction despite decreases in other prominent causes of death, infection rate and changes in socioeconomic factors. Yet there are case studies of nations that demonstrate remarkable declines in maternal mortality in relatively short-time spans. It is evident that provision of quality services to pregnant women during delivery whether it is in the hospital or in homes in rural communities is the key to saving the lives of mothers. In northwestern Europe in the nineteenth century and in south Asia in the twentieth century, midwives were trained and integrated into the health care delivery system. In Great Britain and the United States in the 1930s, hospital deliveries were made safer and accessible to the majority of women. "Those countries that managed to provide professional obstetric care to cover the whole population, including poor and remote areas, achieved a relatively low level of maternal mortality earlier than the others" [14]. The lessons of the past can direct the efforts of the present to reach the World Health Organization's Millennium Development Goal of reducing maternal mortality worldwide by 75% by 2015.

1.3. Current Correlates

1.3.1. Economic Factors

Maternal mortality ratios have been associated with poverty rates [15]; however the relationship is complex requiring political will to tackle the issue [16]. In rural China, low income and literacy rates contributed to high maternal deaths due to their impact on the use of prenatal and obstetrical care [17]. Similarly, in Bangladesh, maternal care-seeking behavior was related to socioeconomic disparities in urban and rural settings [18]. An international study found that female education and literacy were moderate predictors of maternal mortality ratios [19]. Maternal mortality also has a negative effect on gross domestic product in Africa [20]. Many experts in the field of maternal health call for action to reduce poverty and empower women as a means to reduce maternal mortality [21].

1.3.2. Skilled Care

Maternal mortality also has been related to skilled care during delivery [22]; however the skill level of trained birth attendants has been the subject of debate [23]. Mbonye, *et al*. [24] found that the availability of midwives had the highest protective effect on maternal deaths in Uganda. In Nigeria, physician and midwife coverage was a key indicator [25]. In Bangladesh, the skilled midwives facilitated access to emergency care therefore contributing to the reduction in maternal deaths [26].

The provision of emergency obstetric care has decreased maternal deaths in Mali [27] and in Vietnam [28] but not in Nepal [29]. Lack of transport to emergency obstetric care contributed significantly to the maternal death rate in Mozambique [30] and in Thailand [31].

1.3.3. Caesarean Section

In an analysis of national, regional and global levels of births by Caesarean Section (CS), researchers associated with the World Health Organization (WHO) found a strong inverse relationship between CS rates and high maternal mortality levels [32]. An investigation in Nigeria found that the high prevalence of caesarean section refusal related to very poor maternal outcomes [33]. Researchers in the United States discovered that HIV-positive women are more likely than HIV-negative women to die as a result of caesarean section [34].

1.3.4. Other Pregnancy-Related Outcomes

An analysis of data provided by the WHO found a strong correlation between maternal mortality and stillbirth but not skilled delivery attendance of prenatal visits [35]. In its World Health Report, the WHO also cites availability of family planning services, skilled care before during and after birth, post abortion care and safe abortion as related to maternal mortality [4].

1.3.5. Goal

The goal of this study is to determine the correlates of maternal mortality ration among the nations that report health indicators.

2. Methods

This research describes a secondary analysis of data compiled by the World Health Organization (WHO) by na-

tion. The dependent variable of analysis is Maternal Mortality Ratio (MMR). Twenty-two independent variables were chosen after reviewing the professional literature regarding maternal mortality. Nations with total population less than 100,000 were excluded from the analysis.

Descriptive statistics including means, minimum values and maximum values were reported along with the nation that the value represents. Bi-variate Pearson regression analyses were processed with missing values excluded. Strong correlations are determined if the coefficients are greater than 0.70. Scatter plots were examined to identify outliers in the regressions and the nation represented.

The variables with strong bi-variate correlation were entered into a multiple linear regression analysis. Nations with a value reported for each variable were included in the analysis. Person coefficients and R-square values are reported. These analyses were conducted using SPSS version 15.

3. Results

3.1. Descriptive Statistics

Maternal Mortality Ratios (MMRs) are reported by the World Health Organization (WHO, 2008) for 168 of the 180 nations that they include in their data bases. The mean MMR is 326.65 per 100,000 live births (see **Table 1**). This ranges from 4 in Austria to 2000 in Sierra Leone. **Table 1** lists the valid number, mean, minimum and maximum for the 22 independent variables (core health indicators) selected for this analysis.

Table 1. Descriptive statistics.

