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Measuring Maternal Mortality Using Civil Registration Data

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Abstract: Sustainable Development Goal (SDG) target 3.1 aims to reduce the global maternal mortality ratio (MMR) to less than 70 per 100,000 live births by 2030. Part of achieving this goal is having accurate estimates for the maternal mortality ratio. However, producing accurate measures of MMR from well-established civil registration and vital statistics (CRVS) systems remains a problem in the Philippines. In 2017, the World Health Organization (WHO) and the Philippine Statistics Authority (PSA) released two different national estimates of the MMR, indicating an issue on its calculation. With the aim of proposing an official method of estimating MMR in the Philippines, this study explores the use of the Bayesian CRVS adjustment model using civil registration data to improve and standardize the estimation of MMR in the country.

Keywords: Bayesian analysis, vital statistics, official statistics, misclassification, underreporting

1. Introduction:

According to the World Health Organization (WHO), about 810 women a day died in 2017 due to preventable causes related to pregnancy and childbirth (WHO, 2019). These deaths which resulted from complications of pregnancy or childbirth are classified as maternal mortality. The Sustainable Development Goal (SDG) 3 which aims to "ensure healthy lives and promote well-being for all at all ages" addresses this persisting global issue. The formulated strategies of WHO and its partners to end preventable maternal mortality is then adopted to SDG Target 3.1 which is to reduce global maternal mortality ratio (MMR) to less than 70 per 100,000 live births by 2030.

Although these targets for reducing maternal mortality exists, the problem of not having accurate measures of maternal mortality remains. Maternal mortality has many data sources - the Civil Registration System, Household Surveys, Sisterhood Method, Reproductive-age Mortality Studies (RAMOS), and Census (WHO, 2015). However, there are still countries which have not yet established systems for accounting MMR. The implementation of the Civil Registration and Vital Statistics (CRVS) system in other countries are still riddled with issues on reporting errors such as incompleteness of available information or misclassification of the cause of death.

In the Philippines, the civil registration practices are implemented in a way that it is adaptive and flexible to the various cultures present in the country. For instance, the requirement of having a first and last name is relaxed for the indigenous populations who typically give only one name to children. Furthermore, the Philippines being an archipelago posts as a challenge in providing civil registration of the population and recording fatalities in distant communities. This is proven by the low levels of registration in Geographically Isolated and Disadvantaged Areas (GIDA), which includes mountainous regions and islands. Further, large under-registration rates are found among Muslim and indigenous population groups due to their religious and societal traditions and beliefs.

According to WHO, the global MMR in 2017 is estimated at 211 deaths per 100,000 live births, showing a 38% reduction since 2000. WHO estimated the Philippines' MMR at 121 deaths per 100,000 live births. On the other hand, the Philippine Statistics Authority (PSA) estimated the MMR for that same year at 87.3 deaths per 100,000 live births. For PSA, the biggest hindrance in generating estimates of MMR in the country is the underreporting and the misclassification of maternal deaths. These cause data quality problems and gravely affect the estimates PSA generates. PSA uses the CRVS and the household surveys in generating data for the MMR.

With this in mind, the Philippine Statistical Research and Training Institute aims to help improve the reliability and accuracy of the MMR in the Philippines by reviewing the current methodology of its computation and proposing methods for its enhancement. In particular, this study aims to:

a. Review the current methodologies used to measure the national Maternal Mortality Ratio of the Philippines;
b. Review other possible methodologies in measuring maternal mortality; and
c. Propose a localized methodology for the enhancement of measuring MMR in the Philippines.

2. Methodology:

The first part of the study was mainly dedicated to the review of several literatures that delved on maternal mortality. This consisted of reviewing how maternal mortality ratio is being measured in the Philippines and how it is being measured in other countries. For the local review, coordination and meetings with the PSA were done to acquire the framework and methodology used in measuring and computing the national MMR. This also included expounding on various data sources. As for the international setting, it was important to review methodologies employed by other countries and see whether it can be localized in the country. The review of literature was ultimately done in order to propose an appropriate methodology to enhance the measurement of the Maternal Mortality Ratio in the Philippines.

For the second part of the study, a localized methodology was proposed which was based on the different methodologies reviewed. An international method was chosen and was tweaked so that it may be appropriate for the Philippine setting. Part of this is ensuring that the needed data for the method is available or can be made available to the country.

Lastly, the proposed methodology has to be validated and checked whether it provides reliable estimates to the parameter. The validation results must also be presented to the stakeholders, particularly to PSA, to get their approval for its implementation. Due to restraints, the last part of this study has not yet been done but is planned to be executed by this year as well.

3. Result

The World Health Organization (WHO) defined Maternal Mortality as the death of a woman while pregnant or within 42 days of termination of pregnancy, 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 unintentional or incidental causes. Similarly, the Philippine Statistics Authority (PSA) defined MM as the number of women who died for the reasons of pregnancy, childbirth, and the puerperium, to the number of reported live births in a given year, expressed as the number of maternal deaths per 100,000 live births. The Maternal Mortality Ratio (MMR) is generally regarded as the preferred measure of maternal mortality because it describes the frequency of maternal death relative to its risk pool, as measured by the number of live births (Wilmoth, et. Al., 2012).

