Interview Based Diagnosis of
Morbidity and Causes of Death

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INTRODUCTION

Information on causes of morbidity or death is required to establish public health priorities, and to evaluate the impact of interventions. However, vital registration in most developing countries is incomplete (UN, 1988), even among countries with vital registration, information on causes of death is often defective (WHO, 1977; Chackiel, 1990). To overcome this deficiency, investigators have used information derived from interviews (verbal autopsies), to reconstruct events prior to death so as to reach a medically accepted diagnosis.

The objective of a verbal autopsy interview is to identify a limited number of diseases which present as distinct syndromes. In children, these include acute conditions such as neonatal tetanus, prematurity/low birth weight and birth injury, measles, diarrhea/dysentery, acute lower respiratory infection (pneumonia), pertussis, meningitis, and injury. Certain chronic conditions such as tuberculosis (TB), nutritional deficiency, and AIDS are more difficult to diagnose by interview (Gray et al, 1990). In adults, causes of maternal death have been assessed by verbal autopsy (WHO, 1988; Koenig et al, 1988; Fauveau et al, 1988), but there is relatively little information on causes of non-maternal adult deaths (Hayes et al, 1989).

Reporting of deaths has been based on longitudinal population surveillance, or on retrospective information derived from
interviews in population surveys. Surveys are more economic and expeditious than surveillance, but have the disadvantage of a longer average interval between death and interview which could introduce recall errors.

Most investigators employ open ended questions regarding the respondent's views on the probable cause of death, and on use of medical services. This also helps to establish rapport, and can be sensitive to local interpretation or terminology for diseases (Kielman et al, 1983; Zimicki, 1990; Garenne and Fontaine, 1990; Gray et al, 1990; Fauveau et al, 1990). However, unstructured interviews may be difficult to interpret, and are vulnerable to interviewer bias or to culturally specific interpretation of illness.

Most studies also use structured questionnaires, with either a comprehensive list of questions regarding symptoms and signs, or a short series of sensitive "filter" screening questions that direct the interviewer to disease-specific modules containing more detailed questions. An example of a screening questionnaire is given in table 1. To achieve high specificity, the disease-specific modules obtain information on the presence of cardinal symptoms and signs, and the timing of onset, duration and persistence of symptomatology relative to the timing of death. Also, some estimate of severity is needed for certain symptoms; such as diarrhea (e.g., number of stools on the worst day of illness). Local terms for common well-recognized diseases are
often used, although such terminology may be non-specific. Supplemental information from medical records, death certificates, child health cards, immunization records, prescriptions or medicine containers can also provide important information.

The optimal interval between death and interview has not been clearly established. Although some investigators have interviewed relatives "as soon as possible" after death, others feel that it is preferable to wait 2-3 months until the phase of acute grief is over. Garenne and Fontaine (1990) in a Senegalese study, found that interviews conducted less than 3 months after death resulted in a 17.9% non-response and 34.8% unspecified causes of death, compared with 8.8% non-response and 28.9% unspecified causes of death for interviews conducted 3-9 months after the event. In surveys, interviews are usually conducted 2-9 months after the event (Gray et al, 1990), and there is some evidence from neonatal tetanus surveys that a recall period up to six months minimizes omission of events (Galazka and Stroh, 1986).

The diagnosis and classification of causes of death have used disease-specific algorithms based on the presence and timing of symptoms or signs, and the age of the decedent, and/or on a review of questionnaires by physicians. It is conventional to ascribe underlying and contributory causes of death on the basis of the temporal ordering of illnesses and knowledge about the relationship between diseases. However, it is also preferable to record multiple causes of death to avoid bias and to facilitate analysis.
of disease interactions. Some investigators grade diagnostic accuracy by the degree of relative certainty, and classify diagnoses as "definite, possible, or probable" based on the extent to which major or minor criteria are met (Leeuwenburg et al, 1984a).

The World Health Organization has produced simplified coding schemes for lay reporting of illness and death (WHO, 1978). However, these systems are more complex than usually required, and shorter code lists for specific diseases of interest are used in most studies.

Few investigators have attempted to formally validate interview diagnoses of illness or cause of death by comparison with physician diagnoses, confirmatory investigations or laboratory tests (Leeuwenburg et al, 1984a and b, Kalter et al, 1990 and 1991). The epidemiologic plausibility of verbal autopsy diagnosis can be indirectly inferred by comparison of disease patterns derived from interview diagnoses with the known epidemiology of the disease (e.g., variation by age, sex or season). Also, changes in disease patterns following interventions such as immunization can provide indirect evidence for the accuracy of interview diagnoses. However, such indirect evaluation may be flawed because of transfer of diagnoses from the target disease to another condition, or because of the persistence of diagnostic habits that lead to continued reporting of the target disease despite a reduction in its incidence (Zimicki, 1990). This diagnostic bias should not,
however, affect results from randomized trials.

