

## Who Counts? 3



## Interim measures for meeting needs for health sector data: births, deaths, and causes of death

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Most developing countries do not have fully effective civil registration systems to provide necessary information about population health. Interim approaches—both innovative strategies for collection of data, and methods of assessment or estimation of these data—to fill the resulting information gaps have been developed and refined over the past four decades. To respond to the needs for data for births, deaths, and causes of death, data collection systems such as population censuses, sample vital registration systems, demographic surveillance sites, and internationally-coordinated sample survey programmes in combination with enhanced methods of assessment and analysis have been successfully implemented to complement civil registration systems. Methods of assessment and analysis of incomplete information or indirect indicators have also been improved, as have approaches to ascertainment of cause of death by verbal autopsy, disease modelling, and other strategies. Our knowledge of demography and descriptive epidemiology of populations in developing countries has been greatly increased by the widespread use of these interim approaches; although gaps remain, particularly for adult mortality. However, these approaches should not be regarded as substitutes for complete civil registration but rather as complements, essential parts of any fully comprehensive health information system. International organisations, national governments, and academia all have responsibilities in ensuring that data continue to be collected and that methods continue to be improved.

## Introduction

Accurate and timely data for mortality by age, sex, and cause both nationally and subnationally are essential for the design, implementation, monitoring, and assessment of health programmes and policies.<sup>1</sup> In countries with well developed statistical systems, the necessary information for such descriptive epidemiology is derived from civil registration, medically certified cause of death, and population counts from regular censuses or population registers. However, the paper by Mahapatra and colleagues<sup>2</sup> in this Series has convincingly shown that these data are simply not available for many countries with poorly developed statistical systems: in these countries births and deaths might not be registered completely; for those deaths that are recorded, the age at death might be misreported; the cause of death might not be certified by a physician; it might be recorded as an ill-defined cause; and could be misdiagnosed. Population numbers, needed as denominators, can suffer from errors of coverage and errors in reporting the age of individuals. These failures derive from technical and structural weaknesses, ranging from bureaucratic inefficiency and poor management of data to having inadequate incentives, or even disincentives for the population to record vital events.

Both national governments and the international community should give high priority to policies that will upgrade civil registration systems so that all countries will enjoy the benefit of a solid empirical base for health-sector planning. However, experience has shown that such improvements cannot be achieved overnight

and need investment not only in administrative systems but also in public awareness.<sup>3</sup> The number of countries with death registration regarded as complete (by the not very rigorous standard of 90%) increased by only seven from the 1970s to the 1990s.<sup>3</sup> Interim substitutes for civil registration are needed to provide national and subnational estimates of vital events and cause-specific mortality until achievement of complete civil registration with adequate certification of cause of death by a qualified medical practitioner familiar with the principles and procedures of the International Statistical Classification of Diseases and Related Health Problems, 10th revision

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## Key messages

- The complete registration of births and deaths with accurate ascertainment of cause of death—products of a fully functional civil registration system, and an essential component of any health information system—is inadequate in many developing countries
- Interim measures developed over the past four decades have been reasonably adequate substitutes in countries without a fully functional civil registration system, with exception of the assessment of causes of deaths
- These measures, consisting of innovative strategies both for obtaining data and for methods of assessment and analysis, should not, however, be viewed as long-term alternatives to civil registration, but rather as being complementary to such systems
- International agencies should maintain their support for coordinated data collection and sharing activities and for specialised training, while increasing efforts to achieve a fully functional civil registration system
- More intensive and better funded research programmes than we have at present are urgently needed to improve and refine the methods of analysis for converting incomplete or indirect information about mortality and causes of death into valid measures of population health for policymaking and planning

(ICD-10). The purpose of this paper is to review the strengths and weaknesses of interim strategies for collection and analysis of data that have been developed as substitutes for complete civil registration. We also highlight how such interim measures are inadequate, and suggest targets for future development.

### Interim substitutes

Several strategies for collection and analysis of data have been developed as interim substitutes for complete civil

registration, each with its own strengths and weaknesses. Table 1 summarises the potential contributions of different strategies, and figure 1 shows where some of the strategies (eg, targeted questions in population censuses, sample registration systems, demographic surveillance sites, and household surveys) have been used around the world. These sources of data generally have to be supplemented with methods of assessment or adjustment to produce satisfactory estimates. Unfortunately, no one strategy meets all data needs, and the strategies have to be seen as complementary rather than competitive. Existing strategies are also better at estimating some outcomes (eg, child mortality or fertility) than others (eg, adult mortality).

