Performance of cause-specific childhood mortality surveillance by health workers using a short verbal autopsy tool

Rakesh Kumar*, Suresh K Kapoor*, Anand Krishnan*

**Background:** The routine use of verbal autopsy in health-care delivery settings has been limited. Hence, the performance of neonatal and post-neonatal verbal autopsy (VA) tools developed at the Comprehensive Rural Health Services Project (CRHSP), Ballabgarh (India), were assessed.

**Methods:** Short VA tools developed by CRHSP were filled by health workers during their routine house visits while standard VA tools of the International Network of Field Sites with continuous Demographic Evaluation (INDEPTH) were filled by trained research workers for all 143 under-five children deaths that occurred in 2008. The level of agreement in the cause of death assigned by the two VA tools was assessed by *kappa* and by comparison of the cause-specific mortality fractions.

**Results:** Among 65 neonatal deaths, the cause specific mortality fraction (CSMF) was 43.1% and 40% for low birthweight, 15.4% and 26.2% for birth asphyxia, and 7.7% and 10.8% for pneumonia by INDEPTH and CRHSP VA tools respectively. In 78 deaths among 29-days to <5-year olds, the CSMF was 29.4% and 26.9% for diarrhoea, and 16.6% each for pneumonia using the INDEPTH and CRHSP VA tools respectively. *Kappa* for most causes of death was more than 0.8, except for birth asphyxia, which had a *kappa* of 0.678.

**Conclusions:** Short VA tools have a satisfactory performance in field settings, which can be used routinely by health workers for filling the gaps in the cause-of-death information in places where medical certification of cause of death is deficient.

**Key words:** Verbal autopsy, neonatal, mortality, child, India.

**Introduction**

Child mortality is a global priority as enunciated by the Millennium Development Goals (MDGs). The target is to reduce the under-five-child mortality by two thirds in each country. Though child deaths are declining the world over, the rate of decline is not enough to achieve the target by 2015.1,2 India has made some progress in reducing child mortality but it is still far from achieving the MDG. Also, there is large regional variability in childhood morbidity and mortality rates.3

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The information on the distribution and trends of the causes of childhood mortality is important to develop effective health policies and for evaluating existing health programmes addressing the issue of childhood mortality. However, this information is lacking in many developing countries. There is considerable lacuna in vital registration as well as in reporting of the cause of death. The vital registration system in India has been estimated to complete in only be 50% of all deaths. Reliable, medically certified cause-of-death data are available only in 14.5% of all registered deaths.

In places where the system of medical certification of cause of death is deficient, verbal autopsy (VA) is an alternative method to ascertain the cause of death. Verbal autopsy is based on the assumption that most causes of death have distinct symptom complexes that can be recognized, remembered and reported by the lay respondents. Various VA tools have been used in different settings to obtain cause-of-death data. The VA tool developed by the International Network of Field Sites with continuous Demographic Evaluation (INDEPTH) is one such standard tool that is used by many demographic surveillance sites. The INDEPTH VA tools have separate questionnaires for neonatal (0-28 days) and postneonatal (29 days - <5 years) mortality. The factors that may affect the validity of a VA include questionnaire design, type of interviewers and respondents, recall period, cause-of-death ascertainment mechanisms and cause-of-death classification.

Verbal autopsies for childhood deaths have been used in research settings, and in surveys on a large sample of the population. Various verbal autopsy tools for childhood mortality have been validated in different settings, but the focus has largely been on methodological issues. Most of the available VA tools require specialized training and need longer time to complete the interview. Consequently the use of verbal autopsy under routine health-care delivery settings has been limited.

A shorter VA tool that takes less time and requires less intense training was developed at the Comprehensive Rural Health Services Project (CRHSP), Ballabgarh (India) in 2002, which was revised in 2007. Keeping in mind the information needed for ascertaining the causes of death, verbal autopsy tools were designed separately for neonatal (0-28 days) and post-neonatal (29 days – <5 years) deaths. While the experience with these tools has been encouraging, the performance of the tools has never been examined. This study was done with the objective of comparing the cause-specific mortality fraction and agreement between CRHSP and INDEPTH VA tools for major causes of childhood mortality.