Across countries, there are other measures of maternal mortality. Examples of which are the maternal mortality rate (MMRate) - the number of maternal deaths divided by person-years lived by women of reproductive age in a population, and the proportion maternal (PM) - the proportion of deaths among women of reproductive age that are due to maternal causes. The PM is calculated as the number of maternal deaths in a given time period divided by the total deaths among women aged 15-49 years in that time period (WHO, 2019).

There are various possible sources of data on maternal mortality. Table 1 shows its summary.

Table 1. Different Data Sources for Maternal Mortality

DATA SOURCE FOR MATERNAL MORTALITY	DESCRIPTION
Civil Registration System	-involves routine registration of births and deaths -offers cause-specific estimate of maternal mortality -prone to maternal mortality underestimation due to bad data quality
Household Survey	-maternal mortality data can be obtained from National Demographic Health Surveys, Family Planning Survey, and Family Health Surveys of a country -usually identifies death associated with pregnancy and not maternal death -requires large sample size yet results could still be uncertain due to wide confidence intervals -can make us of special methods such as the Sisterhood method or the Reproductive-age Mortality Surveys
Sisterhood method	-embedded in household surveys to obtain information about the survival of all their adult sisters (to determine the number of ever-married sisters, how many are alive, how many are dead, and how many died during pregnancy, etc.) -usually identifies pregnancy-related deaths rather than maternal deaths
Reproductive-age Mortality Survey	-involves identifying and investigating the causes of all deaths of women of reproductive age in a defined area or population, by using multiple sources of data (e.g. interviews with family members)
Census	-procedure of systematically acquiring and recording information about the members of a given population -has no sampling errors and a well-developed formal assessment technique -usually held only every 5 years which limits monitoring maternal mortality

Despite the many sources of data for maternal mortality, many studies claimed that there is an issue of underreporting in maternal mortality due to misclassification and incomplete death registration. Underreporting is fairly present in almost all countries. In the Philippines, the large under registration rates are found among Muslim and indigenous population groups due to their religious and societal traditions and beliefs. However, civil registration practices are implemented in a way that is adaptive and respects various cultures so that the CRVS in the Philippines is flexible to the various cultures present in the country. For example, provisions are in place to facilitate death registration for deceased Muslims who must be buried within 24 hours of the time of death (DOH, 2014).

The persisting problem of underreporting gave rise to the need to improve the measurement of maternal mortality. Hence, the United Nations Maternal Mortality Estimation Inter-Agency Group (UN MMEIG) was formed to share data on maternal mortality, harmonize estimates within the UN system, improve methods for maternal mortality estimation and generate internationally comparable MMR estimates. Their data sources include the CRVS, data from surveillance sites or systems, population-based surveys,

and census. Other data inputs to the model include deaths of women 15-49 years and AIDS-related mortality, live births data, Gross Domestic Product (GDP) per capita measured in purchasing power parity (PPP), GFR, health surveys, and database jointly maintained by WHO and UNICEF.

There were two models used by UN MMEIG for different purposes. First is the Bayesian *CRVS adjustment model* used to account for errors in reporting of maternal death in the CRVS to obtain the CRVS adjustment factors. Second is the Bayesian maternal mortality estimation model (BMat Model) used to estimate the MMR for each country-year of interest.

For the first model, it is said that the CRVS reported maternal deaths are subject to potential error due to missed/unregistered maternal deaths and/or misclassification of maternal deaths within the CRVS. Therefore, an adjustment factor is obtained for CRVS data before it can be included in the BMat model. The CRVS model obtains estimates of sensitivity and specificity for all country-years with CRVS data. Based on these estimates, corresponding estimates of the adjustment factor for country-years with complete CRVS can be obtained. Estimation and projection of maternal mortality indicators can be undertaken using the BMat model. This model is intended to ensure that the MMR estimation approach is consistent across all countries but remains flexible. It based in co-variate-driven trend to inform estimates in countries or country-periods with limited information, captures observed trends in countries with longer time series of observations, and takes into account the differences in stochastic and sampling errors across observations.

Based on this, the researchers arrived at the decision to localize the formula of the CRVS model to estimate the number of true maternal deaths in the CRVS. The empirical method of estimating the completeness of death registration has the difficulty of disaggregating since the model is about the whole death registration. For the BMat Model, the variables are already available in the National Demographic Health Survey (NDHS) of the Philippines. However, the NDHS needs a large sample size for it to be routinely used. Thus, the researchers want to focus on the Bayesian CRVS adjustment model.

The CRVS model was based from a study of Peterson, et. al, where they developed a Bayesian bivariate random walk model to estimate sensitivity and specificity of the reporting on maternal mortality in CRVS data, and associated CRVS adjustment factors. This was fitted to a global data set of CRVS and specialized study data. This new model is now used by the UN MMEIG to account for misclassification errors when estimating maternal mortality using CRVS data.

