Maternal mortality estimation at sub-national level with empirical Bayes method: an illustration of district level MMR estimates in Bangladesh

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Summary

The estimation of maternal mortality ratio (MMR) is notoriously difficult even at a national level in developing countries, and it is not surprising that few countries have attempted ever to estimate MMR at sub-national smaller geographic domains. Studies suggest that maternal mortality is more pronounced among poorer segments of population, in rural areas and in areas where maternal care service availability and utilization are lacking, and exploiting such *a priori* knowledge about the determinants of maternal mortality, we propose to use empirical Bayes prediction method to estimate maternal mortality at sub-national level from the spatial distribution of such factors in the area. This work is influenced by the literature of small area estimation (SAE) methods based on generalized linear mixed models. We illustrate an example of MMR estimation in 64 districts of Bangladesh with the data from Bangladesh Maternal Morbidity and Mortality Survey (BMMS), 2001. BMMS estimated MMR of 382 per 100,000 live births (direct method). Our empirical Bayes estimates show that MMR ranged from 160 to 1055 per 100,000 live births at district levels in Bangladesh. Maternal mortality is more pronounced in the eastern and coastal regions. These areas are known to be culturally conservative, have poor transportation systems, and high neonatal and child mortality rates. The results of the study would benefit health administrators and policy planners in prioritizing and targeting the high mortality areas.

Extended Abstract

The Millennium Development Goal-5 (MDG-5) aims to reduce maternal mortality ratio by three-quarters between 1990 and 2015. An extremely difficult challenge for monitoring progress towards MDG-5 and evaluating safe mother initiatives is estimating maternal mortality. An accurate estimation of maternal mortality is notoriously difficult in developing countries, primarily because complete vital registration systems are absent. Globally, only 13% of births are covered by vital registration systems.

In the absence of complete vital registration with good attribution of causes of deaths, the most commonly employed methods for maternal mortality estimates are household surveys with direct death inquiry, indirect and direct sisterhood methods, and reproductive age mortality surveys (RAMOS). For the countries where no data are available on maternal mortality, regression based methods are used to estimate maternal mortality. Of the 198 countries and territories included in the WHO's study for estimating maternal mortality in 1990, 114 countries (57.6%) had no data available on maternal mortality or could be calculated be with the regression method. Little improvements in data availability occurred subsequent in the estimation of maternal mortality by WHO. There are several reasons for such failures to provide a national level maternal mortality statistics. Maternal mortality is a rare event in a statistical sense, and requires a very large sample size for conducting a household survey for a reliable estimate with a reasonable margin of confidence.

As an example, Bangladesh Maternal Health Services and Maternal Mortality Survey (BMMS, 2001) estimated a targeted sample of 104,323 households for measuring national level maternal mortality and costs about $US 1 million.[11] Even from such a large survey, the estimation of MMR at sub-national geographical areas is not feasible.

Several authors suggest using process indicators such as the percentage of births attended by skilled providers as proxy for maternal mortality. However, process indicators are problematic as proxies for maternal mortality estimates. In Asia, 34% of deliveries are attended by skilled birth attendants (SBA) and the maternal mortality ratio is estimated to be 540. In contrast, in Sub-Saharan Africa about 35% of the deliveries are attended by a SBA, but the MMR is almost twice than that of Asia (920 per 100 000 live births). The process indicators are not necessarily proportionally related to maternal mortality.

Graham et al. proposed the indirect sisterhood method in late 1980s, primarily to overcome the needs of large sample size in household surveys, and several developing countries adopted the method. In this method, the female respondents are asked about the survival status of their siblings, and in case of a sister's death, the timing of death in relationship to pregnancy status of the index sister. By piggybacking on existing surveys, the cost of maternal mortality estimation is generally low. However, sisterhood method is not suitable for sub-national MMR estimates (no information is available on the location where sister died).

Some studies based on RAMOS and through case-finding approaches attempted to estimate sub-national MMR. However, RAMOS and such census-based approaches are

very expensive and often not feasible. In this paper we propose a model based approach where we exploit the areal distribution of population characteristics and contextual factors in predicting MMR in the area. This work This work is influenced by the literature of small area estimation (SAE) methods based on generalized linear mixed models.