Methods
This study was carried out from January to December 2008 in the Intensive Field Practice Area of CRHSP, Ballabgarh, which is a field practice area of the All India Institute of Medical Sciences (AIIMS), New Delhi, India, as well as an INDEPTH Health and Demographic Surveillance site. It covers a population of about 86 000 in 28 villages through its two primary health centres (PHCs). Around 2000 live births occur in this area in one year. Health workers make house-to-house visits to provide basic health services. All deaths are routinely reported and verbal autopsies are done by health workers. Assignment of the cause of death is done by the Medical Officer of the PHC.

Verbal autopsy
The CRHSP neonatal and post-neonatal VA tools are used for deaths in the age groups 0 to 28 days, and 29 days to <5 years,
respectively. These tools have seven sections comprising identification detail; narrative regarding the events leading to death; specific questions on symptoms and signs; history of immunization; treatment; and past diseases in the deceased or other family members. The neonatal VA tool, besides an open narrative section, has 52 close-ended questions without having any filter questions, whereas the post-neonatal tool, in addition, has questions on nutrition history, and five modules with one filter question in each. In the 5 modules the number of items range from 5 to 11. The CRHSP tools require minimal training and take approximately 20 minutes to complete.

The INDEPTH neonatal and post-neonatal VA tools are used for all deaths in the age groups of 0 to 28 days, and 29 days to 12 years, respectively. These tools have seven sections comprising background detail of the deceased; background information of the interview; information regarding the informant; open narrative section; signs and symptoms during neonatal period; accidents and injuries; and treatment history. It takes approximately 60 minutes to complete an INDEPTH VA tool.

The INDEPTH VA tools were translated into the local dialect and pretested at Ballabgarh in a non-project village. Subsequently, independent back-translation of the tools was done. The CRHSP VA tools were developed by modifying the earlier versions of the VA tools. An open narrative section was added. These tools were already being used for routine mortality surveillance in the CRHSP area.

Field research assistants were recruited and trained for three days to administer the INDEPTH VA tools. The assistants were female lay workers with previous experience in data collection for health-related projects. They were trained in the interview technique, as well as on the causes of death. Health workers and health supervisors were trained for a day on administering the CRHSP VA tools. Their training was shorter as they were already using these tools.

All deaths that took place in the intensive field practice area of CRHSP, Ballabgarh, among under-five-children during January to December 2008 were included in the study. The verbal autopsy using both tools (CRHSP and INDEPTH) was conducted for all deaths. As a first step, the CRHSP VA tools were filled by health workers. A time gap was kept between the filling of forms and the date of death (over two weeks but not exceeding six weeks for CRHSP VA tools). After a gap of two weeks and within three months of the death, the same families were visited by field research assistants who completed the translated INDEPTH VA tool. Field supervisors verified the details in the INDEPTH VA tool. In the case of the CRHSP VA tool, details were verified by health supervisors after visiting the household. They also checked the forms for completeness.

Assigning the cause of death

Cause of death assignment for the INDEPTH VA tool was done by the medical officer in-charge of the primary health centre. For the CRHSP VA tool, this function was performed by one of the investigators (RK). Subsequently, causes of death were coded as per the International Statistical Classification of Diseases 10th Revision (ICD-10). Medical officers working in PHCs have public health qualifications, and their course work includes ICD coding. During their postgraduation they would also have gained some hands-on experience on assigning the cause of death and coding the diagnoses. Only one physician was used for the purpose of assigning the cause of death, as use of multiple coders does not have any added benefit.
Statistical analysis
Data were entered into Microsoft Excel 2007 and analysed by using the SPSS version 17.0. The cause-specific mortality fractions (CSMF) were calculated as per the ICD-10 codes. The CSMFs were compared for the CRHSP and INDEPTH VA tools. The performance of CRHSP VA tools was considered satisfactory if the CSMF estimate using the CRHSP VA tools was within 20% of the CSMF obtained by the INDEPTH VA tools.13 The chance-corrected concordance was also estimated for various causes of childhood mortality using Cohen’s kappa. A kappa value of more than 0.75 was considered as “excellent”, 0.40 to 0.75 “as fair to good” and below 0.40 as “poor.”