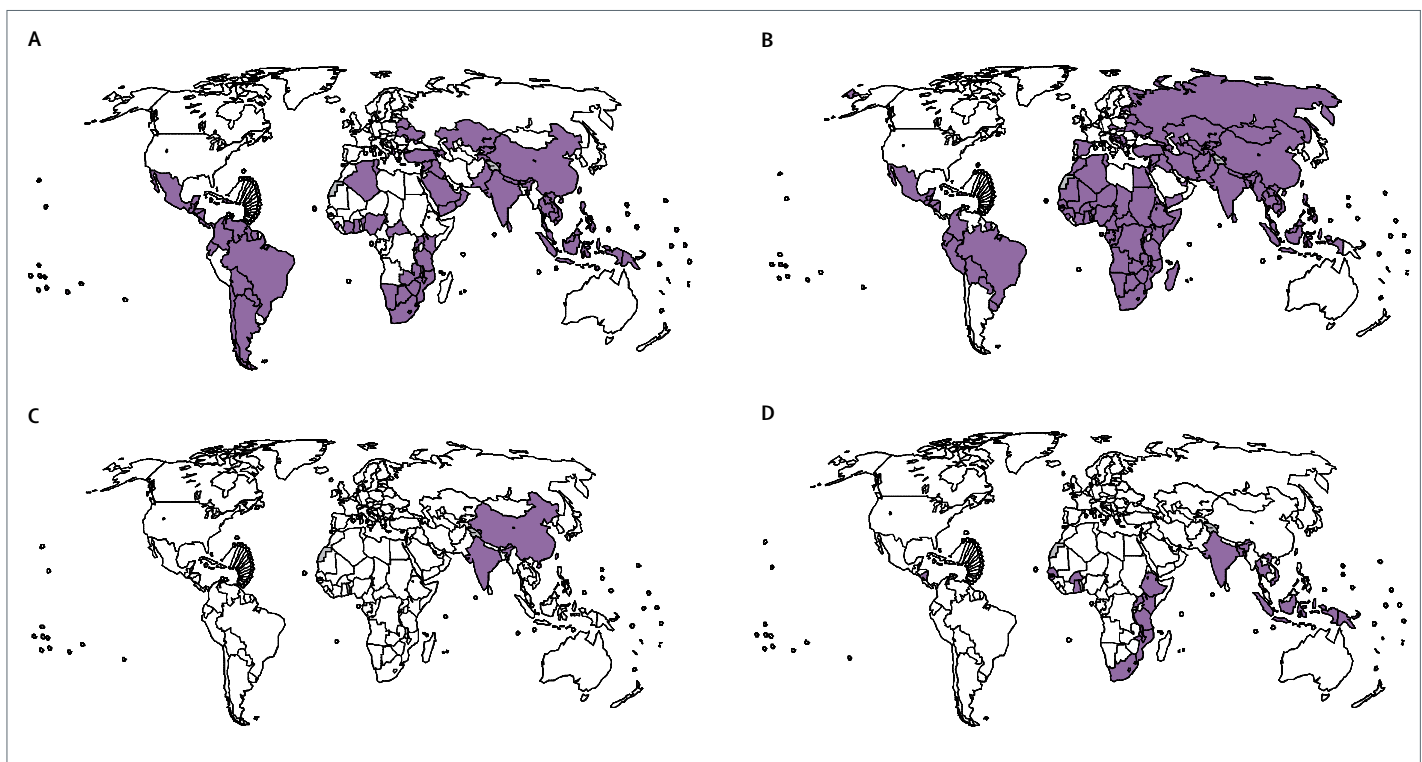
### The population census

Even well developed statistical systems need to include a way to estimate denominators for mortality and fertility rates. Such denominators are expressed in terms of exposure time, (ie, the number of person-years of exposure to risk of an event such as a birth or death). Most countries with well developed systems do regular population censuses to meet this need, although some rely on population registers. However, in countries with less developed systems, the census can offer much more than merely denominators for birth and death rates

|                 | Level of estimate | Civil registration system | Demographic surveillance sites | Sample registration systems | Population censuses | Household sample surveys |
|-----------------|-------------------|---------------------------|--------------------------------|-----------------------------|---------------------|--------------------------|
| Births          | National          | Yes                       | No                             | Yes                         | Maybe*              | Yes                      |
|                 | Differentials     | Yes                       | Limited                        | Limited                     | Maybe*              | Limited                  |
| Child mortality | National          | Yes                       | No                             | Yes                         | Yes†                | Yes                      |
|                 | Differentials     | Yes                       | Limited                        | Limited                     | Yes†                | Limited                  |
| Adult mortality | National          | Yes                       | No                             | Yes                         | Maybe*‡             | Weak¶                    |
|                 | Differentials     | Yes                       | Limited                        | Limited                     | Perhaps*‡           | No                       |
| Cause of death  | All               | Yes                       | Yes§                           | Yes§                        | Maybe§              | Yes§**                   |

\*With assessment and possible adjustment; methods do not always work. †For a recent period by indirect methods. ‡For an intercensal period. ¶Methods measuring parental survival or sibling history. §With verbal autopsy. \*\*For child deaths identified by a full birth history.

