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A Low-Cost, Community Knowledge Approach to Estimate Maternal and Jaundice-Associated Mortality in Rural Bangladesh

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Abstract. In the absence of a civil registration system, a house-to-house survey is often used to estimate cause-specific mortality in low- and middle-income countries. However, house-to-house surveys are resource and time intensive. We applied a low-cost community knowledge approach to identify maternal deaths from any cause and jaundice-associated deaths among persons aged ≥ 14 years, and stillbirths and neonatal deaths in mothers with jaundice during pregnancy in five rural communities in Bangladesh. We estimated the method's sensitivity and cost savings compared with a house-to-house survey. In the five communities with a total of 125,570 population, we identified 13 maternal deaths, 60 deaths among persons aged ≥ 14 years associated with jaundice, five neonatal deaths, and four stillbirths born to a mother with jaundice during pregnancy over the 3-year period before the survey using the community knowledge approach. The sensitivity of community knowledge method in identifying target deaths ranged from 80% for neonatal deaths to 100% for stillbirths and maternal deaths. The community knowledge approach required 36% of the staff time to undertake compared with the house-to-house survey. The community knowledge approach was less expensive but highly sensitive in identifying maternal and jaundice-associated mortality, as well as all-cause adult mortality in rural settings in Bangladesh. This method can be applied in rural settings of other low- and middle-income countries and, in conjunction with hospital-based hepatitis diagnoses, used to monitor the impact of programs to reduce the burden of cause-specific hepatitis mortality, a current World Health Organization priority.

INTRODUCTION

Globally, there are approximately 303,000 maternal deaths annually, most of which occur in low- and middle-income countries.[1] In Bangladesh, the estimated maternal mortality ratio (MMR) declined by about 40% from 322 in 2001 to 194 in 2010.[2] However, the 2010 estimate is considerably higher than the United Nations Sustainable Development Goal of an MMR less than 70 by 2030.[3] A recent secondary analysis of verbal autopsy data in Bangladesh found that 19–25% of maternal deaths had jaundice symptoms and 7–13% of neonatal deaths occurred among babies born to women with symptoms of jaundice.[4] The jaundice was thought to be associated with hepatitis E virus in pregnancy.[4] Hepatitis E, predominately spread by the fecal-oral route, is a common cause of hepatitis worldwide, and pregnant women are the most vulnerable groups with a reported case fatality of 10–25%.[5–7] In many low- and middle-income countries, including Bangladesh, there are no population-based estimates of mortality associated with hepatitis. Alhtough medical certificates through civil registration systems are the ideal solution to generate high-quality data on cause of death,[8] in many resource-constrained settings, such systems are not feasible. In 2015, the World Health Organization (WHO) adopted the first global strategy to eliminate hepatitis as a public health threat by 2030,[9] however, without good estimates of disease burden, it is not possible to track progress.

In the absence of civil registration systems, the verbal autopsy method—where the cause of death is ascertained by interviewing family members and caregivers of decedents—is an alternative method for generating cause of death data.[10] When obtaining cause of death estimates, all households in a sampled area are contacted through a house-to-house survey and a verbal autopsy questionnaire is administered if any member of the household had died within the reference period. For rare events, such as maternal and jaundice-associated deaths, however, a large sample size is required to estimate deaths with sufficient precision.[11,12] Despite surveying more than 175,000 households in the 2010 Bangladesh Maternal Mortality Survey, the MMR estimate remained imprecise (MMR = 194; 95% confidence interval: 149–238).[2]

Because house-to-house surveys are resource and time intensive, several alternative methods have been proposed.[13–18] Most of these methods focus on estimating maternal mortality by setting up formal group discussions with key informants, for example, health workers, community leaders, and religious leaders. The success of these methods depends on identifying and interviewing a sufficient number of key informants.[13,14,17,19] The reported sensitivity of these methods ranged from 84% to 100% for maternal deaths[16,18] and 28% to 81% for other causes of death in comparison with house-to-house surveys.[16,20] These findings highlight the need for alternative low-cost methods with high sensitivity.

In many low- and middle-income countries, people in rural communities actively discuss community events, such as deaths, and therefore are generally able to report any serious events experienced by their neighbours.[21] We earlier took advantage of this strong community knowledge to identify patients with severe illness in the rural communities of Bangladesh.[21–23] In this study, we adapted this community knowledge approach to identify maternal and jaundice-associated deaths in rural communities and estimated its

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sensitivity and cost savings compared with the house-to-house survey approach.

