PUBLIC HEALTH 128 (2014) 384–387

Available online at www.sciencedirect.com

Public Health

journal homepage: www.elsevier.com/puhe

Short Communication

Women's education level, contraceptive use and maternal mortality estimates

E. Koch [a,b,*], B. Calhoun [c], P. Aracena [a], S. Gatica [a], M. Bravo [a]

[a] Division of Epidemiology, MELISA Institute, Concepción, Chile
[b] Doctoral Program, Division of Epidemiology, School of Public Health, Faculty of Medicine, University of Chile, Santiago, Chile
[c] Department of Obstetrics and Gynecology, West Virginia University School of Medicine, USA

ARTICLE INFO

Article history:
Received 12 September 2012
Received in revised form
24 December 2013
Accepted 14 January 2014
Available online 22 March 2014

Introduction

As part of the Millennium Development Goals proposed by the United Nations, research on maternal mortality estimates and the determinants that positively influence maternal health outcomes is key for adequate evidence-based public health interventions. In the case of maternal death statistics, accuracy of estimating methods strongly depends on the quality of official records[1] and, when unavailable, on the variables used in the predictive model, e.g. total fertility rate (TFR), percentage of childbirth delivery by skilled attendants, women's education level, and per capita income, among others. Thus, a thorough evaluation of the reliability of estimated maternal mortality statistics is warranted before drawing any causal inference.

In this regard, a recent report by Ahmed et al.[2] provided the largest global estimate of the possible effect of contraceptive use on maternal mortality reduction and concluded that the 'use of contraception is a substantial and effective primary prevention strategy to reduce maternal mortality in developing countries'. However, the authors acknowledge important limitations on maternal mortality estimates that call for caution about this causal assumption. In fact, when evaluating any statistical correlation prior to accepting the existence of a direct or independent causal association, the potential role of confounders and third-variables known to influence the outcome of interest, needs to be especially considered.

This short communication compares indirect estimates of maternal mortality ratio (MMR) obtained from three different global reports in terms of their ability to reflect actual statistics, and discusses the role of women's education level as a potential confounder of the inverse correlation between contraceptive use and MMR.

Maternal mortality estimates

An important consideration recognized by Ahmed et al.[2] is that their estimates depended on the quality of underlying data, particularly MMR from the World Health Organization (WHO).[3] As the authors pointed out, the maternal mortality ratio database by WHO has many model-based estimates, which are driven by assumptions about data distribution, imputation of missing data, and relevant covariates. Hogan et al.[4] demonstrated potential problems related to overestimations in the number of maternal deaths, possibly leading to an underestimation of the actual progress in maternal health in several countries.

* *Corresponding author*. MELISA Institute, Dalcahue 1120, Suite 101, Concepción, Chile. Tel.: +56 9 6878 9130.
E-mail addresses: ekoch@melisainstitute.com, elardkoch@gmail.com (E. Koch).

http://dx.doi.org/10.1016/j.puhe.2014.01.008

Maternal mortality estimates in countries with a good quality of vital statistics can illustrate the problem. Table 1 compares actual MMR with the estimates reported by Ahmed et al.,[2] WHO,[3] and Hogan et al.[4] for eight countries of the American continent with acknowledged complete and reliable official data. Estimation models used by Ahmed et al.[2] and WHO[3] were similar, including gross domestic product (GDP) per capita adjusted by purchasing power parity, TFR, and percentage of skilled birth attendance. In addition, while both models were adjusted by HIV/AIDS prevalence,[2,3] Ahmed et al.[2] also included contraceptive use as a new *ad hoc* covariate. On the other hand, Hogan et al.[4] considered TFR, GDP per capita, HIV seroprevalence, neonatal mortality, and age-specific female education as covariates. The percentage of skilled birth attendance was also considered but found to be collinear with neonatal mortality, education and GDP per capita.[4] Significant overestimations have been noted in MMR values estimated by Ahmed et al.[2] (as high as 63.6% for Chile) and by WHO[3] (as high as 100.5% for Mexico) for 2008. On the other hand, Hogan et al.[4] estimations for MMR were more accurate, with the highest overestimation being 27.3% for Chile.

The main difference in the equations used to estimate MMR by Ahmed et al.,[2] WHO,[3] and Hogan et al.[4] is that only the latter authors included the average years of education of the female population and neonatal mortality rates in their predictive model. Thus, it is reasonable to think that differences in accuracy of global estimates of MMR would be related to the inclusion or exclusion of these variables. Moreover, because women's education level may have an antecedent role in maternal and neonatal mortality at a population level, this variable merits further consideration.