**Table 1: Contributions of alternative approaches to measurement of key population health indicators**



**Figure 1: Countries with data collection systems**<sup>4,5</sup>

(A) For mortality since 1997 from population censuses; (B) for mortality since 1997 from household surveys; (C) for mortality from sample registration systems; and (D) demographic surveillance sites. The boundaries and names shown and the designations used on this map do not imply the expression of any opinion whatsoever on the part of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted lines on maps represent approximate border lines for which there may not yet be full agreement. WHO 2007. All rights reserved.

through the inclusion of targeted questions. Many censuses in developing countries include summary birth histories for all women aged 15–49 (or an older age cutoff); such histories typically count the number of liveborn children for each woman and the number still alive (or equivalently the number that have died). The average number of children born alive by the age-group of the mother allows for a measure of fertility (especially if women are asked about the timing of a recent birth). The proportions of children who have died of women in different age-groups can help to estimate under-5 mortality by standard methods.<sup>6</sup> Although this approach cannot estimate age patterns of child mortality, it can provide estimates of recent trends, differentials by population subgroup, and perhaps most importantly, differentials by small areas.

The working group for the 2010 round of population censuses recommended that countries without alternative sources of adult mortality estimates include questions about deaths in each household by age and sex in a reference period before the census.<sup>7</sup> Methods have been developed to assess the completeness of reporting of deaths ascertained in this way; assuming that the deaths recorded are representative of the true age pattern of deaths, the coverage relative to the coverage of population denominators can be estimated by accounting identities of population dynamics. One such identity is that the death rate from a population with little migration is equal to the birth rate minus the growth rate; if the birth rate and growth rate can be estimated independently, their difference can be used to validate a measure of the death rate.<sup>8–12</sup> These methods make crucial assumptions: that the reported deaths are representative of all deaths in the population; that reporting of age at death is accurate; and that net migration is zero. At best they estimate coverage only relative to an intercensal (typically a period of 10 years) average level of mortality, but evidence shows them to be an inexpensive approach to adult mortality estimation in the absence of complete civil registration.<sup>13</sup> This approach offers two possible additions for specific causes. First, a question about the time of death relative to pregnancy can be asked to estimate pregnancy-related mortality ratios (panel 1 and table 2 show an example from Latin America), and second, a question about whether death resulted from injury can be included. Households reporting a death, or a sample of them, can be followed-up after the census to do a verbal autopsy (panel 2) to identify the cause of death as precisely as possible.<sup>17,18</sup> These methods for assessment of coverage can also help to estimate the completeness of civil registration data of uncertain quality; after appropriate correction, age-specific mortality rates can then be estimated.

The population census can also contribute to estimates of adult mortality by including simple questions on survival of parents of each respondent. Brass<sup>8</sup> first developed an approach to estimate adult mortality from survey information about survival of parents; the method

#### Panel 1: Estimation of maternal mortality from a census in Honduras

Maternal mortality was identified as a priority for intervention by the government of Honduras in 1992, and several exercises to measure the maternal mortality ratio have been undertaken. The 2002 census of Honduras included questions about deaths in each household in 2001, and recorded the age and sex of each deceased person. Additional questions were included for the deaths of women of reproductive age, as to whether the woman was pregnant at the time of death, died during delivery, or died in the 2 months immediately after delivery. Using such data to estimate maternal mortality ratios needs three pieces of information, each of which must be checked for accuracy, and an assumption. The three pieces of information are accurate counts of deaths of women of reproductive age, of deaths that were pregnancy-related, and of births. The assumption is that deaths that are pregnancy-related are not always recorded as such (eg, the respondent might not have known that the woman in question was pregnant) and that the magnitude of the error is about equal to the proportion of pregnancy-related deaths that are actually maternal deaths according to ICD-10. Each piece of information must be checked for accuracy; unfortunately not much can be done to check the assumption.

Experience with census questions about household deaths suggests a probability of omission of deaths. Assessment of the quality of the data is therefore essential, as is adjustment for omission, if necessary. The female deaths by age reported for 2001 were compared with population change between the 1992 and 2002 censuses using two methods, the general growth balance method and the synthetic extinct generations method.<sup>9,11</sup> These methods suggested a substantial under-reporting of household deaths, for which adjustment has been made. Reported births must also be checked; in this case reporting of births was close to correct. No formal methods exist to assess the reporting of pregnancy-related deaths, but the proportion of all deaths of women that were pregnancy-related can be expected to follow a broadly U-shaped pattern with age, and this pattern was duly seen in Honduras.