Peterson, et al. defined the CRVS adjustment factor $\left(CRVSadj_{c,t}\right)$ based on estimates of sensitivity $\left(\lambda_{c,t}^{(+)}\right)$ and specificity $\left(\lambda_{c,t}^{(-)}\right)$, which varies with the true PM ($p_{c,t}^{truemat}$) , as follows:

$$CRVSadj_{c,t} = \frac{p_{c,t}^{truemat}}{\lambda_{c,t}^{(+)} \cdot p_{c,t}^{(truemat)} + \left(1 - \lambda_{c,t}^{(-)}\right) \cdot \left(1 - p_{c,t}^{(truemat)}\right)}$$

Using this model, the researchers came up with a computation method that will be apt for the Philippine setting. Assuming that the National Demographic Health Survey (NDHS) of the Philippines is the true population for maternal death, the following steps were constructed to estimate the CRVS adjustment factor and be able to compute the proportion of maternal deaths in the Philippines. It is important to note that these stages considered the data availability of the country. Subscripts *world, c* for country, and *t* for time will be disregarded since this will focus only on the Philippine setting.

Stage 1: Randomly select the hyper parameters

$$\lambda_{world}^{(+)} \sim U(0.1, 1)$$
$$\lambda_{world}^{(-)} \sim U(0.995, 1)$$

Stage 2: Once selected, transform the hyper parameters using the eta

$$\eta_{c,t}^{(+)} = \log\left(\frac{\lambda_{world}^{(+)} - 0.1}{1 - \lambda_{world}^{(+)}}\right)$$
$$\eta_{c,t}^{(-)} = \log\left(\frac{\lambda_{world}^{(-)} - 0.95}{1 - \lambda_{world}^{(-)}}\right)$$

Stage 3: Plug-in eta value to the normal distribution to get the prior value

$$\begin{bmatrix}\eta_{c,t_c}^{(+)} \\ \eta_{c,t_c}^{(-)}\end{bmatrix} \sim N_2\left(\begin{bmatrix}\eta_{world}^{(+)} \\ \eta_{world}^{(-)}\end{bmatrix}, \begin{bmatrix}\sigma^{(+)^2} & \rho\cdot\sigma^{(+)}\cdot\sigma^{(-)} \\ \rho\cdot\sigma^{(+)}\cdot\sigma^{(-)} & \sigma^{(-)^2}\end{bmatrix}\right)$$

Stage 4: Get the prior value - f(x)

$$f(x|y) \propto L(y|x)f(x)$$

Stage 5: Set up the likelihood function evaluated at the eta

Stage 6: Transform the eta to get the lambda

$$\eta_{world}^{(+)} = \log\left(\frac{\lambda_{world}^{(+)} - 0.1}{1 - \lambda_{world}^{(+)}}\right)$$
$$\eta_{c,t}^{(-)} = \log\left(\frac{\lambda_{world}^{(-)} - 0.1}{1 - \lambda_{world}^{(-)}}\right)$$

Stage 7: Randomly select the $\gamma_{c,t}^{truemat}$

$$\gamma_{c,t}^{(truemat)} \sim U(0,1)$$

Stage 8: Calculate the remaining gammas

$$\gamma_{c,t}^{(T+)} = \lambda_{c,t}^{(+)} \cdot \gamma_{c,t}^{(truemat)}$$
$$\gamma_{c,t}^{(F-)} = \gamma_{c,t}^{(truemat)} - \rho_{c,t}^{(T+)}$$
$$\gamma_{c,t}^{(T-)} = \lambda_{c,t}^{(-)} \cdot \left(1 - \gamma_{c,t}^{(truemat)}\right)$$
$$\gamma_{c,t}^{(F+)} = \left(1 - \gamma_{c,t}^{(truemat)}\right) - \rho_{c,t}^{(T-)}$$

4. Discussion and Conclusion:

From the results of the review, improving the measurement of maternal mortality is an important endeavour across the globe. Despite the several data sources for maternal mortality, several countries face the problem of underreporting which offshoots countries' estimates of their national maternal mortality. With this, gave the development of models that address this problem.

The UN MMEIG provided two models that can help the issue of underreporting and upon scrutiny, the CRVS model was deemed as a timelier choice to be applied to the Philippine setting. The researchers were able to come up with a step by step procedure on how to implement this model which accounted for the availability of the data in the country.

Now, although the model was taken from a reputed institution and is possible to be implemented in the Philippines, it still needs to be validated through data testing. Unfortunately, this study was not able to run validation tests by applying the model to Philippine data and comparing the estimates generated by this model to the MMR statistics provided before by the PSA. This is the recommended next step for this study. Once the model has been applied to previous data, comparison tests may be conducted and the results of which can be presented to stakeholders, especially the PSA.

Overall, the study brushed through maternal mortality, how it is measured currently, and the possible ways it can be improved. The results provided a possible model that can help improve the current methodology in computing the MMR. Testing the proposed model and comparison tests are next in line to this study. All of these are the steps that can ultimately help improve the measurement and monitoring of maternal mortality in the country.

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