Counting births and deaths 3

A global assessment of civil registration and vital statistics systems: monitoring data quality and progress

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Increasing demand for better quality data and more investment to strengthen civil registration and vital statistics (CRVS) systems will require increased emphasis on objective, comparable, cost-effective monitoring and assessment methods to measure progress. We apply a composite index (the vital statistics performance index [VSPI]) to assess the performance of CRVS systems in 148 countries or territories during 1980–2012 and classify them into five distinct performance categories, ranging from rudimentary (with scores close to zero) to satisfactory (with scores close to one), with a mean VSPI score since 2005 of 0·61 (SD 0·31). As expected, the best performing systems were mostly in the European region, the Americas, and Australasia, with only two countries from east Asia and Latin America. Most low-scoring countries were in the African or Asian regions. Globally, only modest progress has been made since 2000, with the percentage of deaths registered increasing from 36% to 38%, and the percentage of children aged under 5 years whose birth has been registered increasing from 58% to 65%. However, several individual countries have made substantial improvements to their CRVS systems in the past 30 years by capturing more deaths and improving accuracy of cause-of-death information. Future monitoring of the effects of CRVS strengthening will greatly benefit from application of a metric like the VSPI, which is objective, costless to compute, and able to identify components of the system that make the largest contributions to good or poor performance.

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This is the third in a Series of four papers about counting births and deaths

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Introduction

Well functioning civil registration and vital statistics (CRVS) systems provide governments with reliable and up-to-date information about the number of births and deaths, and causes of death, in their populations, which enables them to deliver health and social development programmes more effectively.[1] However, many low-income and middle-income countries have registration systems that cover only part of the population, with no cause of death data for those dying outside hospitals and no routine compilation of data for analysis, dissemination, and policy purposes.[2–4] Although donors and development agencies have recognised the need for vital statistics to monitor the millennium development goals (MDGs), international support for improvement of CRVS has been underfunded and poorly coordinated. Few methods and strategic approaches have been available to improve CRVS systems, and the absence of global and regional leadership has led to widespread inertia in development of CRVS systems. Further, absence of a global database and globally applicable framework to cost-effectively monitor and

Search strategy and selection criteria

The search strategy included a search of websites of international health and development agencies with mandates covering aspects of civil registration and vital statistics (CRVS), a search of relevant electronic databases (PubMed and Google Scholar), scanning of reference lists from relevant published studies, study of conference proceedings, and direct contacts with technical and in-country experts for references to relevant publications and grey literature. Preference was given to papers with a focus on low-income and middle-income countries and that addressed CRVS in a systemic way. Exclusion criteria were a reference period before 2000 and the production of vital statistics from sources other than the civil registration system.

Key messages

- Global progress with civil registration and vital statistics (CRVS) systems in the past 30 years has been disappointingly slow, despite their importance for population health and human development
- Evidence from some countries suggests that rapid and sustained progress is possible with the key components of a CRVS system, such as registration completeness, cause-of-death data quality, and the level of detail on causes of death that is available
- Death registration completeness has improved only modestly, but system development progress has led to an increase in the number of deaths recorded by systems able to reliably assign a cause of death
- Results from the specific component analysis of national CRVS systems suggest that efforts to improve completeness of registration, report causes of death in more detail (eg, age and sex, and more detailed cause lists), and strengthen cause of death certification practice will have the greatest immediate benefit for CRVS improvement strategies
- Monitoring the effect of CRVS strengthening activities will greatly benefit from performance index metrics that identify the largest contributors to poor and good performance

assess national CRVS systems has hindered efforts to advocate and build more reliable CRVS systems.[2]

Monitoring CRVS progress

In view of the increased demand for better vital statistics, and the investments that will need to be made both by governments and donors, there is obvious interest to ensure that CRVS strengthening activities are working, and that systems are improving according to plan.[5] We might reasonably expect, therefore, that funding the new regional CRVS strengthening plans that Abouzahr and colleagues[2,3] describe will need more than simply assessment of whether planned activities have taken place, or not, or whether countries have taken substantial steps towards establishment of a system of registration and certification of births, deaths, and causes of death.[6] Rather, for maximum effect, each regional plan will need an accountability framework with specific, measurable indicators that can reliably and efficiently ascertain whether the implemented activities have had the desired effect.[7] The ability to track and prove global progress will be crucial, especially for the 2015 sustainable development agenda.