|  | Reported number or proportion | Estimated completeness or accuracy | Adjusted number or proportion |
|--|-------------------------------|------------------------------------|-------------------------------|
| Deaths of women aged 15–49 years                       | 1753                          | 0.587                              | 2987                          |
| Proportion of those deaths that were pregnancy-related | 10%                           | 1.0                                | 10%                           |
| Births   | 170 389                       | 0.996                              | 169 707                       |
| Estimated maternal mortality ratio                     | 107                           | n/a                                | 183                           |

Table 2: Maternal mortality in Honduras in 2001 recorded in the 2002 Census<sup>13</sup>

has been refined since.<sup>6,19,20</sup> The basic idea is that the proportion of respondents of a specific age whose mother or father has died will vary with the level of adult mortality. This method is attractive because the basic questions are so simple and can also be included in household surveys, but the estimates obtained are of average mortality over a long period in the past, and seem to underestimate overall mortality somewhat.<sup>13</sup>

#### Sample registration systems

Some countries have responded to inadequate civil registration by the implementation of registration of a sample of births and deaths. The best known, and probably most successful, example of this approach is the Indian Sample Registration System,<sup>21</sup> which started in 1964 and expanded to cover the whole country by 1970. In sample areas (about 7000 areas covering nearly 1% of the

**Panel 2: Verbal autopsy methods**

Demands have increased for robust, comparable data for mortality for evidence-based resource allocation and for assessment of public-health interventions in middle-income and low-income countries.<sup>14</sup> Since a functional civil registration system capable of giving robust estimates of cause-specific mortality rates does not exist in these settings, assessment of causes of death needs to be based on an alternative approach. One approach used in many settings is the verbal autopsy, whereby family members of an identified deceased person provide information about the circumstances surrounding their death. This information can consist of a check list of symptoms, a narrative description of the process leading up to death, cause of death as indicated at a health facility, or any combination of these methods.<sup>15</sup> However, the heterogeneity of verbal autopsy tools and differences in operating procedures for verbal autopsy render comparisons of data between demographic surveillance sites impossible. The need for standard verbal autopsy tools and procedures for international use has been recognised since the introduction of this method.<sup>14</sup>

Verbal autopsy methods have undergone several important developments. First, WHO in collaboration with partners has made the first step toward harmonising the cause-specific data for mortality obtained by verbal autopsy by proposing standard questionnaires for adult, child, and neonatal deaths and a core cause-of-death tabulation list that includes the categories of disease that are important worldwide and have a reasonable probability of being ascertained by verbal autopsy.<sup>15</sup> The validity of proposed standard verbal autopsy instruments will probably be similar to those that have already been validated in similar settings. However, further validation of these instruments in different settings will be needed. Meanwhile, application of a standard verbal autopsy questionnaire and core cause-of-death list should be advocated by international and national organisations to improve comparisons of data for verbal autopsy between sites. Second, an innovative technique to assign causes of death has been developed.<sup>16</sup> Estimates from this method do not need review by physicians, expert algorithms, or parametric statistical modelling, which can substantially enhance the ability to compare or reproduce the results from verbal autopsies. Further work on the procedures to ascertain causes of death from verbal autopsy is needed to improve consistency and sustainability of verbal autopsy systems. The proliferation of household surveys and the 2010 round of censuses will provide opportunities to implement verbal autopsy modules and to increase information about cause of death.

However, several operational and technical issues need to be assessed before recommending verbal autopsy modules widely in household surveys or censuses. Operationally, debate continues about whether verbal autopsy modules should be integrated in surveys or done separately after identifying deaths in the household. A trade-off is obvious between the burden imposed on respondents, when integrated, and the higher chance of loss to follow-up if implemented separately. Verbal autopsy also needs special training of people to interview and code the responses. Cost-effectiveness of different options should be carefully assessed. We also need to know how large the sample size would need to be to derive meaningful distribution of cause of death by age and sex for main causes; how large the sample size would need to be to monitor significant changes in deaths from specific causes; and what would be done if the sample was small. WHO is working with partners to develop guidelines for these issues to inform potential users of verbal autopsy modules and to enhance the consistency of cause-of-death information derived from verbal autopsy tools, and allow comparisons to be made between countries.

population), a part-time registrar records births and deaths continuously; additionally, twice a year, an independent survey team interviews all sample households, asking specifically about births and deaths in the previous 6 months. The two sets of events are then matched, and any discrepancies are investigated. The final count of events is the total of matched events plus those recorded only by the registrar plus those recorded only by the household interview. Independent evaluation suggests that the system captures about 85% of deaths.<sup>22,23</sup> Panel 3 reviews developments in the Indian Sample Registration System and in a broadly similar system (of disease surveillance points) in China. Although this system has been successful in India, sample registration systems need sophisticated administration, sustainable resources, and like civil registration systems, they are susceptible to disruption by civil unrest.