INTERVIEW BASED DIAGNOSIS OF SPECIFIC DISEASES

The following review will examine verbal autopsy diagnoses for childhood conditions of public health importance in developing countries. For each disease we briefly review the main questions used in verbal autopsy diagnoses, and evidence for the accuracy of verbal autopsy diagnoses, as well as experience with field studies.

Neonatal Tetanus

Neonatal tetanus is estimated to cause 500,000 deaths in developing countries and the case fatality rate is thought to be around 85% (Stanfield and Galazka, 1984; Galazka and Stroh, 1986). Symptoms usually commence two to fourteen days after birth, and death generally occurs between the third and thirtieth day. While a definitive diagnosis is based on the clinical features and isolation of the causative organism, the clinical presentation is sufficiently distinctive to permit diagnosis by maternal interview.

The World Health Organization (WHO 1982, 1984a) has conducted numerous clinical studies and mortality surveys using an algorithm for tetanus diagnosis based on the questions in table 2.

The differential diagnosis of neonatal tetanus requires exclusion of brain damage due to congenital defects, birth trauma
or asphyxia, which usually present within the first day of life as poor feeding, weak crying, flaccidity, coma or seizures (Galazka and Stroh, 1986).

The validity of verbal autopsy diagnoses of neonatal tetanus is difficult to assess directly. In larger clinical series, cessation of suckling is reported in 69-100% of confirmed cases, rigidity or spasms in 97-100%, and trismus/risus sardonicus in 71-100% of cases (Galazka and Stroh, 1986). A study by Kalter et al (1990) in the Philippines found a sensitivity of 94-100% using a modification of the World Health Organization algorithm, but the specificity could not be adequately assessed.

Verbal autopsy diagnoses of neonatal tetanus have epidemiologic plausibility as indicated by the age distribution of putative tetanus deaths, and urban/rural or seasonal differentials. Also, verbal autopsies used in the evaluation of preventive programs have shown substantial declines in neonatal tetanus deaths as compared to control populations (Foster, 1984; Galazka and Stroh, 1986). In summary, the World Health Organization algorithm for neonatal tetanus appears to be sensitive, but it is difficult to determine specificity, and it is likely that some nontetanus deaths are misclassified as tetanus.

**Perinatal Deaths**

The majority of births and perinatal deaths in developing
countries occur without medical supervision and are often not recorded in vital registration. Demographic surveys also underestimate perinatal mortality because of failure of maternal recall, or because interviews only ask questions about live births, and thus omit stillbirths. Nevertheless, a number of investigations suggest that there are approximately seven million perinatal deaths annually (Edouard, 1985).

Hospital based studies in developing countries suggest that 55-75% of perinatal deaths are associated with prematurity and low birth weight (Barros et al, 1987; Kramer, 1987; Ferraz et al, 1990; Gray et al, 1990). However, because the majority of deliveries occur at home, birth weight measures are seldom available. Estimates of gestational age are particularly problematic in cultures where women often do not know the dates of their last menstrual period. Thus, objective measures of prematurity/low birth weight are currently not available for the overwhelming majority of births, and diagnosis is often based on maternal interview regarding the small size of the baby at birth.

Birth trauma or asphyxia due to complications of delivery and/or poor obstetrical care are also thought to be major problems, but little information is available outside of hospital deliveries. Also, it may be difficult to differentiate between deaths due to these conditions, and deaths due to prematurity/low birth weight (WHO, 1984b).
Prospective studies have used structured maternal interviews and open-ended interviews to determine causes of perinatal death in India (Kielman et al, 1983; Shah, 1984), Bangladesh (Fauveau et al, 1990a) and Kenya (Norbeck et al, 1984). The findings are summarized in table 3. About one third or more of perinatal deaths were ascribed to low birth weight in the three South Asian studies, compared to one quarter in the Kenyan study. In all four studies, over one-third of deaths were attributed to birth trauma/asphyxia, and in approximately one-fifth of cases no specific cause could be identified. The findings were generally consistent between studies, and suggest that verbal autopsies can be used to identify major perinatal conditions.

Measles

Measles usually occurs in children over the age of five months, and is estimated to cause around 1.5 million deaths during childhood in developing countries (Aaby et al, 1987; Foster, 1984). The majority of deaths are associated with complications such as acute lower respiratory infection or diarrhea. Also, following acute measles, there is an increased risk of subsequent mortality for nine to twelve months due to postmeasles pneumonia, diarrhea and nutritional deficiencies. Although there is debate over the duration of such postmeasles mortality, deaths within one to three months of an acute episode are frequently attributed to measles. Measles is often recognized by the mother and frequently there are
local terms for the disease. The occurrence of a measles epidemic, or of other cases in the household, also helps to establish measles as a probable cause.