Role of women's education level

Women's education level has been consistently identified as a strong predictor of maternal death[5,6] and intermediate variables, such as contraceptive use,[7] utilization of maternal healthcare facilities,[8] and skilled attendance at birth.[9] As illustrated above, neither Ahmed et al.[2] nor WHO[3] considered female education level in their predictive models, contributing to error and making their estimations from official MMR records more imprecise. Moreover, variations in women's education level, neglected in these models, might explain an important part of the inverse correlation between contraceptive use and MMR.

The major role of women's education level modulating other determinants of maternal mortality has been recently highlighted in a natural experiment that analysed parallel time series in Chile year-by-year between 1957 and 2007 using autoregressive models.[6] The Chilean times series data are reanalysed in Fig. 1, to illustrate changes in beta coefficients of seven predictors of MMR (per 100,000 live births) before and after controlling for parallel changes on the average schooling years of the female population of reproductive age. For instance, per each 1% increase of skilled birth attendance, the MMR decreased 2.2 per 100,000 live births each year; however, when the parallel increase in average schooling years was considered, the estimated effect was practically doubled (a decrease of 4.6 per 100,000 live births each year). Conversely, over 80% of the direct relationship between TFR and MMR was explained by changes in the number of years of women's education. Thus, changes in women's education level may increase, decrease or override the impact of other variables in predictive or explanatory models of MMR.

Another interesting result from the Chilean experiment is that the increase in the percentage of first-time pregnancies at advanced ages (30 years old or more) was directly associated with the MMR after controlling for parallel changes in education years. For every 1% increase in the number of primiparous women giving birth at older ages, an increase of 30 maternal deaths per 100,000 live births each year was estimated to occur (Fig. 1). This finding indicates that some causes or correlates of fertility decline may have adverse consequences on maternal health, provoking a 'fertility paradox': when TFR decreases leading to a delayed motherhood it may

Table 1 – Differences in MMR estimates compared to MMR official data in eight American countries with complete statistics registries of maternal deaths for 2008.

Country	Actual MMR[a]	Ahmed et al.		WHO report		Hogan et al.	
		MMR[b]	Error (%)	MMR[c]	Error (%)	MMR[d]	Error (%)
Canada	9	7	−22.2	12	+33.3	7	−22.2
Chile	16.5	27	+63.6	26	+57.6	21	+27.3
United States	18.7	13	−30.5	24	+28.3	17	−9.1
Costa Rica	33.3	35	+5.1	44	+32.1	25	−24.9
Cuba	46.5	43	−7.5	53	+14.0	40	−14.0
Argentina	39.7	49	+23.4	70	+76.3	49	+23.4
Mexico	42.4[e]	62	+46.2	85	+100.5	52	+22.6
Colombia	62.8	76	+21.0	85	+35.4	46	−26.8

Actual MMR depicts calculated MMR from maternal deaths and live births extracted from official statistics sources instead of estimations for each country. Error percentages were calculated vis-à-vis between each study and actual MMR data.
Data on MMR was obtained from:
[a] Koch et al.[6]
[b] Ahmed et al.[2]
[c] WHO report.[3]
[d] Hogan et al.[4]
[e] Koch et al.[1]

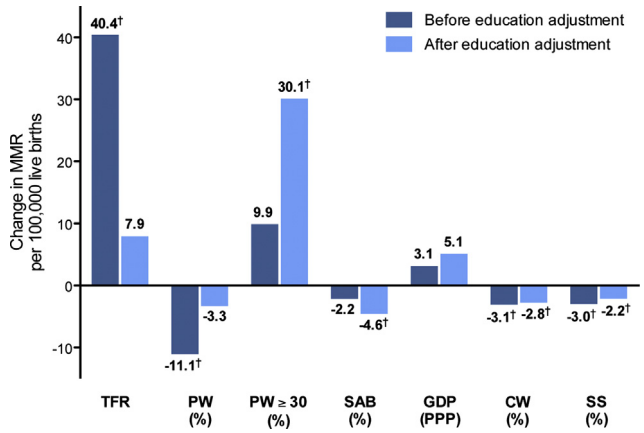

Fig. 1 – Change in beta coefficients of MMR per 100,000 live births each year by unit of change in seven independent variables before (*dark blue*) and after (*light blue*) adjusting for women's education level. TFR is Total Fertility Rate; PW and PW ≥30 is the percentage of Primiparous Women and Primiparous Women ≥30 years of age from the total live births respectively; SAB is the percentage of Skilled Attendance of Birth each year, GDP (PPP) is Gross Domestic Product per capita adjusted by Purchasing Power Parity, CW is the percentage of Clean Water supply coverage, and SS is the percentage of Sanitary Sewer coverage. †P < 0.001 based on autoregressive integrated moving average (ARIMA) models using Chilean data from a 50-years time series study.[6] (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

also have a deleterious impact on maternal health via an increase of the obstetric risk associated with childbearing at advanced ages.[6]