**Demographic surveillance sites**

Another approach, similar to sample registration systems in terms of actively identifying events through regular

household visits, but different in being limited to a defined geographic region and thus not necessarily representative of the national population, is the demographic surveillance site. The INDEPTH Network provides a coordination role across 37 such sites, 26 of which are in Africa, in 19 countries. The exact process of surveillance varies substantially from yearly household surveys done by interviewers to fortnightly visits to each household by local registrars. The aim is to ensure that all vital events in the period since the last visit are recorded. The population under surveillance is usually 50 000–200 000, although methods are available to establish the appropriate sample size.<sup>30</sup> The best known (and longest-lived) example of a demographic surveillance system is the Matlab site in Bangladesh. The main limitation of data from such surveillance is that they are restricted to small geographic areas, which are usually intervention trial sites with small populations, and numbers cannot be generalised reliably. Panel 4 and figure 2 show how demographic surveillance systems have contributed to health planning in Ghana.

### Panel 3: Developments in sample registration systems in India and China

The Indian Sample Registration System has recently introduced improvements to ascertainment of cause of death. Since 2001, each sample household in which a death has occurred has been visited by government surveyors to establish retrospectively, as much as possible, the underlying causes of death by an advanced form of verbal autopsy. The field staff have been trained an average of three times on how to record the symptoms, signs, and key circumstances leading to death on a two-page structured form with a brief narrative in local language. A random sample of about 10% of the units is resurveyed by an independent team as a check on the quality, completeness, and accuracy of the fieldwork. Preliminary results from several states suggest that the distribution of underlying causes of death based on the random reinterview did not differ substantially from the cause of death derived from the reports of the original supervisors.<sup>24</sup> Earlier studies in India that have used very similar methods have established reasonably high specificity, but variable sensitivity for most common causes of death in adults.<sup>25,26</sup> The assignment of causes of death includes medical assessment by two independent trained physicians who examined the field reports. Reports are assigned randomly on the basis of the language of the narrative to two of 120 physicians from all states (to increase ability of comparison between states). If the two physicians do not agree an ICD-10 code, their forms are reassigned to each other automatically (and anonymously) for reconciliation. Continuing disagreements are referred to a third senior physician who adjudicates the final ICD-10 code. Preliminary findings have examined the amount and causes of maternal mortality in India,<sup>27</sup> and reports on causes of death and specific conditions will be published in 2007.

China has also introduced improvements to the disease surveillance point system.<sup>28</sup> This system covered a nationally representative population sample scattered across the 31 provinces or autonomous regions of China. The system was almost non-functional in 2002 because of budget constraints. After an assessment in 2004, and additional resources, the system was strengthened and adjusted to improve how well it represents the population. The revised system includes 160 districts and counties scattered in all provinces, autonomous regions, and municipalities, with a population coverage of 73 million people; nearly 6% of the total population of China.<sup>29</sup> The new system has run since 2006, and will produce about 500 000 death reports annually, with the potential for population-based surveys and disease surveillance. In rural areas, about 80% of adult deaths take place at home, with few occurring at the township hospital or other tertiary hospitals in the vicinity. For deaths taking place at home, the event is reported by a village health worker to the disease prevention unit at the township hospital. A staff member from the unit visits the household, and completes a death certificate on the basis of a verbal autopsy combined with available documents from most recent contact with health services. For deaths taking place in the township hospital, disease surveillance staff collect the death certificate from the hospital, where it should have been completed by the physician who attended the death. For deaths occurring in other hospitals, relatives of the deceased submit physician-certified death certificates to the disease prevention unit at the township hospital. The disease surveillance points and civil registration systems are planned to be merged in the future.

### Demographic household surveys

One of the most important developments of the past 30 years in understanding levels and trends in worldwide child mortality has been the internationally coordinated demographic household survey programme. The first such programme was the World Fertility Survey<sup>33</sup> implemented in the 1970s and early 1980s with surveys in more than 40 countries, and has since been followed by the Demographic and Health Surveys (DHS) and UNICEF's Multiple Indicator Cluster Survey programmes. Almost all countries with inadequate civil registration have done sample surveys of households in one or other of these programmes, which provide most of what we know about levels and trends in infant and child mortality in such countries.<sup>34</sup> A key strength of the DHS programme has been rapid publication of results and access to data for individuals, which has enabled a wide range of analyses.

The main innovation of these surveys is the widespread use of a full birth history, whereby every sampled woman (in some settings limited to ever-married women only) is asked about the date of birth of each of her liveborn children, whether the child is still alive, and if not, how old the child was at death.