METHODS

Study population and sites. This study is a part of a larger project in Bangladesh, where mortality associated with hepatitis E is being estimated by combining hospital-based hepatitis E surveillance data and mortality survey data collected through the community knowledge approach in 91 unions (the smallest level administrative area in Bangladesh with an average population of 26,000 people[24]) in the catchment area of six surveillance hospitals. We randomly selected five rural unions from the catchment area of two hospitals (two unions near Jahural Islam Medical College Hospital, Kishoreganj, and three near Shaheed Ziaur Rahman Medical College Hospital, Bogra) to compare the community knowledge survey and house-to-house survey methods. Unions typically consist of 19–20 villages,[24] which consist of a number of *paras* (neighborhoods) that are composed of a group of *baris* (household compounds consisting of six to seven households).[25,26]

In both the community knowledge and house-to-house surveys, we estimated 1) maternal deaths from any cause; 2) stillbirths and neonatal deaths born to a mother with jaundice during pregnancy; and 3) deaths associated with jaundice among men and nonpregnant women aged at least 14 years. However, to identify the target deaths, we recorded all stillbirths, neonatal deaths, and deaths aged at least 14 years in the study areas during the 3-year time period. Maternal death was defined as the death of a woman while pregnant or within 42 days of termination of pregnancy from any cause but not from unintentional injuries or incidental causes (causes not related to pregnancy).[27] Neonatal death was defined as a death during the first 28 days of life, and stillbirth was defined as a baby born to a mother without signs of life. Jaundice-associated death was defined as having a new onset of either yellow eyes or skin during illness preceding death.

Mortality survey using community knowledge approach. The mortality survey using community knowledge approach was conducted in the catchment area of Jahural Islam Medical College during October–November 2014 and in the catchment area of Shaheed Ziaur Rahman Medical College Hospital during October 2016–January 2017. Two field teams, each comprised four data collectors and one field supervisor, worked to identify deaths in the study sites. One field team was assigned to each union and one field research assistant was assigned to each village. The team followed a standard procedure to identify deaths using the community knowledge approach (Figure 1). The team first visited the villages' markets and tea stalls (key gathering points in rural Bangladesh). By talking with the people gathered there they were able to draw a map of the village, including village roads, important locations, such as schools, mosques, and health posts, village *paras* and some influential *baris* and prepared a list of all *baris* in the village.

The team then asked the gathering about deaths in the previous 3 years for each listed *bari*. In addition to all-cause deaths, the team asked specifically about maternal deaths and people who had jaundice at the time of death. As a check on data completeness, the team determined whether the number of deaths identified using the community knowledge approach was at least 80% of the probable number of deaths in the village in the previous 3 years, calculated by multiplying the village population estimate from the 2011 population census by the crude death rate in rural Bangladesh of six per 1,000 persons per year.[24,28] If the number of deaths was fewer than 80% of the probable number of deaths, the team checked the list with another group of village residents, and repeated the aforementioned procedure. The team also asked people