So far, CRVS performance has been assessed by three broad approaches:[8] expert reviews,[9–18] country self-assessments,[19,20] and external assessment of CRVS output.[21–25] Each approach has advantages and limitations. The regional CRVS plans are based on the application of, and evidence produced by, the WHO and University of Queensland (UQ) assessment methods[1,3,20] and the lessons learnt[26–30] in countries. Although these methods enable country stakeholders to jointly assess the entire CRVS system (inputs, processes, and output) the self-assessment approach used means that some subjectivity is unavoidable.

Most attempts to assess CRVS sytems globally have focused on one aspect of the system, such as birth registration coverage[15,31] or coverage and quality of cause-of-death certification.[4,32] Since 1999, UNICEF has included a question in its multiple indicator cluster surveys done in about 50 low-income and middle-income countries that asks mothers about the registration status of their children under the age of 5 years. Similar information has likewise been recorded as part of the Demographic and Health Surveys (DHS) platform. However, although the estimates derived from these two survey programmes provide insights into the proportion of children in this age group whose births have been registered,[31] the year of registration is needed to calculate standard birth registration rates. Furthermore, as acknowledged by UNICEF,[15] what mothers report as registered might differ greatly from what civil registration reports because of confusion between the birth notification paper (delivered by the health facility or doctor) and the birth registration certificate. Based on data around 2009, the WHO undertook a global assessment[32] of the quality of cause-of-death data, classifying countries into three categories on the basis of use of International Classification of Diseases (ICD) 9 or 10, coverage levels, and the proportion of ill-defined causes,[32] but did not quantify the effects of these factors on data quality or make a composite index. The only agency that routinely collects information for both birth and death registration is the UN. However, the country coverage is incomplete, and the data have methodological problems because many countries report according to the year in which registration took place and not the year in which the event occurred. Therefore, these data cannot be used to correctly calculate registration coverage for any specific birth or death cohort.[33]

A major limitation of these sources of CRVS performance is that none can effectively and reliably be used to monitor global progress with CRVS systems development. To critically appraise development, quality, and policy utility of CRVS systems, we apply a new composite indicator[8] that objectively assesses system performance on the basis of mortality data generated from CRVS systems worldwide. No other CRVS assessment method based on output data has used a composite metric to empirically summarise system performance.

Measurement of CRVS performance

Methodological research suggests that the performance of CRVS systems, which includes utility of data produced, can be adequately measured by a single composite metric, the vital statistics performance index (VSPI).[8] The VSPI assesses CRVS performance through use of mortality data as a proxy for the quality and utility of all of the vital statistics produced by the civil registration system. This proposition is justified by the observation that birth registration levels are generally higher than those of death registration.[33]

The VSPI was computed on a continuous scale from zero to one for each calendar year of vital statistics data that have been reported since 1980 and are publicly available for a country. A value of one or close to one signifies that the data for that country in that year (country-year records) accurately represent the epidemiological profile of the population from which they are generated, and are fit for policy use, whereas a value of zero indicates that data are unrepresentative of the epidemiological profile in that population and thus are of little or no use for policy.

Description of the six VSPI components

The VSPI metric comprises six components: completeness of death reporting, quality of death reporting, level of cause-specific detail, internal consistency, quality of age and sex reporting, and data availability or timeliness, each of which captures a different aspect of data accuracy or utility.[8] A key characteristic of the utility of all CRVS systems is the extent to which they cover the entire population and register all births and deaths. The completeness estimate of the VSPI is generated by a combination of adult and child mortality estimates and the registered numbers of deaths. A frequently used measure of quality of cause of death reporting is the

proportion of ill-defined deaths.[34] The VSPI uses the broader concept of so-called garbage coding from the Global Burden of Disease (GBD) lexicon, with further classification of ill-defined codes into entirely meaningless (such as ill-defined causes) or somewhat meaningful (such as malignant neoplasm of unspecified site).[35,36] To meet the needs of public health planners, a minimum level of detail of the cause of death list is needed. The indicator measures the number of separate categories of cause of death reported compared with the GBD 2010 cause list of 192 individual categories.[37] Another component of data quality assessed is internal consistency, namely, the extent to which reported causes are biologically plausible. Missing data for age and sex of the decedent (ie, demographic characteristics) contribute to decreased data utility. Finally, an often overlooked component of CRVS performance is public availability and timeliness of data. This timeliness is captured by a weighted smoothing algorithm that emphasises consistent and recent data availability over intermittent and untimely data.