The World Health Organization Expanded Program of Immunization (WHO, 1984a) and other investigations (Aaby et al, 1984; Garenne and Aaby, 1990) have used verbal autopsy methods to diagnose deaths associated with measles. The most common questions are listed in table 4.

Several studies suggest that interview based diagnosis of measles is generally reliable (table 5). However, in a survey of unvaccinated children in Mozambique, Cutts et al (1990) found that a maternal history of measles had a sensitivity of only 50% and a specificity of 83% compared with serologic diagnosis. Several studies using verbal autopsies have shown declines in measles deaths following immunization programs, which adds epidemiologic plausibility to the verbal autopsy diagnosis (Hull et al, 1983; Clemens et al, 1988; Aaby et al, 1984b, Koenig et al, 1989). In summary, the verbal autopsy diagnosis of measles is probably reliable.

Diarrhea

Acute or chronic diarrheas and dysentery are associated with around five million deaths among children in developing countries (Black, 1984; Feachem, 1986). Most studies of diarrheal morbidity
or mortality define an episode of diarrhea as a history of more than three to four loose or liquid stools per day, and dysentery is defined as frequent liquid stools containing blood (WHO, 1989). Open-ended questions on the presence of "diarrhea" may be unreliable, because of the subjective nature of maternal assessment and because of cultural variation in the use of local terms (Kendall et al, 1984). Since diarrheal deaths are generally associated with dehydration, interviews usually ask questions about signs of dehydration such as thirst, sunken eyes, dry mouth etc (Black, 1984; WHO, 1989).

A hospital based study in the Philippines compared verbal autopsy diagnoses of diarrhea deaths with confirmed clinical diagnoses in 43 children who died as a result of diarrhea alone, and in 92 children who died of diarrhea plus other associated illnesses (Kalter et al, 1990). Among the children in whom diarrhea was the sole cause of death, a history of loose or liquid stools had a sensitivity of 84% and a specificity of 79%, and in the children who died of diarrhea with another disease, the sensitivity was 78% and specificity 79%. A related study of children who survived a diarrheal episode showed high sensitivity (95%) and specificity (80%) for interview based diagnoses (Kalter et al, 1991). However, the interview diagnosis of moderate or severe dehydration was unsatisfactory in both fatal and non-fatal cases.

Black et al (1982) in a Bangladesh study compared maternal
histories of diarrhea with observation of stool consistency, and found 80% agreement. However, a similar Kenyan study, found that maternal reports of "diarrhea" (without specifying the number or consistency of stools) could be confirmed by visual inspection of stool specimens in only 60% of episodes (Leeuwenburg et al., 1984b). Field studies using maternal interviews have shown age, sex and seasonal patterns of diarrhea which are consistent with those observed in clinical studies (Black, 1984; Mata, 1983). Also, studies of oral rehydration fluid therapy programs have demonstrated declines in diarrheal mortality based on verbal autopsy diagnoses, which are consistent with observations from clinical trials (Oberle et al., 1980; Kielman et al., 1985; El-Rafie et al., 1990). This suggests epidemiologic plausibility for interview-based diagnoses.

In summary, verbal autopsy diagnoses of diarrhea appear to be reliable if adequate information is obtained on stool frequency and consistency. However, maternal recognition or recall of the severity of dehydration may be problematic.

**Acute Lower Respiratory Infections**

It is estimated that acute lower respiratory infection or pneumonia is responsible for approximately four million deaths among children in developing countries (Leowski, 1986; Graham, 1990).
The diagnosis of acute lower respiratory infection is difficult, because the symptoms and signs vary with age of the child, and severity of illness (Graham, 1990; Steinhoff, 1990). WHO (1990) has developed simplified diagnostic guidelines for case management. In children one month or older, pneumonia is defined by cough, chest indrawing, and rapid breathing (>50 per minute). In neonates, more emphasis is placed upon signs of general sepsis such as inability to drink, fever or hypothermia (Redd, 1990). Several investigators have assessed some of these criteria in sick children presenting with cough at hospitals, or children with cough referred from community surveillance. The diagnosis of pneumonia was based on physician examination and/or x-ray. Among hospitalized infants under three months of age in Vellore, rapid breathing has relatively low sensitivity (61%) and specificity (55%), whereas chest retraction was found to be highly sensitive but non-specific (Berman, 1990). In older children presenting at hospital, a respiration rate >50 per minute had sensitivities ranging from 72-90%, and specificities ranging from 62 to 91%. Also, chest retraction was found to be both sensitive and specific in these hospital based investigations (Leventhal 1982, Shann et al 1984, Cherian et al 1988). However, among Gambian children identified by field workers during community surveillance, Campbell et al (1989) found that the sensitivity of both tachypnea and chest indrawing were lower (64 and 65% respectively). Thus, the WHO criteria appear to be useful for children who are sufficiently sick to present at hospital, but may be less satisfactory in very young infants, or among older children identified during routine
population screening. However, these guidelines are difficult to use for verbal autopsy, and there is still no well-defined algorithm for the postmortem diagnosis of pneumonia.