Data from the Bangladesh Maternal Health Services and Maternal Mortality Survey (BMMS), 2001 are used for this analysis. The BMMS is a nationally representative survey of 103,796 ever-married women of reproductive age. Household questionnaire inquired about the deaths for all women and their pregnancy status at the time of death. Our analysis used the direct maternal mortality estimation method (Hill, 2006). There 64 districts in Bangladesh. We estimated maternal mortality ratios and rates for 64 districts from the empirical Bayes estimates after fitting a generalized linear mixed model with log link (Poisson model) with the following covariates: socio-economic status, urban-rural residence, skilled birth attendance at delivery, distance of hospital from the household area, and time to travel to the hospital. Table 1 shows the MMR estimates for the 64 districts. MMR was lowest in Dhaka district, the capital of Bangladesh (160 per 100,000 live births), and highest in Sylhet (1055 per 100,000 LB). The spatial distribution of MMR is shown in Fig. 1. Geographically, maternal mortality was most pronounced in the districts of Sylhet and Chittagong divisions in coastal areas.

A comparison of our results with an earlier study in Bangladesh (Rahman et al, 2002) which utilized case-finding approach to identify deaths through hospital and community

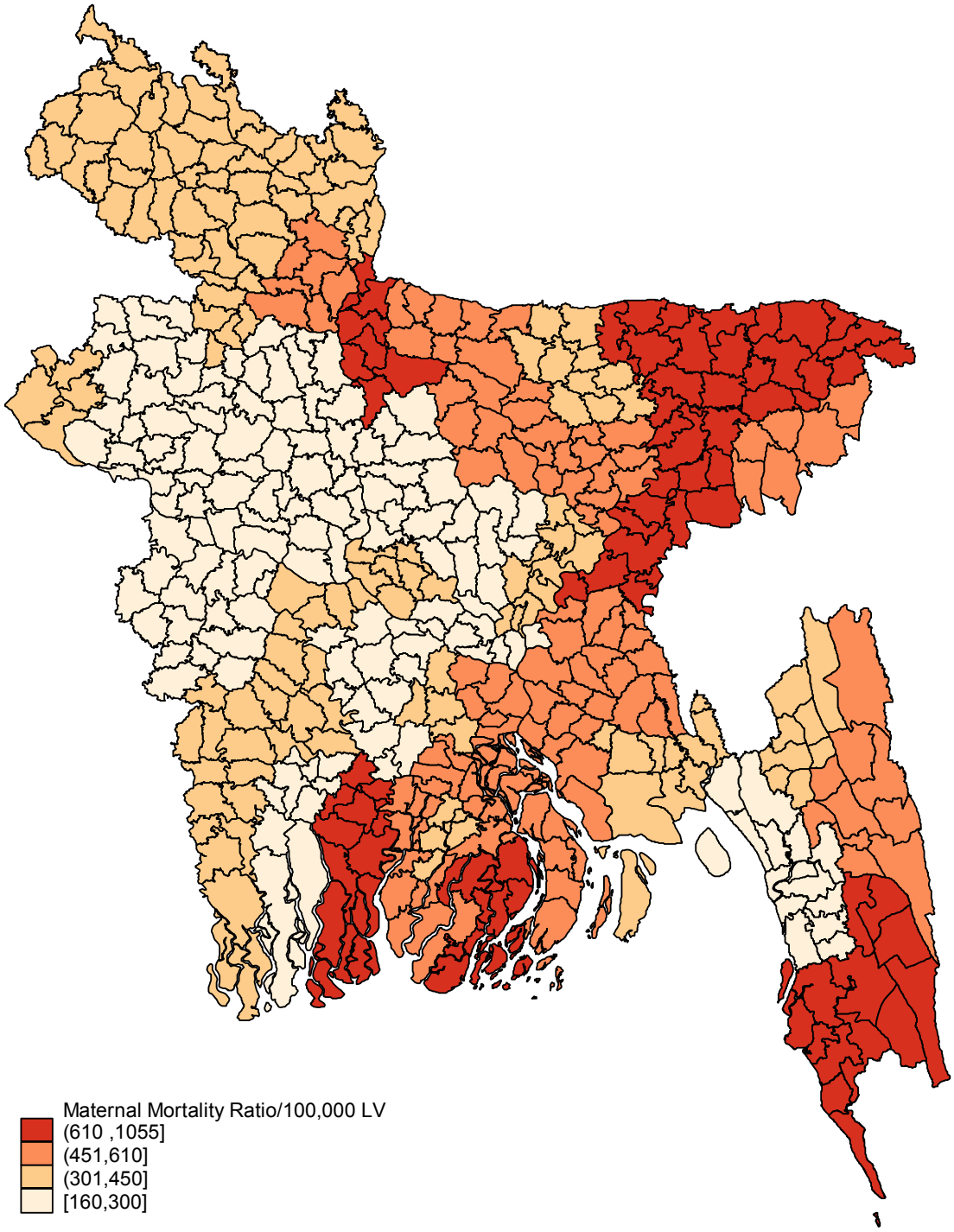
auditing (Appendix-I) shows remarkable similarities in spatial distribution of maternal deaths.