These data permit the calculation of both fertility rates and child mortality rates for the past 15–20 years. Cross-national analyses of associations between child mortality risks and both socioeconomic (eg, maternal education and household economic status) and biodemographic (eg, preceding birth interval or age of mother) variables are especially useful.<sup>35,36</sup>

These surveys typically include small but nationally representative samples of 3000–30 000 households (although three such surveys in India have included about 90 000 households). The small samples allow for careful monitoring of the quality of data, but restrict the ability to make precise estimates of some indicators for subnational areas or population subgroups; for example, even the very large samples in India were unable to quantify trends in maternal mortality between 1992–93 and 2006 reliably because of a large margin of error.<sup>27</sup>

Data from these surveys are useful for assessment of the performance of civil registration systems. Figure 3 shows a comparison of the estimates of under-5 child mortality from two household surveys in Azerbaijan to estimates from civil registration, clearly showing the high level of under-reporting of deaths in the civil registration system.

#### Panel 4: Demographic surveillance systems in practice in Ghana

Demographic surveillance systems continuously record longitudinal demographic data, usually within small geographically defined populations. These systems start with an initial census to define the baseline denominator population and thereafter continuously monitor this population at well defined periods of time to record changes or events that take place in the initial population.

Although the length of follow-up varies, three times a year is typical. During these routine visits, vital events such as births, deaths, migrations, and in some cases pregnancies are registered and monitored.<sup>31</sup> Deaths recorded by field workers are followed up with verbal autopsy interviews using standardised interview protocols.<sup>32</sup>

In Ghana, three demographic surveillance sites are strategically located in the north (Navrongo), the central belt (Kintampo), and the coast (Dodowa) (figure 2). The three sites cover entire districts with a total population of nearly 400 000. Together, these sites provide representation of the main ecological divisions of the country. Data gathered at these sites could therefore be said to fairly represent the main ecological or geographical zones of Ghana. All three sites are administered by the Ghana Health Service and work closely with the respective district health services. The three sites are members of the INDEPTH Network and thus collaborate closely with one another in technology sharing and transfer, including strengthening or building of capacity.

Coverage of vital events in the demographic surveillance areas is almost 100% because all households are visited at least three times a year and births, deaths, and migration events are recorded. Verbal autopsy to ascertain cause of death is done for all deaths reported. Other demographic or health-related data such as pregnancies are also recorded. Demographic surveillance data therefore constitute one of the most reliable and perhaps, in the current circumstance of low civil registration coverage, the most important source of health information in Ghana. The Ghana Health Service launched a programme in 2004 for transforming clinic-based primary health care and reproductive health services to community-based health services based on results of an experiment done by the Navrongo Health Research Centre at the Navrongo site. Known as the Community-based Health Planning and Service, the programme promotes the idea that communities can be active participants in the provision of their own health care. It places community health officers and volunteers in all 138 districts of Ghana to provide basic health services to all communities. The community health officers and volunteers live and work in the communities, providing door-to-door services to individuals within households.

For more on the INDEPTH Network see <http://www.indepth-network.org>

For more on the Ghana Community-based Health Planning and Service see <http://www.ghana-chps.org>

In 1991, DHS introduced a maternal mortality module into selected surveys. This module collected a complete history of siblings (ie, for each sibling born of the same mother, the age of those still alive and the year and age at death for those that have died), essentially a complete birth history of the respondent's mother. For sisters

who had died between the ages of 15 and 49 years, further questions on the timing of death relative to pregnancy were asked to identify pregnancy-related deaths. The sibling history theoretically permits the estimation of overall mortality for men and women from birth to age 50 years and the estimation of pregnancy-related mortality ratios.<sup>39</sup> Analysis of DHS sibling histories has suggested that overall mortality and pregnancy-related mortality ratios were generally under-estimated.<sup>39,40</sup>

#### Potential uses of incomplete data

Although civil registration systems in developing countries frequently fail to record all events, incomplete data that are available can still be used (although it is often not tabulated because of concerns about quality). We have discussed above the analytic methods for assessing the completeness of registration of adult deaths; if reporting is complete enough for the recorded deaths to be plausibly representative of all deaths in terms of age distribution (Preston<sup>41</sup> suggests a minimum level of completeness of around 60%) the data can be adjusted to give largely unbiased estimates of adult mortality.<sup>12</sup> About 40 developing countries might have sufficiently complete data to make reliable estimates.<sup>2</sup> Other examples of uses for incomplete data exist also. Civil registration is usually more complete in cities, especially capital cities, of developing countries than it is in rural areas. Analysts have taken advantage of such data to examine issues such as seasonal variation in mortality and the effects of HIV on mortality.<sup>42,43</sup>