Maternal recall or recognition of non-fatal acute lower respiratory infection in children has have been evaluated in a number of investigations. In the Gambia, maternal interviews conducted at the time of hospitalization were found to agree with clinical diagnoses of pneumonia in 84% of cases (Alonso, 1987). In the Philippines, interviews with mother's of children with acute lower respiratory infection who had been discharged from hospital, were compared to physician's diagnosis. A combination of cough, fever and dyspnea gave a sensitivity of 68% and a specificity of 84% for the maternal interview diagnoses (Kalter, 1991).

A validation study of 100 hospitalized Philippino children who died of confirmed acute lower respiratory infection found that the maternal interview based diagnosis of pneumonia was problematic (Kalter et al, 1990). A history of cough lasting four or more days and dyspnnea for one or more days had a sensitivity and specificity of 59 and 77%, respectively. The main difficulty was that many children who died from diseases other than pneumonia also had a cough and signs of terminal respiratory distress, which could only be differentiated from acute lower respiratory infection by the duration of symptoms. We know of no other study to validate the verbal autopsy diagnosis of acute lower respiratory infection. However, New Guinean randomized double-blind field trials of
pneumococcal vaccines which used verbal autopsy diagnoses, observed lower acute lower respiratory infection morbidity and mortality among vaccine recipients than among placebo controls (Riley et al, 1981 and 1986). Also, non-randomized field studies of antibiotic therapy have reported declines in pneumonia mortality (Bang et al, 1990; Black, 1990). These findings suggest that the interview based diagnosis of pneumonia is sufficiently accurate to detect the impact of interventions.

**Pertussis**

Pertussis is believed to cause around four percent of deaths in children (Foster, 1984; Muller et al, 1984). Most deaths occur within three months of infection. A presumptive diagnosis can be based on a history of paroxysmal coughing for two or more weeks, with choking and/or vomiting after the paroxysms. There may also be a characteristic "whooping" sound during inspiration, and children frequently have conjunctival hemorrhages.

There has been no direct validation of verbal autopsy diagnoses. In a Kenyan surveillance study, Voorhoeve et al. (1978) compared diagnoses of pertussis based on laboratory findings with maternal histories obtained six to twelve months after the illness. Among confirmed cases, maternal recall was concordant with the clinical diagnosis in 91% of cases. Also, a clinical study in the U.S.A. found that a history of prolonged cough (≥ 14 days) had a sensitivity of 98% and a specificity of 63% for the diagnosis of
pertussis (Patriarca et al, 1988). Several vaccine trials using interview based diagnoses have shown declines in pertussis morbidity and mortality (Foster, 1984; Muller et al, 1984). It is therefore likely that the interview diagnosis for pertussis is satisfactory in field settings.

Malaria

Malaria is widespread throughout the moist tropics, particularly in West Africa, (WHO, 1979; Clyde, 1987). Because of the complex epidemiology of malaria, it is difficult to estimate its impact on mortality. Studies by Greenwood et al (1987) in the Gambia suggest that acute malaria is responsible for around four percent of infant deaths and 25% of deaths among children aged 1 to 4 years. Both acute and chronic malaria can also contribute to mortality from other diseases by undermining health (e.g., anemia) (Bradley and Keymer, 1984), and maternal malaria infection during pregnancy results in reduced birth weight (McGregor et al, 1983). Thus studies of mortality following malaria control programs have demonstrated declines in death rates beyond that expected from declines in acute malaria deaths alone (Gray, 1974; Greenwood, 1988).