Data sources

The data used to calculate the VSPI score and the six quality components for each country were extracted from the mortality database of the GBD 2010 Study[37] (last updated for GBD 2013 Study). This database is the most comprehensive database for human mortality assembled so far, and makes use of publicly available sources from

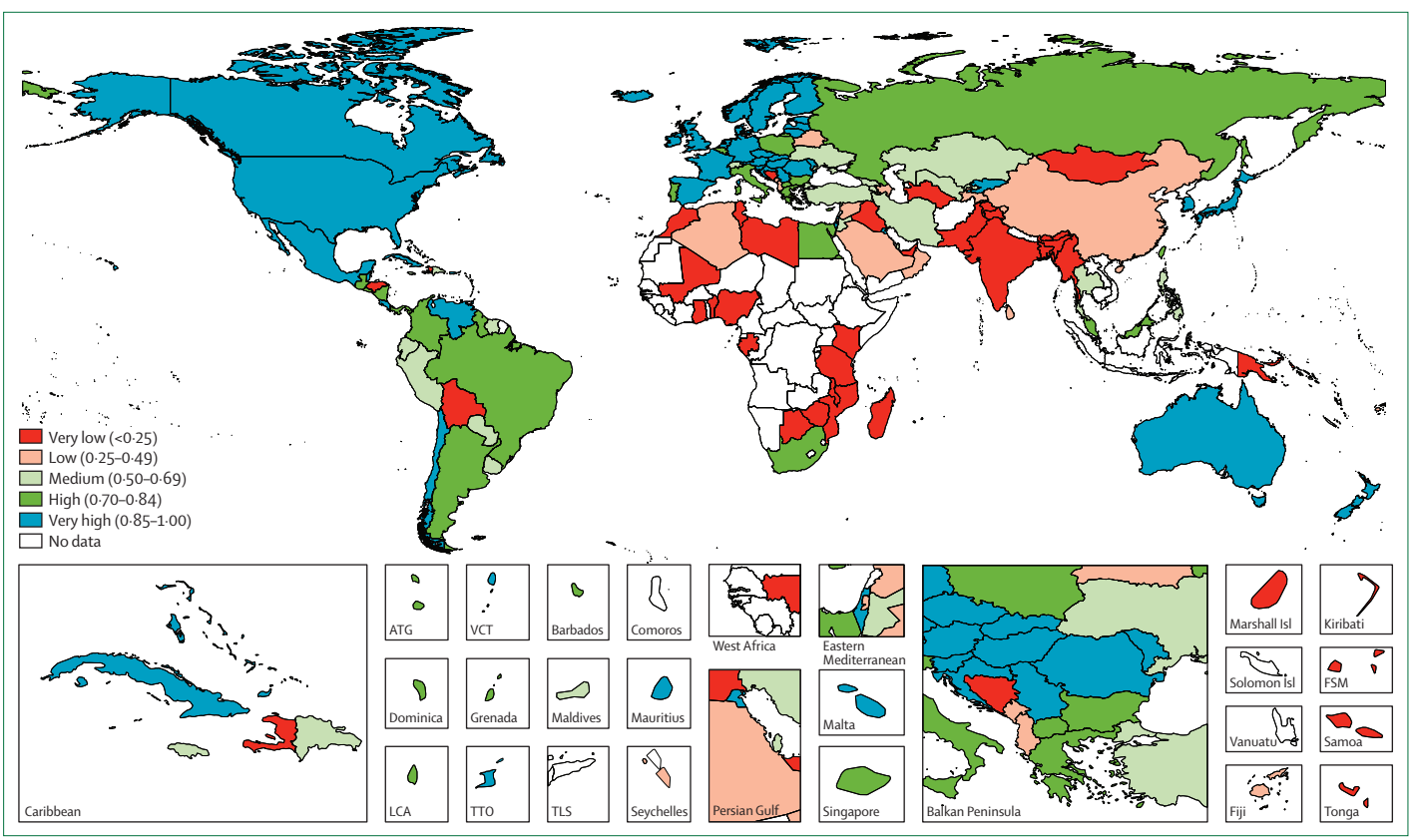

Figure 1: **Typology of civil registration and vital statistics (CRVS) systems on the basis of vital statistics performance index (VSPI) scores for best available year between 2005 and 2012**
ATG=Antigua. VCT=St Vincent. LCA=Santa Lucia. TTO=Trinidad and Tobago. TLS=Timor Leste. FSM=Federated States of Micronesia. Group 1: (Very high VSPI ≥0·85) includes 46 countries with satisfactory death registration systems capable of producing data of sufficient quality for public health, research, and planning purposes. Most of these countries are in Europe, North America, and Australasia, all regions with a long tradition of civil registration. Some, however, are low-income and middle-income countries from Latin America and the Caribbean (Chile, Cuba, and Venezuela), the Middle East (Kuwait), Africa (Mauritius), and Central Asia (Kyrgyzstan). All are characterised by death registration completeness close to 100%, and with sufficiently reliable and detailed cause-of-death data for most public health purposes. Mortality statistics in these countries are generally timely and publicly available. Group 2: (High VSPI 0·70–0·84) includes 28 countries with well functioning systems; all are typically able to register most deaths but their mortality data are less timely and include more ill-defined and unspecified causes of death. Most of the countries in this group are from Europe (eg, Belgium, Bulgaria, Greece, Italy, Macedonia, Poland, Portugal, and Russia) and Latin America (eg, Argentina, Brazil, Colombia, and Guatemala), and some countries or territories from Asia (eg, Hong Kong, Malaysia, Singapore, and Taiwan) and Africa (Egypt and South Africa). Group 3: (Medium VSPI 0·50–0·69) includes 21 countries