Ethical issues
Approval from the AIIMS Ethics Committee was obtained before the start of the study. Field workers and assistants were trained in interview techniques, so as to minimize the trauma to the respondent when discussing the death of a loved one. Written informed consent was taken from all interviewees before administration of the INDEPTH VA tools. The CRHSP VA tools were already being used as a routine surveillance activity; hence, consent was not taken for it. Information gathered from interviewees was kept confidential.

Results
One hundred and forty three deaths occurred among under-five-children in the CRHSP population during 2008. Sixty five deaths occurred in the neonatal period (0-28 days); 60% of these deaths were in the early neonatal period (0-7 days). Seventy eight deaths occurred in the period from 29-days to <5 years; 58% of these deaths were between 29 days to <1 year. Most neonates died in hospital (56%) or on way to hospital (38%), whereas only 22% of the 29-days to <5 year-olds died at hospital and 65% died at home. There were more males (58%) among neonatal deaths compared to the 29-days to <5 year-olds (50%). The number of deaths for which a specific cause could be assigned was found to be greater in the case of CRHSP VA tools as compared with the INDEPTH VA tools (Table 1). There was not much misclassification in ascertainment of the cause of death as the chance-corrected concordance for major causes of death was “fair to good” or “excellent” (Table 2).

Low birthweight was the most common cause of death in both early and late neonatal period. The CSMF of low birthweight and prematurity by INDEPTH and CRHSP VA tools was 46.2% and 41.1% respectively, in the early neonatal period, and 38.4% by both tools in the late neonatal period. Birth asphyxia was another common cause of death in the early neonatal period, using both the VA tools, with a CSMF of 25.6% and 38.5%, respectively; however it was a less common cause of death in the late neonatal period with a CSMF of 0% and 7.7% respectively, using the INDEPTH and CRHSP VA tools. The CSMF of pneumonia in the early neonatal period was 5.1% according to both tools, and 11.5% and 19.2% in the late neonatal period, using the INDEPTH and CRHSP VA tools respectively. The CSMF of congenital malformation was 7.7% according to both tools in the early neonatal period, and 7.7% and 3.8% in the late neonatal period, using the INDEPTH and CRHSP VA tools respectively.

Diarrhoea was the most common cause of death among 29-days to <5 year-olds (Table 1). In children aged 29-days to <1 year, diarrhoea was the cause of death in 42.2% and 37.7% children, according to the INDEPTH and CRHSP VA tools respectively; however in children aged 1 year to <5 years, diarrhoea was the cause of death in 12.1% children, using both tools. Among children of 1 year
Table 1: Cause-specific mortality fractions in less-than-five-year old children by INDEPTH and CRHSP verbal autopsy tools