The clinical diagnosis of malaria is difficult, and definitive diagnosis depends on demonstration of parasites in the blood. In West African studies, a presumptive diagnosis of acute malaria was made on the basis of a history of high fever in a previously well
child, without significant concomitant illness (Bradley and Gilles, 1984; Greenwood et al, 1987; Trape et al, 1987; Greenwood et al, 1988). However, it is difficult to assess the validity of such presumptive diagnoses, because children in endemic malarious areas often have parasitemia without fever, and children with malaria who receive antimalarial drugs may have no parasitemia at the time a blood smear is taken. Morbidity surveys in the Gambia found that 65% of children with fever had malaria parasites in their blood, but 30% of afebrile children also had parasitemia (Greenwood et al, 1987). Similarly, a study of Congolese school children by Trape et al (1987) showed that among febrile children suspected to have malaria, the diagnosis could only be confirmed by blood smear in 20% of the cases. Thus, fever as a criteria for malaria diagnosis is insensitive and nonspecific. However, one investigation of 16 seriously ill hospitalized Gambian children with confirmed malaria found that open ended interviews with mothers gave a presumptive diagnosis of malaria in 75% of cases (Alonso et al, 1987). Despite these problems with diagnosis, it is noteworthy that a randomized trial of chemoprophylaxis using verbal autopsy diagnosis, showed substantial declines in malaria mortality among treated children (Greenwood et al, 1988). Since this was a randomized study with blind observation, it is unlikely that diagnostic bias affected diagnosis.
Meningitis

Cerebrospinal meningitis is a major public health problem in tropical Africa where epidemics occur during the dry season in a "meningitis belt" of Sahelian countries extending from Sudan to Mali (Greenwood et al, 1984; Tikhomirov, 1987).

Criteria for the verbal autopsy diagnosis have not been well established, but studies in Senegal and Nigeria used an algorithm based on fever, headache, neck extension (often with flexed arms and legs), and swollen fontanelle in infants (Garenne and Fontaine, 1990; Bradley et al, 1984). Additional signs included convulsions and photophobia. Since most deaths occur during epidemics, the presence of other cases usually provides strong supporting evidence. No validation studies for the interview-based diagnosis of meningitis are available.

Chronic Illnesses: Malnutrition, Tuberculosis and AIDS

Many children suffer from chronic ill health as a consequence of nutritional deficiencies, recurrent acute infections and chronic infections such as tuberculosis (Mosley and Chen, 1984). Pediatric AIDS is also a growing a public health problem. However, it is difficult to distinguish these chronic conditions from one another using verbal autopsy.

Anthropometric studies have shown that protein-calorie
malnutrition increases the risk of death from a number of infectious diseases (Chen et al, 1980; Briend et al, 1987; Martorel and Ho, 1984). However, anthropometric information is seldom available. In a Bangladesh study (Fauveau et al, 1990), mid upper arm circumference was available for 253 children within one month of death. Using a mid arm circumference <110 mm as a criterion for malnutrition, it was found that a verbal autopsy diagnosis of "severe malnutrition", agreed with the classification based on mid arm circumference in 88% of cases.

Vitamin A deficiency can lead to blindness and has been associated with increased risks of morbidity and mortality from a variety of infections (Sommer et al, 1983, 1984). Also, Vitamin A supplementation can reduce mortality (Sommer et al, 1986; Barclay et al, 1987; Rahmathullah, 1990). Vitamin A deficiency is thought to be common in many developing countries as indicated by the prevalence of xerophthalmia or its precursor of night blindness (Sommer et al, 1981). Thus, a history of these visual problems may provide an indicator of vitamin A deficiency prior to death.

Tuberculosis is widespread in the developing world, particularly in Africa and South Asia (Styblo et al, 1981). Due to the lack of reliable data, it is difficult to estimate the mortality attributable to tuberculosis, although in general, incidence and mortality rates are high during infancy and early childhood. The protean manifestations of childhood tuberculosis make diagnosis difficult in the absence of X-ray investigations,
bacteriologic or serological tests.

Perinatal transmission of Human Immunodeficiency Virus (HIV) is an increasing problem in sub-Saharan Africa (Quinn et al, 1986; Piot et al, 1988), and mortality among infected children is high (Hira et al, 1989). Children with HIV often have multiple acute and chronic infections, and in developing countries where such infections are common, the clinical diagnosis of pediatric AIDS may be difficult without confirmatory serological tests. Also, the interpretation of positive HIV tests during the first year of life is complicated by the passive transmission of maternal antibodies (Mok et al, 1987; Rubinstein, 1986). A provisional WHO case definition for pediatric AIDS consists of three major signs; weight loss or slow growth, chronic diarrhea and prolonged fever; minor signs include chronic cough, a variety of infections and dermatitis (Quinn et al, 1986).

The utility of this case definition for verbal autopsy has not been evaluated. Hospital based in Kinshasa, Zaire, (Mann et al, 1986) report a higher proportion of seropositive as compared with seronegative children, presented with unspecified gastrointestinal and pulmonary conditions and malnutrition (Table 6). However, these conditions were found to have low positive predictive value for HIV seropositivity, varying from 14% for pulmonary conditions up to 36% for malnutrition. In Lusaka, Zambia, Hira et al (1989) found more pronounced differentials in presenting symptoms among seropositive and seronegative children (Table 6), and the positive
predictive value of the presenting conditions varied from 26.4% for recurrent cough up to 73.9% for lymphadenopathy. Thus, the utility of the WHO case definition depends on the relative prevalence of marker diseases among seropositive and negative children, which is likely to vary between populations. In summary, there is as yet no validated algorithm for the verbal autopsy diagnosis of pediatric AIDS in developing countries.