in which the CRVS systems are operational but do not have complete population coverage and the detail, and quality of mortality data are less useful for policy; moreover, data are not consistently made available. This group primarily comprises countries from central Asia (eg, Armenia, Kazakhstan, Georgia, Ukraine, and Uzbekistan), southeast Asia (eg, Thailand and Philippines), the Middle East (eg, Iran, Jordan, and Turkey) and Latin America (eg, Ecuador, Peru, Paraguay, and Uruguay). Group 4: (Low VSPI 0·25–0·49) includes 14 countries or jurisdictions with CRVS systems that are still evolving with respect to registration completeness and quality of data. This group includes Albania, Algeria, Azerbaijan, Belarus, Bosnia, Brunei, China, Fiji, Montenegro, Oman, Palestine, Sri Lanka, Syria, and Tajikistan. China has made substantial progress with its CRVS system in recent years. Group 5: (Very low VSPI <0·25) includes 39 countries primarily from south Asia and southeast Asia, including the large populations of Bangladesh, India, Myanmar, and Pakistan, several from Africa (Ghana, Kenya, Libya, Morocco, Tanzania, and Zimbabwe), one from South America (Bolivia), and some Pacific Island populations (Kiribati, Marshall Islands, and Tonga). Most of these countries only report data sporadically and for only a fraction of all deaths that occur. Any cause-specific mortality data reported from these countries usually comes from hospitals. For the remaining 60 or so countries, most of which are in Africa, civil registration systems are either non-existent or so weak that data are not compiled or reported.

countries, including data recorded by WHO, the UN, and from statistical and research publications. The mortality data selected for this analysis were limited to data derived from civil registration, or from hospital reporting systems, in countries with poorly functioning registration systems. Additionally, systems that do not record (or report) cause-of-death data but only register deaths by age and sex (16% of all country-year records) have been included in this global analysis.