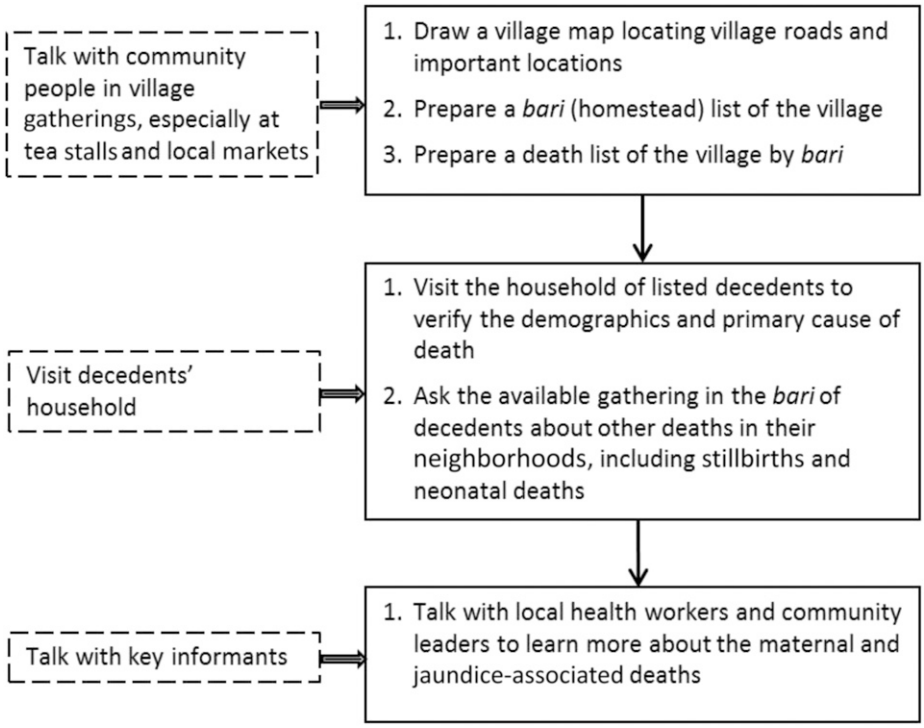

FIGURE 1. Steps involved in the mortality survey using community knowledge approach.

who were gathered at markets and tea stalls about key informants (local government health workers, village doctors, traditional healers, birth attendants, religious leaders, and people involved with funeral ceremonies), that is people who were likely to be well-informed about deaths in their community.

The team then visited the households of each of the decedents in the list of deaths and verified the primary cause of death by talking with the family members. They specifically asked if the patients had yellow eyes or skin in the illness preceding death, or if the patient died during pregnancy or within 42 days of pregnancy. For stillbirths and neonatal deaths, they asked if the mother had yellow eyes or skin during pregnancy. The team recorded the name of the decedents and their basic demographic information, including age and gender. For maternal and jaundice-associated deaths, the team additionally recorded their residential address and sought written consent from the caregivers of the decedents to administer a full-length WHO verbal autopsy questionnaire to collect detailed information on signs and symptoms preceding death.[10] In addition to verification of the listed deaths, the team asked the residents of that *bari* about any other deaths in neighboring *baris* and updated the list accordingly. The team also asked the *bari* residents, especially the women, if they knew any women in their locality who had jaundice during pregnancy and experienced a stillbirth or whose baby died within a month of delivery. This procedure was continued for all deaths listed in the village. In addition, the team met with the key informants, who were identified by the village gathering to ask them about the maternal and jaundice-associated deaths in their village. If the village population exceeded 2,000 people, the team divided the village into two to three parts and applied the same procedure in each part.

Mortality survey using house-to-house survey approach. In the house-to-house survey, we identified maternal and jaundice-associated deaths that occurred in the same 3-year time frame as the community knowledge survey. The only difference between the two approaches was the method to identify deaths—in the community knowledge approach, mortality data were collected using the community's knowledge about deaths in their neighborhoods, whereas in the house-house survey approach, mortality data were collected by visiting every household.

The house-to-house mortality survey was conducted 12 months after the mortality survey using community knowledge approach in the catchment area of Jahural Islam Medical College and 2 months after the community knowledge survey in the catchment area of Shaheed Ziaur Rahman Medical College Hospital. In the house-to-house survey, the team visited all the households in the study unions and asked the adult family members if there were any maternal deaths, stillbirths, neonatal deaths, and deaths at least aged 14 years in their household during the same, 3-year period used for the community knowledge survey. If any death in the household met these criteria, the team listed the primary cause of death along with their names and basic demographic information. They specifically asked if the households had any maternal deaths, jaundice-associated deaths among men and nonpregnant women aged at least 14 years, and stillbirths and neonatal deaths born to a mother with jaundice during pregnancy in the 3-year time period. For the target deaths (maternal and jaundice-associated deaths), residential address of the decedents was collected in addition to demographic information. However, no verbal autopsies were performed as they had already been conducted as part of the community knowledge survey. If any household was found locked or no adult family member was available at the time of visit, the team visited the household up to three times to attempt to collect death information. If there was any household that migrated to the study areas after the community knowledge survey, the team excluded them from the house-to-house survey.

Evaluation of community knowledge approach. We attempted to match the maternal and jaundice-associated deaths identified in the two surveys individually by using their names, residential addresses, and other demographic information. We calculated the sensitivity of the community knowledge approach to identify maternal and jaundice-associated deaths considering the house-to-house survey to be the gold standard.