Table 1: Maternal mortality estimates from 64 districts in Bangladesh.

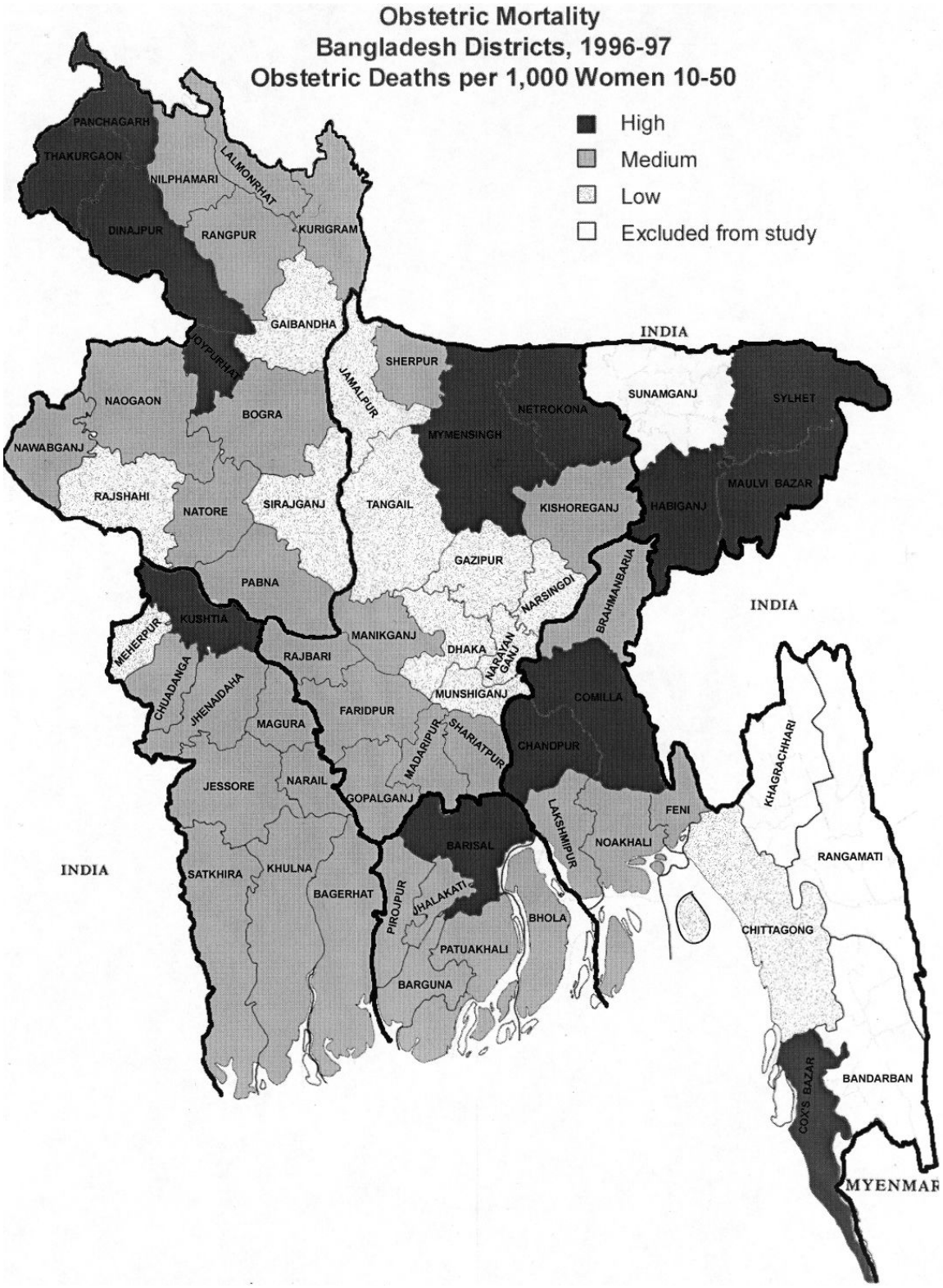
District	MMR/100,000 LB	District	MMR/100,000 LB	Rank
Alphabetical order		Rank order		
BAGERHAT	747	DHAKA	160	1
BANDARBAN	780	RAJSHAHI	193	2
BARISAL	473	TANGAIL	195	3
BHOLA	610	BOGRA	247	4
BOGRA	247	MUNSHIGANJ	247	5
BORGUNA	457	MEHERPUR	256	6
BRAHMANBARIA	763	CHITTAGONG	261	7
CHANDPUR	517	KUSHTIA	265	8
CHAPAI NAWABGANJ	327	GAZIPUR	270	9
CHITTAGONG	261	KHULNA	280	10
CHUADANGA	287	CHUADANGA	287	11
COMILLA	461	PABNA	288	12
COX'S BAZAR	887	FARIDPUR	292	13
DHAKA	160	NATOR	292	14
DINAJPUR	370	GOPALGANJ	295	15
FARIDPUR	292	SIRAJGANJ	300	16
FENI	325	NAOGAON	300	17
GAIBANDHA	475	JHENAIDAH	301	18
GAZIPUR	270	JESSORE	310	19
GOPALGANJ	295	JOYPURHAT	316	20
HABIGANJ	844	MANIKGANJ	317	21
JAMALPUR	623	NARAYANGANJ	323	22
JESSORE	310	FENI	325	23
JHALAKATI	451	CHAPAI NAWABGANJ	327	24
JHENAIDAH	301	NARSINGDI	328	25
JOYPURHAT	316	LALMONIRHAT	336	26
KHAGRACHHARI	436	NOAKHALI	337	27
KHULNA	280	PANCHAGAR	341	28
KISHOREGANJ	482	KURIGRAM	348	29
KURIGRAM	348	RAJBARI	355	30
KUSHTIA	265	THAKURGAON	367	31
LAKSMIPUR	473	DINAJPUR	370	32
LALMONIRHAT	336	NILPHAMARI	372	33
MADARIPUR	403	NARAIL	381	34
MAGURA	386	MAGURA	386	35
MANIKGANJ	317	SATKHIRA	400	36
MEHERPUR	256	MADARIPUR	403	37