Accidents and Violence

Injuries are potentially important but often overlooked causes of death, particularly during childhood and adolescence (Smith and Barss, 1990). It is relatively easy to obtain information on deaths due to injury by asking descriptive questions on the how the injury occurred (external cause) and on the nature and location of the injury (WHO, 1978). However, there may be underreporting of causes such as infanticide, and imprecise descriptions of the nature and location of injury. Confirmation of deaths due to injury may also be obtained from medical or legal records.

Distribution of Causes of Death in Rural Populations of Africa and Asia

Several surveillance studies of rural populations in sub-Saharan Africa and south Asia have used verbal autopsy to determine causes of death during the neonatal and postneonatal periods, and childhood (Tables 7 and 8). Biweekly household surveillance was
conducted in Narangwal, India; Machakos, Kenya; Matlab, and Teknaf, Bangladesh, but surveillance in Niakhar, Senegal is conducted annually. In Farafenni, the Gambia, deaths were reported by a resident local reporter and interviews were conducted by a physician. All investigations used both open ended interviews supplemented by questionnaires, and final assignment of diagnosis was made by a panel of physicians.

Low birth weight/prematurity was a major cause of neonatal death in all studies, but proportional mortality from birth trauma/asphyxia, birth defects and neonatal tetanus varied markedly (Table 7). Diarrhea was a relatively infrequent cause of neonatal death, and the contribution of pneumonia varied from 6.7 to 17.5%. The proportion of deaths of unknown cause was higher (29%) in Niakhar, Senegal, where surveys were conducted annually, as compared to the other studies which conducted biweekly surveillance.

During the postneonatal and childhood periods, diarrhea was a major cause of death in all studies, except Farafenni, Gambia (Table 8). Pneumonia accounted for 15.7 to 22.1% of deaths, and malnutrition was responsible for between 3 to 11.3% of deaths. There was, however, wide divergence in the proportion of deaths ascribed to measles (0 to 22.4%), and malaria and meningitis were only reported as a cause of death in the African studies, particularly in the Gambia. Accidents also varied widely from zero to 10.5% of deaths. The proportion of deaths of unknown cause was
again highest (24.2%) in Niakhar, Senegal where survey rounds were infrequent.

The differences in proportional mortality between these studies could be due to variation in the levels of mortality and associated differences in the cause structure of mortality. For example, Gambia and Senegal which have the highest postneonatal and childhood mortality rates, report a substantial proportion of deaths from malaria and meningitis. However, some of the variation between studies is almost certainly due to misclassification of cause of death due to differences in procedures.

SUMMARY AND CONCLUSIONS

It is unlikely that reliable information on causes of death will be available for major populations in developing countries until there is widespread registration and adequate medical service coverage. In the interim, researchers and policy makers will depend upon information derived from secondary sources such as interviews with relatives of the deceased. Such verbal autopsy diagnoses will always be subject to error, but can provide data of value to public health, particularly for allocation of health priorities and evaluation of intervention programs.

This review suggests that verbal autopsies may provide relatively reliable diagnoses of selected perinatal conditions, and
acute diseases such as diarrhea, measles, neonatal tetanus, pertussis and meningitis, and probably for injuries. However, diagnosis maybe more problematic for other acute conditions such as pneumonia and malaria, or chronic conditions such as tuberculosis and AIDS. There clearly needs to be more research to validate verbal autopsy diagnoses against standard clinical diagnoses so as to determine the most sensitive and specific questions for interviews, and to determine the effects of cross-cultural variation on the interpretation of questions.
References


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<table>
<thead>
<tr>
<th>Question</th>
<th>Example of Patient Screening Questions</th>
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<td>8. Injury module</td>
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<td>7. Pertussis module</td>
<td>&lt;--- Pertussis module</td>
</tr>
<tr>
<td>6. Measles module</td>
<td>&lt;--- Measles module</td>
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<tr>
<td>5. Tetanus module</td>
<td>&lt;--- Tetanus module</td>
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<td>4. ARRI module</td>
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<td>3. ARRI module</td>
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<tr>
<td>2. Diarrhea module</td>
<td>&lt;--- Diarrhea module</td>
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<tr>
<td>1. Blood in stools</td>
<td>&lt;--- Blood in stools</td>
</tr>
<tr>
<td></td>
<td>Frequent loose or liquid stools</td>
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</tbody>
</table>
Algorithm for Neonatal Tetanus

TABLE 2

1. Did the infant die between the 3rd and 20th day of life?
2. Was the infant able to suckle (and/or cry) after birth?
3. Did the infant stop suckling (and/or crying) when it became ill?
4. Did the infant’s body become rigid?
5. Did the infant have convulsions?
6. Did the mother receive two tetanus toxoid immunizations during this pregnancy or her last pregnancy?
7. What was done to cut the cord and dress the stump?
8. Are diagnostic tests of neonatal tetanus (28, 36, 42).