Even though enumerating maternal and jaundice-associated deaths was the primary objective of this study, in both surveys we attempted to identify all neonatal deaths, stillbirths and all deaths among residents aged at least 14 years to verify whether the deaths were associated with jaundice or pregnancy. For these deaths, we recorded the names and demographic information of the decedents but did not record the residential addresses. In the villages of Bangladesh, where adult literacy rate is approximately 54%,[29] many people are unable to report their date of birth, and many people are better known by their nickname. Therefore, for other causes of death, it was not possible to match the decedents individually without their residential addresses. Instead, we compared the total number of identified deaths in the two surveys in three broad age-groups: death of persons aged at least 14 years, neonatal deaths and stillbirths.

Comparing the staff time required for the community knowledge method and house-to-house survey. The main cost items of carrying out a survey are staff training, salaries, transportation, and overnight accommodation at study sites. The cost of staff training is a one-time cost and is similar in both survey methods. The expenses for staff salary, transportation, and overnight accommodation are directly related to the person-days required to complete the survey. Therefore, to compare costs we compared the person-days required for the community knowledge approach and the house-to-house survey. Unlike the community knowledge method, the house-to-house survey did not include verbal autopsy interviews for target maternal and jaundice-associated deaths. A verbal autopsy interview required one and a half hours on average, including the time for consenting process, and an interviewer could conduct four verbal autopsy interviews per day. Therefore, to make valid comparisons, we deducted the person-days required for verbal autopsies from the total person-days recorded for the community knowledge method. We calculated the percentage of staff time saved by the community knowledge approach compared with the house-to-house survey using the following formula:

$$\text{Percentage of staff time} = \frac{\text{Person days required for community knowledge survey} - \text{Days required for verbal autopsy}}{\text{Person days required for house-to-house survey}} \times 100$$

Ethical approval. The study protocol was reviewed and approved by the institutional review boards of the International

TABLE 1
Maternal deaths and jaundice-associated deaths identified in house-to-house survey and community knowledge survey in five unions, Bangladesh

Death category	Deaths identified		Deaths matched individually* in both surveys, *n*	Sensitivity of community knowledge method (95% CI)
	Community knowledge method	House-to-house method		
Maternal deaths	13	13	13	100.0 (75.3–100.0)
Deaths among persons aged ≥ 14 years associated with jaundice	60	62	60	96.8 (88.9–99.6)
Neonatal deaths born to mother with jaundice during pregnancy	5	5	4	80.0 (28.4–99.5)
Stillbirths born to mother with jaundice during pregnancy	4	3	3	100.0 (29.2–100.0)

Note: Total population in five unions was 125,570 in 2011 population census.
* Deaths were matched individually by name, gender, age, and residence address.

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RESULTS

Comparing the community knowledge and house-to-house surveys. In the five unions, we identified a total population of 125,570 in 30,504 households. Using the community knowledge approach we identified 13 maternal deaths, 60 deaths among persons aged ≥ 14 years associated with jaundice, five neonatal deaths, and four stillbirths born to a mother with jaundice during pregnancy over the 3-year period before the survey (Table 1). In the house-to-house survey, a total of 450 (1.5%) households were not contactable after three visits and the team identified two additional deaths aged among persons ≥ 14 years that had not been identified using the community knowledge approach but also missed one stillbirth that had been identified using the community knowledge approach. One neonatal death identified in the house-to-house survey did not match individually with the deaths identified in the community knowledge approach. The sensitivity of the community knowledge method for targeted deaths ranged from 80% for neonatal deaths to 100% for stillbirths and maternal deaths (Table 1).

All-cause deaths identified in the community knowledge survey to verify whether the deaths were associated with jaundice or pregnancy included 94% of all-cause deaths among persons aged ≥ 14 years, 66% of all-cause neonatal deaths and 74% of the all-cause stillbirths that were identified through the house-to-house survey (Table 2).

Comparison of staff time required to undertake each survey method. A total of 84 person-days were required to complete the community knowledge survey in the five unions, including performing 82 verbal autopsy interviews. By contrast, the house-to-house survey required 177 person-days without any verbal autopsy interview (Table 3). Hence, the community knowledge approach took 36% of the staff time to undertake compared with the house-to-house survey.

DISCUSSION

The community knowledge approach was highly sensitive in identifying maternal and jaundice-associated deaths in rural communities in Bangladesh and required only one-third of the staff time compared with the house-to-house survey. Because in the community knowledge method, death information was collected from multiple sources, a death missed in one source had the possibility of being captured in another source. Collecting information on additional deaths from people at the decedents' household and from key informants required minimal extra time and resources, as the team was already there to collect data on cause of death.