<table>
<thead>
<tr>
<th>Cause of death (ICD codes)</th>
<th>INDEPTH</th>
<th>CRHSP</th>
<th>INDEPTH</th>
<th>CRHSP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low birthweight (P07.0- P07.3)</td>
<td>43.1</td>
<td>40.0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Birth asphyxia (P21.9)</td>
<td>15.4</td>
<td>26.2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Diarrhoea (A09)</td>
<td>0</td>
<td>29.4</td>
<td>26.9</td>
<td></td>
</tr>
<tr>
<td>Pneumonia (J18)</td>
<td>7.7</td>
<td>10.8</td>
<td>16.6</td>
<td>16.6</td>
</tr>
<tr>
<td>Neurological disorder (G00-G99)</td>
<td>0</td>
<td>0</td>
<td>6.4</td>
<td>6.4</td>
</tr>
<tr>
<td>External injury (S00-Y98)</td>
<td>6.2</td>
<td>4.6</td>
<td>6.4</td>
<td>6.4</td>
</tr>
<tr>
<td>Protein-energy malnutrition (E40-E46)</td>
<td>0</td>
<td>0</td>
<td>5.1</td>
<td>7.7</td>
</tr>
<tr>
<td>Other infectious diseases (A00- B99 except A09)</td>
<td>0</td>
<td>0</td>
<td>3.8</td>
<td>5.1</td>
</tr>
<tr>
<td>Congenital malformation (Q00-Q99)</td>
<td>7.7</td>
<td>6.2</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Malignant neoplasm (C00-D48)</td>
<td>0</td>
<td>0</td>
<td>1.2</td>
<td>2.5</td>
</tr>
<tr>
<td>Others</td>
<td>1.4</td>
<td>1.4</td>
<td>5.6</td>
<td>5.4</td>
</tr>
<tr>
<td>Unclassified (R00-R99)</td>
<td>18.5</td>
<td>10.8</td>
<td>23.0</td>
<td>20.5</td>
</tr>
</tbody>
</table>

CRHSP = Comprehensive Rural Health Service Project, INDEPTH = International Network of Field Sites with continuous Demographic Evaluation

Table 2: Level of agreement between INDEPTH and CRHSP verbal autopsy tools for various causes of death among under-five children

<table>
<thead>
<tr>
<th>Cause of death</th>
<th>0 - 28 days N=65</th>
<th>29 days - &lt;5 years N=78</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>Kappa (SE)</td>
</tr>
<tr>
<td>Low birthweight (P07.0- P07.3)</td>
<td>28</td>
<td>0.878 (0.109)</td>
</tr>
<tr>
<td>Birth asphyxia (P21.9)</td>
<td>10</td>
<td>0.678 (0.118)</td>
</tr>
<tr>
<td>Pneumonia (J18)</td>
<td>5</td>
<td>0.817 (0.125)</td>
</tr>
<tr>
<td>Diarrhoea (A09)</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>Congenital malformation (Q00-Q99)</td>
<td>4</td>
<td>0.881 (0.118)</td>
</tr>
<tr>
<td>Malignant neoplasm (C00-D48)</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>Protein-energy malnutrition (E40-E46)</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>Neurological disorder (G00-G99)</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>External injury (S00-Y98)</td>
<td>5</td>
<td>0.849 (0.148)</td>
</tr>
</tbody>
</table>

SE=Standard Error, CRHSP=Comprehensive Rural Health Service Project, INDEPTH = International Network of Field Sites with continuous Demographic Evaluation

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to <5 years in age, external injury was the common cause of death, with CSMF according to both tools being 15.2%. Pneumonia was another common cause of death in this age group with 17.7% and 22.2% deaths respectively, using the INDEPTH and CRHSP VA tools. Neurological disorders and protein-energy malnutrition were the other important causes of death in this age group.

**Discussion**

The ideal mortality measurement should be routine, reproducible, low cost and sustainable. Use of short verbal autopsy tools to generate cause-specific mortality fractions at the local level can help in better planning of health-care services as health workers who used short verbal autopsy tools had a “fair to good” level of agreement in causes of deaths, as compared with those arrived at by the INDEPTH tools (Table 2). A study in the CRHSP area had reported earlier that the performance of verbal autopsy tools by health-care workers in routine health-care delivery settings was good for adult deaths.22

In the neonatal age group, low birthweight and prematurity was the most common cause of mortality. It had a CSMF of 40%, using the CRHSP VA tool, which is within the acceptable limit (20%) of CSMF, according to the INDEPTH VA tool. Low birthweight as a cause of death was more common than other studies conducted in a similar setting8 or elsewhere,23,24 which reported a CSMF in the range of 10-30%. Misclassification of cases of sepsis or pneumonia as low birth-weight may be the reason for a higher CSMF in this study, as in this study the CSMF of pneumonia or sepsis was quite low in comparison with other studies.8,23,24 Most babies born prematurely or with a low birthweight are likely to die from sepsis or pneumonia, but this study underestimated pneumonia as a cause of death in many neonates. It is important to decide a priori, how to classify deaths in the neonatal period. Should prematurity or low birthweight be considered an “underlying cause” or a “risk factor” as many premature or low-birth-weight babies may die due to other causes such as pneumonia, diarrhoea or sepsis?