MOULVI BAZAR	492	RANGPUR	413	38
MUNSHIGANJ	247	NETRAKONA	426	39
MYMENSINGH	524	KHAGRACHHARI	436	40
NAOGAON	300	JHALAKATI	451	41
NARAIL	381	BORGUNA	457	42
NARAYANGANJ	323	SHERPUR	458	43
NARSINGDI	328	COMILLA	461	44
NATOR	292	SHARIATPUR	472	45
NETRAKONA	426	BARISAL	473	46
NILPHAMARI	372	LAKSMIPUR	473	47
NOAKHALI	337	GAIBANDHA	475	48
PABNA	288	KISHOREGANJ	482	49
PANCHAGAR	341	MOULVI BAZAR	492	50
PATUAKHALI	696	PIROJPUR	500	51
PIROJPUR	500	RANGAMATI	512	52
RAJBARI	355	CHANDPUR	517	53
RAJSHAHI	193	MYMENSINGH	524	54
RANGAMATI	512	BHOLA	610	55
RANGPUR	413	JAMALPUR	623	56
SATKHIRA	400	PATUAKHALI	696	57
SHARIATPUR	472	BAGERHAT	747	58
SHERPUR	458	BRAHMANBARIA	763	59
SIRAJGANJ	300	BANDARBAN	780	60
SUNAMGANJ	795	SUNAMGANJ	795	61
SYLHET	1055	HABIGANJ	844	62
TANGAIL	195	COX'S BAZAR	887	63
THAKURGAON	367	SYLHET	1055	64

Fig. 1: Maternal Mortality Ratio (MMR) estimates in Bangladesh



Appendix-1:



Source: Rahman *et a1*. 2002