CRVS performance in countries between 1980 and 2012

We calculated the VSPI and its components for each of the 3507 country-years of vital statistics available for 148 countries and territories between 1980 and 2012. We chose 2012 as the most recent year to include to give countries up to 2 years to finalise processing and dissemination of their vital statistics. The availability of data for countries ranged from 1 year (eight countries) to all 33 years (14 countries). We classified populations into five categories of CRVS performance on the basis of the best VSPI score since 2005 (figure 1). Use of the best, rather than the most recent, score enables systems to be judged on their demonstrable CRVS capability, recognising that this capability might be affected by temporary data-processing problems, organisational issues, or external factors.

The historical European model, in which national civil registration systems have developed over hundreds of years, has induced pessimism about the prospects of rapid progress with CRVS systems in low-income and middle-income countries.[38] 5-yearly average country scores for a 32-year period suggest that this is not necessarily the case (table). Indeed, some countries have shown that substantial system improvement is possible within a decade, through a combination of government commitment, strategic application of CRVS tools and methods, innovation, and increased demand for data.

Although most countries that have the strongest performing systems at present (VSPI ≥0·85) had well functioning systems in the 1980s, some did not, and have made substantial and consistent progress since then (eg, the Baltic States, Belize, Brazil, Costa Rica, Croatia, El Salvador, the Republic of Korea, Kyrgyzstan, Mexico, Moldova, Macedonia, Slovenia, and South Africa). Systems in other countries began to improve later (after 2000), such as Bahrain, Cyprus, Egypt, Iran, Jordan, Malaysia, Maldives, Nicaragua, Qatar, and Saudi Arabia, showing that substantial CRVS progress is possible in less than a decade; indeed, system improvements in China, Fiji, Oman, Taiwan, and Turkey suggest that substantial progress is possible in 5 years.[8,39] Countries in which CRVS system performance has not improved in the past 30 years (based on publicly available data) include Burma, Libya, Zimbabwe, and some Pacific Island countries. Some countries, having attained functional CRVS systems in the 1990s, have struggled to make further progress, including Armenia, Dominican Republic, Georgia, Grenada, Jamaica, Paraguay, Peru, the Philippines, and Sri Lanka. Of even greater concern, CRVS system performance in many of the former Soviet states has declined, notably in Azerbaijan, Belarus, Kazakhstan, Tajikistan, and Turkmenistan.

The vital statistics performance of a CRVS system depends on the quality of data produced, which is collectively captured by the first five components of the VSPI, and availability and timeliness of the data, which are measured by the last component. Importantly, VSPI scores can be affected by organisational or political factors and policies that disrupt or delay the availability of data, which decrease the VSPI score for reasons other than data quality.[40]

Contribution of data quality components to CRVS performance

Although the composite nature of the VSPI enables assessment of overall CRVS performance, the individual scores for each of the six components of the composite metric identify the major determinants of change or stagnation in the vital statistics output. For countries with weaker systems, improvement of registration completeness through interventions such as effective integration of community health workers in notification of vital events, application of mobile phones and other related information and communication technology (ICT) innovations that enable real-time tracking of vital events across the country, should be given higher priority than other improvement measures. Of the six quality components of the VSPI, implementation of measures to improve completeness is likely to be more complex and time-consuming than the technical interventions available to improve the scores of other components. For example, purposeful and strategic initiatives to train doctors in correct medical certification, adoption of the standard international cause-of-death certificate, and use of more detailed cause-of-death lists to improve the policy relevance of CRVS data are all cost-effective interventions that countries can implement in a fairly short period of time to improve the quality of cause-of-death statistics (as has been done in some countries).

More information about the individual contribution of specific quality components (registration completeness, cause-of-death data quality [garbage coding], demographic information about decedents, implausible diagnoses, and amount of cause of death detail) to each country's VSPI score can be found in a paper by Phillips and colleagues.[8] Among countries with poor system performance (VSPI <0·70), three components (registration completeness, cause of death detail, and data quality) account for much of the observed weakness, providing very clear policy guidance about priority interventions; only weaker systems (VSPI <0·50) show evidence of incorrect reporting of sex or age of decedents or biologically implausible diagnoses.