Variable	Valid n	Missing n	Mean	Minimum	Maximum
MMR	168	12	326.65	4 *Ireland*	2000 *Sierra Leone*
IMR	180	0	41.96	2 *Iceland*	165 *Afghanistan*
HIV M	144	36	189.6	1 *Japan*	7200 *Liberia*
HIV P	144	36	2276	52 *Cuba*	34,457 *Swaziland*
1 PRENATAL	77	103	78.96	27 *Ethiopia*	100 *Dominican Republic/Santa Lucia*
4 PRENATAL	90	90	63.91	9 *Rwanda*	100 *Cuba*
ATTEND	169	11	76.96	6 *Ethiopia*	100 (37 *Nations*)
CONTRA	108	72	44.65	2.8 *Chad*	90.2 *China*
C SECT	96	84	11.01	1 (9 *Nations*)	32 *Dominican Republic/Italy*
MD	177	3	1.47	0.02 *Niger*	5.91 *Cuba*
RN	177	3	3.45	0.11 *Haiti*	15.2 *Ireland*
MIDWIVES	121	59	0.3243	0.00 *Burundi/Cameroon*	4.27 *Ireland*
% GDP	176	4	6.153	1.6 *Equatorial Guinea*	15.4 *USA*
PCH I$	176	4	738.1	15.3 *DR Congo*	6096.2 *USA*
PCH US$	176	4	447.8	0.2 *DPR Korea*	5334.9 *Luxemburg*
POP URBAN	177	3	53.82	10 *Burundi*	100 *Singapore*
TFR	179	1	3.142	1.1 *Ukraine*	7.8 *Timor Leste*
AFR	164	16	6.013	0.2 *RO Korea*	20.7 *Niger*
ALR	118	62	78.70	19.0 *Mali*	99.8 *Cuba*
SCHOOL M	144	36	87.08	36 *Djibouti*	100 (6 *nations*)
SCHOOL F	144	36	84.79	28 *Djibouti*	100 *Canada*
GNI	158	22	10,406.84	640 *Burundi*	65,340 *Luxemburg*
POVERTY	75	105	16.19	2 (26 *nations*)	76 *Zambia*

3.2. Bi-Variate Analyses

Strong positive Pearson two-tailed correlations were found between MMR and infant mortality rate (0.866), total fertility rate (0.854), poverty rate (0.756), and adolescent fertility rate (0.710). Strong negative correlations were found between MMR and percentage of births attended by a skilled attendant (−0.786), percentage of women using contraceptives (−0.786), and adult literacy rate (−0.710). Week negative correlations were found between MMR and cesarean section rate (−0.657), percentage of females attending elementary school (−0.649), density of physicians (−0.619), percentage of males attending elementary school (−0.617), percentage of population in urban areas (−0.583), the percentage of women receiving at least four prenatal visits (−0.541), density of nurses (−0.529), GNI (−0.518), and health expenditure (−0.420). Little or no correlation was found between MMR and, the prevalence rate of HIV (0.290), the percentage of women receiving at least one prenatal care visit (−0.287), the percentage of GDP spent on health (−0.267), the density of midwives (−0.237), and the mean number of persons with HIV (0.199) (**Table 2**).

3.3. Multiple Linear Regression

A multiple linear regression was calculated to predict a nation's MMR based on infant mortality rate (IMR), percent of births attended by a skilled provider (ATTEND), percent of women using contraceptives (CONTRA), total fertility rate (TFR), adolescent fertility rate (AFR), adult literacy rate (ALR), and percent of population in poverty (POVERTY). A significant regression equation was found (F (7, 43) = 501.329, $p < 0.0001$), with an R^2 of 0.812. A nation's MMR is equal to 501.32 per 100,000 live births + 2.82 (IMR) + 0.876 (ATTEND) – 4.965 (CONTRA) + 27.234 (TFR) – 3.124 (AFR) – 3.407 (ALR) + 5.862 (POVERTY). Poverty rate is a significant independent variable in the equation.

Table 2. Bi-variate correlations of variables with maternal mortality rate.

Variable	Valid n	Pearson correlation	Significance (two-tailed)
IMR	168	0.866**	0.000
HIV M	142	0.199*	0.018
HIV P	142	0.290**	0.000
1 PRENATAL	75	−0.287*	0.013
4 PRENATAL	88	−0.541**	0.000
ATTEND	160	−0.786**	0.000
CONTRA	107	−0.786**	0.000
C SECT	94	−0.657**	0.000
MD	167	−0.619**	0.000
RN	167	−0.529**	0.000
MIDWIVES	115	−0.237*	0.011
% GDP	166	−0.267**	0.001
PCH I$	166	−0.420**	0.000
PCH US$	166	−0.335**	0.000
POP URBAN	167	−0.583**	0.000
TFR	167	0.854**	0.000
AFR	157	0.710**	0.000
ALR	114	−0.758**	0.000
SCHOOL M	135	−0.617**	0.000
SCHOOL F	135	−0.649**	0.000
GNI	150	−0.518**	0.000
POVERTY	75	0.756**	0.000

*Correlation is significant at the 0.05 level; **Correlation is significant at the 0.01 level.