Birth asphyxia was another common cause of death in this study, though the CRHSP VA tool diagnosed it as a cause of death more commonly (26.2%) than the INDEPTH VA tool (15.4%). The reason for this large difference could be more unclassified deaths in the case of the INDEPTH VA tool. The narrative section plays a major role in assignment of the cause of death for birth asphyxia. It is possible that health-care workers were able to extract more information on events surrounding birth. They had worked in the area for a longer period and had a better rapport with the informants. The CSMF of birth asphyxia was similar to that reported globally or from the South-East Asia Region,23,24 though a study in northern India had found a much lower CSMF of birth asphyxia.8 The CSMF of perinatal conditions in the neonatal period was found to be 71% in a large sample survey in India.25 The CSMF of congenital malformations was similar in both CRHSP VA and INDEPTH VA tools and was consistent throughout the study.8,23-24

In the age group of 29 days to <5 years, diarrhoea and pneumonia were the two most common causes of death. The CSMF for these common causes of death by the CRHSP VA tool was within the acceptable limit (20%) of the CSMF, using the INDEPTH VA tool. The CSMFs during infancy obtained in this study, was similar to other studies.23,25 However, in the post-infancy period, the CSMF of diarrhoea was much lower in this study. Injuries were a common cause of death in this study; similar results have been found elsewhere.25
The chance-corrected concordance between CRHSP and INDEPTH VA tools was excellent for most causes of death except for birth asphyxia. Very few studies have presented results in terms of kappa; though some authors argue that it could be a better method. The chance-corrected concordance was better for pneumonia than a study conducted in Kenya. The performance of the CRHSP VA tool for birth asphyxia and low birthweight in the neonatal period was similar to other studies; however, the performance in these studies was measured in terms of validity. In contrast to the other studies, the performance of the 29 days to <5 year VA tool was better for diarrhoea and pneumonia.

In all cases, the CRHSP VA tools were administered before the INDEPTH VA tool. A gap of two to six weeks is too short to forget the elements of earlier interview, yet any longer gap would affect the quality of recall. The INDEPTH tool is more detailed. It was felt that there is more chance of it influencing recall than the CRHSP tool. Also, the CRHSP tool is filled routinely, a practice that was not interfered with in the study protocol, whereas the INDEPTH tool was filled in the research mode. It would have been ideal to validate the VA instruments against medical certification; however preponderance of home deaths precluded this option. Attempts were made to retrieve the medical records of the deceased in case of hospital deaths, but these records could not be traced in most cases as these are usually destroyed after the death of the child. Records could not be retrieved from hospitals also, as deaths had occurred in hospitals that were spread across a wide geographic area. Moreover, selective admission to hospitals in a rural area may bias the validation of a tool that is used in a field setting.

Overall, in the 29 days to <5 year period, the CSMFs by CRHSP VA tool were within the 20% limit of the CSMF by the INDEPTH VA tool for most causes of deaths. However, in neonatal deaths, most CSMFs by the CRHSP VA tool were not found to be within the 20% limit of the CSMF by the INDEPTH VA tool. The smaller number of deaths in the neonatal age group could probably be the reason for this difference. Many factors including the design, type of interviewers and respondents, the recall period, cause-of-death ascertainment mechanisms and cause-of-death classification affect the performance of VA tools.

It can be concluded that despite the limitations mentioned above, the CRHSP VA tools performed satisfactorily in the field setting. The use of CRHSP tool takes less time to complete the forms, requires less intense training, and provides data that are useful for priority setting. Hence, the use of short VA tool by health workers can fill the gaps in cause-specific childhood mortality information in places where medical certification of cause of death is deficient.

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