The community knowledge approach identified 94% of all-cause deaths among persons aged ≥ 14 years but only 66% of all-cause neonatal deaths and 74% of all-cause stillbirths. People may be less informed about neonatal deaths and stillbirths in their community, as observed in other key informant mortality studies.[16] In our study, the team focused primarily on maternal and jaundice-associated deaths when communicating with the community. The sensitivity of identifying all-cause deaths might have been higher if the goal of the study was not restricted to identifying particular causes of death.

In this study, our targeted causes of deaths were maternal deaths and jaundice-associated deaths, and therefore, we identified and verified deaths in both sexes and in a wide range of ages. However, if the target deaths were restricted to maternal deaths, verifying only the deaths in women of reproductive age would be sufficient. Identifying and verifying deaths only in women of reproductive age would further minimize the cost of a maternal mortality survey using the community knowledge approach.

There are a number of study limitations. The house-to-house survey was conducted 2–12 months after the community knowledge survey and the people in the community were asked about deaths in the same 3-year period that was used for the community knowledge survey in each union. The different recall periods in the two surveys may have led to

TABLE 2
All-cause deaths identified by community knowledge survey and house-to-house survey

Death groups	Deaths identified		Percentage of deaths identified by community knowledge method*
	Community knowledge method	House-to-house method	
Deaths among persons aged ≥ 14 years	1,959	2,093	93.6
Neonatal deaths	203	310	65.5
Stillbirths	148	201	73.6

* Percentage was calculated in comparison with house-to-house survey.

TABLE 3
Staff person-days required for the community knowledge survey and the house-to-house survey

Characteristics	Community knowledge method	House-to-house method
Total days required to complete the survey	84	177
Number of verbal autopsy interview conducted	82	–
Days required to perform verbal autopsy interviews*	20	–
Days required without verbal autopsy	64	177

* Considering four verbal autopsy interviews per person-day.

differences in identifying deaths. However, for maternal and jaundice-associated deaths, the team carefully verified the date of death and therefore there is little chance of under reporting or overreporting of these deaths. Furthermore, it is possible that during the gap between the two surveys, especially in the catchment areas of Jahural Islam Medical College Hospital, some households could have migrated out from the study areas and there might have been some deaths among those households. Although the actual proportion migrating out of each study union during the gap between surveys is unknown, the out-migration rate in rural Bangladesh is estimated to be approximately 3.4% of population per year[30]; however, most of these migrations are related to marriage or single household member's movement for work and education.[30,31] Any deaths among migrated family members during the gap between the two surveys should have been reported by other family members in the house-to-house survey, suggesting that any impact on sensitivity due to migration is likely to be low. For all-cause deaths, we could not match the decedents individually identified in the two surveys because we did not collect the residential address of decedents and the family members could not report the date of birth of decedents in many instances. For some death categories, specifically for stillbirths and neonatal deaths, we had few deaths, resulting in wide confidence intervals for the sensitivity estimates. Finally, the community knowledge approach is likely to only be applicable in rural settings because people in urban settings are less likely to maintain tie with neighbours.[32–34]

In conclusion, in the absence of a complete civil registration system the community knowledge method offers a low-cost and highly sensitive alternative to house-to-house surveys for estimating jaundice-associated mortality and all-cause adult mortality in rural settings of low- and middle-income countries. It would specifically be useful in the communities with close social interaction. Many studies in Asia and Africa used the key informant method to identify deaths in rural areas[13,14,17]; the community knowledge approach would be well suited in those settings to identify deaths with high sensitivity. Although the primary goal of this study was to estimate the sensitivity of the method in identifying jaundice-associated deaths, the method was successful in detecting all-cause adult deaths but not all-cause neonatal deaths and stillbirths. Further studies are required to determine the validity of the method for detecting neonatal deaths and stillbirths. Validation of this method is also required in each setting before using it as an alternative of the house-to-house survey. The estimates of jaundice-associated mortality obtained in this study can be used in conjunction with hospital-based diagnoses of hepatitis to calculate population-based estimates of cause-specific hepatitis mortality, including hepatitis E.[21–23] While the heaviest burden of hepatitis rests in low- and middle-income countries,[35] this low-cost survey method could be a valuable tool for estimating true global burden of hepatitis to track progress toward the WHO target of elimination of viral hepatitis by 2030.[7,9]

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