4. Discussion

4.1. Descriptive Statistics

There are great disparities among nations in MMRs and other core health indicators. The greatest disparities among nations are demonstrated in the numbers of persons living with HIV, where the mean in Liberia is 7200 times the mean in Japan and the prevalence of HIV where the rate in Swaziland is 662 times the rate in Cuba. Maternal Mortality Ratios are the second most disparate where 4 of every 100,000 live births in Ireland result in the death of the mother while 500 times more, 2000 per 100,000 live births, occur in Sierra Leone.

4.2. Bi-Variate Analyses

Reducing total fertility, poverty and adolescent fertility rates are likely to have a strong positive affect on MMRs. Likewise, increasing the percentage of women delivering babies in the presence of a trained attendant, increasing the percentage of women using contraceptives and increasing the adult literacy rate may also decrease MMRs significantly.

The results indicating little or no correlation between MMR and density of midwives can be somewhat misleading. In countries like the United States where the physician and nurse density is high, the density of midwives is reported as zero yet there is a relatively low MMR. In the absence of highly trained birth attendants such as physicians and nurses, the density of midwives may have a significant affect in reducing MMR.

The bi-variate analyses indicate a strong correlation between MMR and IMR. These are often not independent events. When a mother dies in childbirth or due to complications of pregnancy, the infant frequently suffers, as well. Independently reducing infant mortality may not affect the MMR however; programs to improve maternal and infant health usually seek to improve both infant and maternal outcomes at once.

4.3. Outliers

Examination of the scatter plots created by the bi-variate regression analysis has identified some nations that have high MMRs despite having similar values of independent variables as other nations. For example, United Republic of Tanzania has a relatively high MMR (1500 per 100,000 births) as compared to Gambia (540 per 100,000 births) and Madagascar (550 per 100,000 births) despite similar poverty rates (58%, 59% and 61% respectively). Afghanistan and Sierra Leone have relatively high MMRs (1900 and 2000 respectively) as compared to Benin and Guinea (850 and 740) despite similarly low adult literacy rates (28.1%, 35.1%, 34.7% and 29.5% respectively). Malawi has a disproportionally high MMR (1800) compared to Tajikistan (100) even though they have similar contraceptive rates (32.5% and 33.9% respectively). Sierra Leone and Niger have high MMRs (2000 and 1600 respectively) compared to Papua New Guinea and Bangladesh (300 and 380 respectively) despite having very similar rates of attended births (42% for both Sierra Leone and Papua New Guinea and 16% and 13% respectively for Niger and Bangladesh). Angola and Niger have relatively high MMRs (1700 and 1600) compared to Liberia (760) despite similar IMRs (154 per 1000 live births, 150 and 157 respectively). Also, Malawi has a high MMR (1800) compared to Azerbaijan (94) despite similar IMRs (78 and 74 respectively).

While Zimbabwe and Jordan have similar total fertility rates (3.4 per woman and 3.3), Zimbabwe has a much higher MMR (1100 compared to 41). Similarly, Sierra Leone and Congo have similar total fertility rates (6.5 and 6.3 respectively) however Congo has a much lower MMR (510 vs. 2000). A final outlier is Rwanda which has a high MMR (1400) compared to Thailand (100) though they have similar adolescent fertility rates (3.6 and 3.5 respectively). These outliers point out the need to examine both the positive factors that nations employ despite their profound challenges like high levels of poverty and high fertility rates and the negative factors that increase MMRs in the presence of more protective factors such as relatively low infant mortality.

4.4. Multiple Linear Regression

Eighty-one percent of the variation in MMR can be explained by differences in IMR, percent of births attended by a skilled provider, percent of women using contraceptive, total fertility rate, adolescent fertility rate, adult literacy rate and poverty. An unexpected finding in the multiple linear regression results is that adolescent fertility rates inversely affected MMRs in the regression equation. This is contrary to the results of the bi-variate regression where adolescent fertility rates had a strong positive correlation.

The variable with the largest coefficient and therefore the greatest affect on MMR in the multiple linear regression is total fertility rate. The total fertility rate, the average number of children per woman, has declined dramatically in many nations throughout the world. According to demographic transition theories, it is usually preceded by reductions in infant mortality [36]. Total fertility rate also is related to the education and empowerment of girls and women. Women with more career choices often choose to have fewer children.

4.5. Limitations

A cross-sectional analysis such as this does not infer causation or temporal sequence of events. The data base is compiled by the WHO using estimation techniques for many variables including MMR since many countries have inadequate vital records. Using the nations as units of analysis ignores the disparities in these measures within nations.

5. Conclusion

In order for nations to experience a significant reduction in maternal mortality they must increase the percent of births attended by a skilled provider by training physicians, nurses or midwives and increasing access to care. They must also increase the percentage of women using contraceptives by making them affordable, accessible and acceptable. They need to improve adult literacy by investing in education. Reduction in total fertility rate traditionally does not occur until infant mortality rates are low and stable; however, if a nation can reduce the total fertility rate and infant mortality rate, MMRs will also recede. Nations must also work to fight poverty which goes hand in hand with maternal death.

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