	1980–84	1985–89	1990–94	1995–99	2000–04	2005–09	2010–12
Afghanistan	..	..	..	..	..	..	..
Albania	0·0	16·1	42·1*	60·7	59·0	27·1†	5·3†
Algeria	9·4*	6·0*	4·4*	3·2*	4·4*	23·1*	15·1*
Andorra	0·0	0·0	1·6*	2·3	1·5*	6·5*	7·0*
Angola	..	..	..	..	..	..	..
Antigua and Barbuda	11·2*	45·0	70·2	77·7	81·0	82·1	52·4
Argentina	85·4	84·8	84·6	83·7	81·9	80·7	66·5*
Armenia	11·5*	31·2	43·1	45·6	46·6*	32·9*	45·7
Australia	93·9	93·8	93·7	93·0	92·5	92·0	86·7
Austria	90·5	90·1	90·0	89·1	87·5	91·1	86·0
Azerbaijan	12·5*	31·9	41·8†	41·6	38·6†	27·1*	13·5*
Bahamas	66·4*	48·2*	27·9*	66·7	82·0	84·1	40·1
Bahrain	7·0*	14·8*	10·2*	10·6*	37·0	58·6	39·3*
Bangladesh	0·0	0·0	0·0	0·0†	0·0	0·0	0·0
Barbados	78·5	79·0	80·8	52·5	51·4	75·5	37·5
Belarus	21·1*	39·5	50·8	45·7*	48·6*	33·3*	28·9*
Belgium	82·7	84·1	85·5	86·8	56·1*	75·3	69·6
Belize	63·6	50·3*	48·9*	65·0	79·3	85·2	54·9
Benin	0·0	0·0	0·0	0·1†	0·1†	0·0	0·0
Bermuda	72·0*	79·9	89·5	89·6	89·1	83·8*	41·7*
Bhutan	0·0	0·0	0·0	0·0	5·5†	6·0	4·0
Bolivia	0·0	0·7*	0·9	0·1	21·9	16·8†	4·4
Bosnia and Herzegovina	1·2*	41·5	56·7	13·2*	9·2*	10·1*	19·0*
Botswana	0·0	0·0	0·0	0·0	0·0	6·2†	4·5
Brazil	65·8	65·5	67·6	71·5	75·3	79·9	68·8*
Brunei Darussalam	3·6*	9·0*	8·8*	21·6*	30·8*	22·5*	35·8*
Bulgaria	84·9	86·1	85·3	83·8	80·3	82·0	82·9
Burkina Faso	..	..	..	..	..	..	..
Burundi	..	..	..	..	..	..	..
Cambodia	..	..	..	..	..	..	..
Cameroon	..	..	..	..	..	..	..
Canada	93·2	92·3	90·5	89·1	89·0	90·8	60·6*
Cape Verde	18·4*	7·0*	4·1*	1·6*	0·9*	0·2	0·0
Central African Republic	..	..	..	..	..	..	..
Chad	..	..	..	..	..	..	..
Chile	85·3	86·2	87·0	88·1	89·0	90·6	60·4*
China	0·0	0·0	0·2	0·5	0·7†	7·3†	28·6
Colombia	73·3	76·1	77·5	78·3	82·7	80·1*	40·1*
Comoros	..	..	..	..	..	..	..
Congo (Brazzaville)	..	..	..	..	..	..	..
Costa Rica	80·0	85·0	85·7	87·8	89·7	90·2	84·9
Côte d'Ivoire	..	..	..	..	..	..	..
Croatia	0·0	41·1	75·1	82·7	85·5	87·0	88·8
Cuba	91·2	90·8	90·9	89·8	88·2	90·5	74·3
Cyprus	10·8*	10·7*	10·7*	11·7*	20·6*	60·5	76·6
Czech Republic	10·3*	39·5*	82·2	88·8	89·0	89·7	90·3
Democratic Republic of the Congo	..	..	..	..	..	..	..
Denmark	80·2	65·8	63·2	78·5	87·3	88·2	82·7
Djibouti	..	..	..	..	..	..	..
Dominica	67·5	68·9	70·4	70·8	70·8	79·1	67·9
Dominican Republic	54·1	58·1	50·6	47·7	49·0	50·9	40·8
Ecuador	82·5	79·0	75·5	71·5	68·8	65·3	51·6