Algorithm to determine:

- What was done to cut the cord and dress the stump?
- Did the mother receive two tetanus toxoid immunizations during this pregnancy or her last pregnancy?
- Did the infant have convulsions?
- Did the infant’s body become rigid?
- Did the infant stop suckling (and/or crying) when it became ill?
- Was the infant able to suckle (and/or cry) after birth?
- Did the infant die between the 3rd and 20th day of life?
TABLE 3

Distributions of Causes of Death During the Perinatal Period in Community Studies Using Verbal Autopsy

<table>
<thead>
<tr>
<th>Author, Study Site</th>
<th>Number of Deaths</th>
<th>Low Birth Weight/ Prematurity %</th>
<th>Birth Trauma/ Asphyxia %</th>
<th>Birth Defects %</th>
<th>Infection %</th>
<th>Unknown/ Ill Defined %</th>
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<td>32.2</td>
<td>37.1</td>
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<td>Shah et al. (1984)</td>
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<td>37.8</td>
<td>36.4</td>
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<td>24.9</td>
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*Deaths in the first week of life only.
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<td>1. Was the child 5 or more months old?</td>
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</tr>
<tr>
<td>2. Did the child have fever?</td>
<td>Yes</td>
</tr>
<tr>
<td>3. Was there a blotchy rash lasting 3 or more days?</td>
<td>Yes</td>
</tr>
<tr>
<td>4. Was there a peeling or darkening of the skin among children who</td>
<td>Yes</td>
</tr>
<tr>
<td>were other cases of measles in the household or a household of</td>
<td>Yes</td>
</tr>
<tr>
<td>death?</td>
<td>Yes</td>
</tr>
<tr>
<td>5. Was there cough, runny nose or red eyes (conjunctivitis)?</td>
<td>Yes</td>
</tr>
<tr>
<td>6. Were there other cases of measles in the household or a household of</td>
<td>Yes</td>
</tr>
<tr>
<td>death?</td>
<td>Yes</td>
</tr>
<tr>
<td>7. Did the above conditions occur within 1-3 months prior to measles?</td>
<td>Yes</td>
</tr>
</tbody>
</table>

**Table 4**

Diagnostic Algorithm for Measles
<table>
<thead>
<tr>
<th>Authors and population</th>
<th>Source of information/ criteria for confirmed diagnosis</th>
<th>Sensitivity %</th>
<th>Specificity %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kalter et al. (1990) Philippines Hospital deaths 48 measles deaths 98 non-measles deaths</td>
<td>Maternal interview/ physician diagnosis</td>
<td>98</td>
<td>90</td>
</tr>
<tr>
<td>Kalter et al. (1991) Philippines Hospital morbidity 36 measles cases 225 non-measles cases</td>
<td>Maternal interview/ physician diagnosis</td>
<td>94</td>
<td>94</td>
</tr>
<tr>
<td>Leeuwenberg et al. (1984b) Kenya population surveillance</td>
<td>Physician diagnosis based on a checklist/ &quot;definite&quot; serological diagnoses</td>
<td>85.3</td>
<td>66.7</td>
</tr>
<tr>
<td>307 &quot;Definite&quot; cases 95 &quot;Probable&quot; cases 154 Non-measles cases</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Physician diagnosis based on checklist/ &quot;Definite and probable&quot; serological diagnoses</td>
<td>92.5</td>
<td>72.7</td>
</tr>
<tr>
<td>Cutts (1990) Mozambique population survey of unvaccinated children 29 confirmed measles 67 non-measles</td>
<td>Maternal history/ serology</td>
<td>50</td>
<td>83</td>
</tr>
</tbody>
</table>
The association between selected illnesses on admission and HIV status in hospitalized African children