Discussion

The findings described above should draw one's attention to the importance of considering women's education level as a major social determinant when constructing predictive or explanatory models for MMR. It is important to note that correlation should not be immediately translated into direct causation at a population level. Since attained education is acknowledged as an indicator of early life circumstances,[10] it may have a potential antecedent causal role on other intermediate variables of reproductive behaviour in adult life, such as contraceptive use, fertility, and age at first delivery. Without increasing women's education level, the simple availability of maternal health facilities, contraceptives and skilled personnel may be insufficient to decrease maternal deaths. In this sense, increasing education would also be related to a higher knowledge and skills for self-care favouring the utilization of available maternal health facilities, including access to early antenatal care, timely pre-, peri- and postnatal care, and family planning methods.[5–9] In addition, education promotes higher autonomy in women, allowing them to take control of their own fertility using the method of regulation of their preference.

Interestingly, a longer female education may enhance participation of women in the workforce, likely encouraging them to control their own fertility, and potentially leading them to a delayed motherhood. This may result in an increase in the probability of complications and maternal deaths for pre-existing chronic conditions and other indirect causes of maternal morbidity. Thus, an emerging problem in developing nations with low fertility rates, such as Chile, is not how many children a mother has, but when she has them, especially the first child. Moreover, it is plausible that this 'fertility paradox' may have a role in the upward trend of MMR observed in several developed nations over the last decade, an issue that requires further research.

Finally, it is important to remark that when official records of maternal deaths and live births are reliable and readily available, these should be preferred over indirect estimates of MMR. Conversely, when official data are unavailable, estimation models for MMR considering women's education level should be preferred to monitor progress on maternal health in the context of the Millennium Development Goals.

Author statements

This study was conducted on behalf of the Chilean Maternal Mortality Research Initiative (CMMRI).

Ethical approval

None required.

Funding

None declared.

Competing interests

None declared.

REFERENCES

1. Koch E, Aracena P, Gatica S, Bravo M, Huerta-Zepeda A, Calhoun BC. Fundamental discrepancies in abortion estimates and abortion-related mortality: a reevaluation of recent studies in Mexico with special reference to the International Classification of Diseases. *Int J Womens Health* 2012;**4**:613–23.
2. Ahmed S, Li Q, Liu L, Tsui AO. Maternal deaths averted by contraceptive use: an analysis of 172 countries. *Lancet* 2012;**380**:111–25.
3. WHO, UNICEF, UNFPA, The World Bank. *Trends in maternal mortality: 1990 to 2008*. Geneva: World Health Organization; 2010.
4. Hogan MC, Foreman KJ, Naghavi M, Ahn SY, Wang M, Makela SM, Lopez AD, Lozano R, Murray CJ. Maternal mortality for 181 countries, 1980–2008: a systematic analysis

of progress towards Millennium Development Goal 5. *Lancet* 2010;**375**:1609–23.
5. McAlister C, Baskett TF. Female education and maternal mortality: a worldwide survey. *J Obstet Gynaecol Can* 2006;**28**:983–90.
6. Koch E, Thorp J, Bravo M, Gatica S, Romero CX, Aguilera H, Ahlers I. Women's education level, maternal health facilities, abortion legislation and maternal deaths: a natural experiment in Chile from 1957 to 2007. *PLoS One* 2012;**7**:e36613.
7. Nketiah-Amponsah E, Arthur E, Aaron A. Correlates of contraceptive use among Ghanaian women of reproductive age (15–49 years). *Afr J Reprod Health* 2012;**16**:155–70.
8. Simkhada B, Teijlingen ER, Porter M, Simkhada P. Factors affecting the utilization of antenatal care in developing countries: systematic review of the literature. *J Adv Nurs* 2008;**61**:244–60.
9. Mengesha ZB, Biks GA, Ayele TA, Tessema GA, Koye DN. Determinants of skilled attendance for delivery in Northwest Ethiopia: a community based nested case control study. *BMC Public Health* 2013;**13**:130.
10. Koch E, Romero T, Romero CX, Akel C, Manríquez L, Paredes M, Román C, Taylor A, Vargas M, Kirschbaum A. Impact of education, income and chronic disease risk factors on mortality of adults: does 'a pauper-rich paradox' exist in Latin American societies? *Public Health* 2010;**124**:39–48.