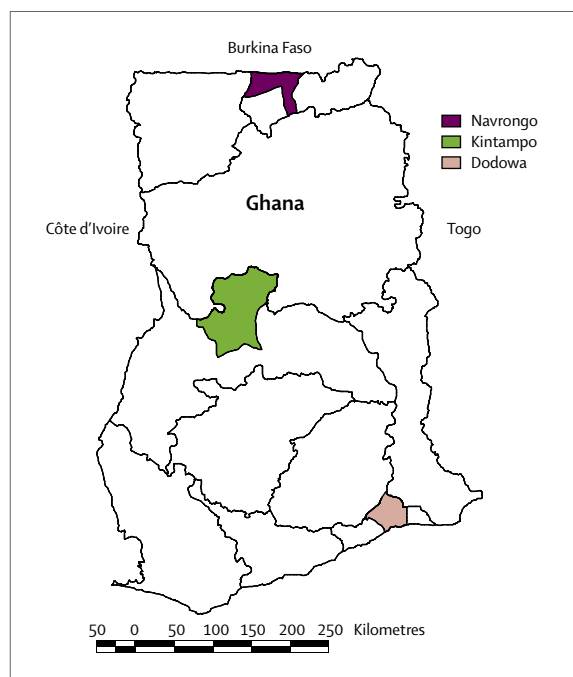


Figure 2: Demographic surveillance sites in Ghana

Incomplete information about cause of death from hospital records provides an alternative approach to the use of verbal autopsy; even though recording of cause of death in hospitals is far from perfect in countries with inadequate statistical systems, the recorded cause has substantial information content, especially if assessed in combination with case notes. However, deaths occurring in hospitals (or other facilities in which cause of death can be established with some degree of validity) cannot be regarded as a random sample of all deaths in a population. They will be biased by various characteristics, including the underlying cause of death. However, if the selection process can be satisfactorily modelled, the recorded distribution can be weighted appropriately to calculate a distribution representative of the whole population. Information from hospital records also gives valuable insights into both underlying or multiple causes of death, which is increasingly relevant in view of the rising proportion of non-communicable diseases worldwide.

## Modelling

Models of age patterns of mortality have a long history. The potential value of such models rests on the empirical observation that human mortality systematically varies with age: it is high in infancy, drops to a minimum around age 10 years, and then increases exponentially with age. This regular pattern has given rise to the development of many model life-table systems, mostly on the basis of the historical experience of countries that now have low mortality.<sup>5,44,45</sup> One contemporary problem with such models is the difficulty in incorporating excess AIDS mortality in a simple way.

Models have also been developed for calculating distributions of deaths by cause. Initially, simple linear models were developed to predict the relationship between overall mortality and structure of deaths by cause.<sup>46–48</sup> Subsequent compositional models that allowed for prediction of non-linear relationships,<sup>49–51</sup> have further refined the estimation of the distributions by cause of death of children aged under 5 years.<sup>51,52</sup> Disease models have also been developed to predict mortality from cancer dependent on its incidence.<sup>53,54</sup> Although models are useful to assess the plausibility of local data from verbal autopsy or civil registration, models are neither a substitute for reliable directly-obtained data for mortality nor are they useful for monitoring trends over time.<sup>55</sup>

Methods of estimating the quality of data for cause of death exist, with reallocation algorithms applied to senility and ill-defined causes, including vague diagnoses of cancer and cardiovascular diseases,<sup>49</sup> and police records have been used to correct vital registration data for traffic crashes. The joint application of disease modelling with prudent interpretation of locally available data can yield useful estimates of cause-of-death patterns for a population.<sup>49,56</sup>

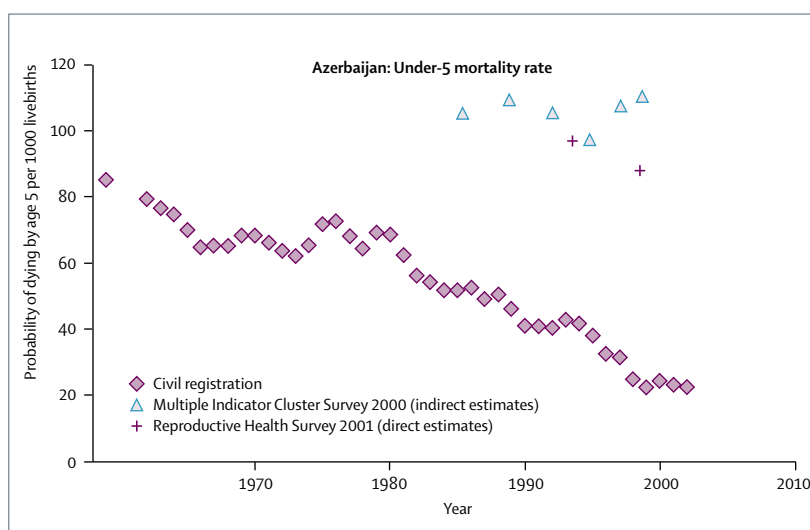


Figure 3: Mortality rates of children aged under 5 years in Azerbaijan recorded by civil registration and household surveys<sup>4,3738</sup>

## Complementary methods for obtaining data

The discussion of interim measures should not be interpreted to mean that a fully developed health information system can rely exclusively on civil registration data combined with denominators from censuses or population registers. Such data provide an essential basis for descriptive epidemiology, but need supplementation for in-depth analyses and also need periodic validation.