<table>
<thead>
<tr>
<th>Author, age range and number of children</th>
<th>Conditions found on admission</th>
<th>Percent of children with each condition by HIV status</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>HIV positive</td>
</tr>
<tr>
<td>Mann et al. (1986)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kinshasa, Zaire</td>
<td>Gastrointestinal</td>
<td>55</td>
</tr>
<tr>
<td>Ages 9-24 months</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 HIV + children</td>
<td>Pulmonary</td>
<td>30</td>
</tr>
<tr>
<td>136 HIV - children</td>
<td>Malnutrition</td>
<td>60</td>
</tr>
<tr>
<td>Hira et al. (1989)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lusaka, Zambia</td>
<td>Recurrent diarrhea</td>
<td>80</td>
</tr>
<tr>
<td>Ages 13-24 months</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 HIV + children</td>
<td>Pneumonia</td>
<td>56</td>
</tr>
<tr>
<td>101 HIV - children</td>
<td>Recurrent cough</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Failure to thrive</td>
<td>92</td>
</tr>
<tr>
<td></td>
<td>Lymphadenopathy</td>
<td>68</td>
</tr>
<tr>
<td>Causes of death</td>
<td>Study, year and number of deaths</td>
<td></td>
</tr>
<tr>
<td>-------------------------------------</td>
<td>----------------------------------</td>
<td></td>
</tr>
<tr>
<td>Low birthweight/prematurity</td>
<td>38.7</td>
<td>21.7</td>
</tr>
<tr>
<td>Birth trauma/asphyxia</td>
<td>12.2</td>
<td>6.7</td>
</tr>
<tr>
<td>Neonatal tetanus</td>
<td>14.7</td>
<td>30.8</td>
</tr>
<tr>
<td>Diarrhea</td>
<td>1.1</td>
<td>3.3</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>10.1</td>
<td>6.7</td>
</tr>
<tr>
<td>Other infections</td>
<td>9.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Congenital abnormalities</td>
<td>0</td>
<td>11.7</td>
</tr>
<tr>
<td>Other conditions</td>
<td>2.2</td>
<td>0</td>
</tr>
<tr>
<td>Unknown</td>
<td>11.4</td>
<td>16.6</td>
</tr>
<tr>
<td>Mortality rate (per 1000 live births)</td>
<td>(47.4)</td>
<td>(88.8)</td>
</tr>
</tbody>
</table>
**TABLE 8**

Distributions of causes of death during the postneonatal period and childhood in south Asian and African studies using interview based diagnoses

<table>
<thead>
<tr>
<th>Causes of death</th>
<th>Study, year, number of deaths and ages</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Causes of death</th>
<th>Distribution of causes of death %</th>
<th>Distribution of causes of death %</th>
<th>Distribution of causes of death %</th>
<th>Distribution of causes of death %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diarrhea</td>
<td>38.1</td>
<td>43.4</td>
<td>9.9</td>
<td>30.5</td>
</tr>
<tr>
<td>Acute lower</td>
<td>22.1</td>
<td>20.2</td>
<td>19.0</td>
<td>15.7</td>
</tr>
<tr>
<td>pneumonia infection</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measles</td>
<td>4.9</td>
<td>0</td>
<td>4.2</td>
<td>9.0</td>
</tr>
<tr>
<td>Pertussis</td>
<td>1.2</td>
<td>0</td>
<td>0</td>
<td>4.4</td>
</tr>
<tr>
<td>Malaria</td>
<td>0</td>
<td>0</td>
<td>17.6</td>
<td>8.8</td>
</tr>
<tr>
<td>Meningitis</td>
<td>0</td>
<td>0</td>
<td>12.0</td>
<td>0.2</td>
</tr>
<tr>
<td>Tuberculosis/</td>
<td>0</td>
<td>0</td>
<td>3.5</td>
<td>0</td>
</tr>
<tr>
<td>chronic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>respiratory</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other infections</td>
<td>6.6</td>
<td>12.1</td>
<td>4.2</td>
<td>2.1</td>
</tr>
</tbody>
</table>

(cont'd)
TABLE 8
Distributions of causes of death during the postneonatal period and childhood in south Asian and African studies using interview based diagnoses (cont'd)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Causes of death</td>
<td>Distribution of causes of death</td>
<td>Distribution of causes of death</td>
<td>Distribution of causes of death</td>
<td>Distribution of causes of death</td>
<td>Distribution of causes of death</td>
</tr>
<tr>
<td>Malnutrition</td>
<td>7.7</td>
<td>8.0</td>
<td>11.3</td>
<td>3.0</td>
<td>9.0</td>
</tr>
<tr>
<td>Accidents</td>
<td>10.5</td>
<td>4.0</td>
<td>----</td>
<td>0.5</td>
<td>1.8</td>
</tr>
<tr>
<td>Other</td>
<td>2.6</td>
<td>0</td>
<td>4.9</td>
<td>1.6</td>
<td>0</td>
</tr>
<tr>
<td>Unknown</td>
<td>6.5</td>
<td>12.1</td>
<td>13.3</td>
<td>24.2</td>
<td>5.3</td>
</tr>
<tr>
<td>Mortality during the specified ages (per 1000)</td>
<td>(48)</td>
<td>(73)</td>
<td>(228)</td>
<td>(264)</td>
<td>(56)</td>
</tr>
</tbody>
</table>