A particular shortcoming of civil registration data is the absence of good socioeconomic information. Linking of death records to earlier survey information, as in the National Death Index in the USA,<sup>57</sup> has proved especially useful by providing characteristics of individuals for several years before their death, thus converting cross-sectional data into prospective data.

Also missing from civil registration data is information about risk factors and the health status of living people, such as is provided by health examination surveys such as the National Health and Nutrition Examination Survey or interview surveys such as the National Health Interview Survey in the USA. Thus, survey programmes are an essential component of fully developed systems, and they provide interim mechanisms for countries with inadequate systems.

## What interim methods cannot do

Inevitably, interim solutions described here cannot fulfil all functions. By their nature, interim approaches generally rely on retrospective reports of events; they are thus prone to selection bias. For example, both full and summary birth histories exclude births and deaths of children of women who have died. Any strong association between the risk of death of the child and that of the mother will bias estimates of child mortality and distort associations with predictor variables.

Similarly, retrospective reports cannot give timely warning of mortality crises: by the time a census or survey has been done, the crisis, be it a famine or genocide, will usually have happened a long time ago. Sample registration might identify a crisis, but the nature of the system of obtaining and checking data, such as that used by the Indian Sample Registration System delays access to timely results. Sample sites might entirely miss health events because of the sampling design or choice of sample population. A demographic surveillance site might provide useful information (an example is the analysis of the demographic effects of civil war in Bangladesh in 1971<sup>58</sup>), but generally inadequate access to data and poor representation of a population by such data are drawbacks. Continuous monitoring of vital events with medical certification of deaths through a civil registration system is the only satisfactory mechanism.

### Conclusions and recommendations

The interim methods for estimation of vital statistics discussed here have largely been developed in the past four decades as cost-effective alternatives for deriving demographic estimates in the absence of civil registration. Substantial progress with these methods means that we now know much more than before about the demography and descriptive epidemiology of populations across the world. Necessity has truly been the mother of invention for this subject, since much of this achievement has been in response to the absence in many poor countries of the optimum information source, namely a fully functioning civil registration system.

However, these methods are not alternatives to each other, and should not be viewed as such, but as complementary with powerful synergistic potential. Although they are substitutes and interim measures in the world's poor countries, such surveys and methods also continue to have a valuable role in providing a range of information that is complementary to that of civil registration in those countries fortunate enough to have fully developed statistical systems and they can also be used as independent validation and quality controls for civil registration systems. Thus, state-of-the-art health information systems consist of two complementary parts, first a universal and effective civil registration system, and second, a variable range of information from censuses and sample surveys in addition to civil registration systems.

Most of the world's poor countries already have the second part in place today through external technical assistance and funding; in fact, this part of the system is the more intellectually advanced and technically difficult of the two. These countries need investment only in the basic, less demanding part (civil registration) to rapidly achieve health information equality with the most advanced countries in the world. Such equality is a substantial development that is worth the effort. The

development of these data sources and application of methods of assessment and estimation has resulted in a substantial body of workers around the world, in government, academia and the private sector, with highly relevant skills and experience who are able to assist countries now seeking to improve or build their civil registration systems. The existence of this human capital provides a unique opportunity for the world's poorest countries to leapfrog to a position of technological equivalence with the most developed countries in terms of their health and demographic information systems.

The incentive to complete such a system is large for both poor countries and the world's development agencies, because having both civil registration and complementary systems running together, as the world's developed countries do, results in great synergy. Thus, the crucial decision that we advocate is not investment in civil registration systems around the world so that all alternative systems can be abandoned as mere interim measures that will no longer be needed. On the contrary, the technical capacity built in the past several decades to create and refine these alternative systems will be crucial for establishing, improving, continually monitoring, and adding value to civil registration systems in poor countries. Groups that have invested in making the alternative systems work should be asked for support and leadership for building these civil registration systems, which will complete the information goals they have been striving towards.

International organisations need to maintain a leading role in supporting coordinated survey programmes such as DHS and in both encouraging countries to include relevant questions in their censuses and surveys and in supporting those countries with analysis of obtained data. A stronger research effort than at present is needed to improve methods of estimating mortality, and the ascertainment of cause of death by standardised verbal autopsy instruments or by incomplete information about cause of death from health facilities. Despite the need for such progress, for many countries we now have enough information to be reasonably confident about mortality estimates in populations, or at least about the probable extent of uncertainty in the estimates. We might all take solace in the words of Major Greenwood, who commented more than half a century ago that: "making the best the enemy of the good is a sure way to hinder any statistical progress. The scientific purist who will wait for medical statistics until they are nosologically exact, is no wiser than Horace's rustic waiting for the river to flow away".<sup>59</sup>

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