(Table continues on next page)

	1980–84	1985–89	1990–94	1995–99	2000–04	2005–09	2010–12
(Continued from previous page)							
Egypt	40·4*	19·2*	27·9*	16·5*	41·6	67·9	68·5
El Salvador	29·6*	28·7*	38·8*	56·8	69·6	73·5	48·0*
Equatorial Guinea	..	..	..	..	..	..	..
Eritrea	..	..	..	..	..	..	..
Estonia	21·3*†	38·9†	53·6†	80·0	91·7	93·5	94·5
Ethiopia							
Fiji	9·0*	7·1*	2·8*	5·3*	14·0*	8·1	25·3
Finland	81·2	73·4	89·5	93·7	94·5	95·1	90·0
France	83·0	83·9	84·8	84·6	84·7	86·4	72·0*
Gabon	0·0	0·0	0·0	0·0	0·5†	1·0†	0·3
Georgia	12·4*†	32·2†	39·3*†	41·4†	52·3*	53·4*	42·4*
Germany	86·5	86·9	87·8	88·5	88·9	89·5	89·8
Ghana	0·0	0·0	0·0	0·0	2·1	1·1	0·7
Greece	84·2	83·1	81·5	81·0	78·6	76·5	65·8
Grenada	6·7*	24·5*	58·5	59·4*	46·7*	76·0	67·1
Guatemala	71·2*	58·9*	79·9	81·8	73·1	74·2	49·0*
Guinea	..	..	..	..	..	..	..
Guinea-Bissau	..	..	..	..	..	..	..
Guyana	8·2*	21·8*	63·5	77·2	62·9	70·7	44·2
Haiti	1·5*	0·6*	0·2*	0·5	5·0	4·9	1·0
Honduras	37·6	19·9	23·0*	5·0	0·6	0·1	0·0
Hong Kong	85·8	86·1	86·0	83·6	81·9	82·5	77·2
Hungary	93·7	93·0	92·8	93·6	94·9	95·4	95·7
Iceland	91·5	92·6	91·2	90·5	91·2	91·3	60·6*
India	20·5	13·7	14·5	8·2	4·9	4·6*	3·8*
Indonesia	..	..	..	..	..	..	..
Iran	9·1	7·2*	3·4*	8·3*	30·4†	50·7	45·6
Iraq	0·0	1·3*	2·0	0·3	0·0	5·2	9·4
Ireland	91·5	91·6	91·5	90·5	86·9	85·3	72·7
Israel	86·2	86·6	87·2	87·9	88·5	88·5	84·2*
Italy	86·3	86·3	86·5	86·5	81·7*	64·1*	65·5
Jamaica	62·2	69·4	51·2	11·7*	40·0	53·5	15·7
Japan	88·3	87·8	86·8	88·1	88·8	88·0	81·9
Jordan	1·1*	0·6*	0·8*	0·5*	3·3	39·4	45·2
Kazakhstan	13·6*	36·3	62·4	80·3	68·7	50·0*	36·3
Kenya	0·0	0·0	0·0	0·0	0·0	0·0†	0·0
Kiribati	0·0	0·0	21·1*	50·9	42·9*	9·8*	1·6
Kuwait	89·8	74·6*	28·0*	52·1	66·5	81·3	80·7
Kyrgyzstan	12·5*	33·2	43·3	44·9	63·1	81·8	71·7*
Laos	..	..	..	..	..	..	..
Latvia	53·4†	53·4†	54·2	66·7	85·7	88·7	90·4
Lebanon	..	..	..	..	..	..	..
Lesotho	..	..	..	..	..	..	..
Liberia	..	..	..	..	..	..	..
Libya	1·1*	0·7·0*	1·0	2·0*	2·9*	1·9	1·0
Lithuania	21·1*†	38·5†	55·8†	83·7	92·6	93·8	78·4*
Luxembourg	85·3	85·9	86·2	86·3	86·9	86·4	81·4
Macau	2·2*	4·8*	9·5*	16·5*	9·0*	7·5*	6·0*
Macedonia	1·1*	1·2*	32·9*	74·3	78·7	75·8	67·6*
Madagascar	0·4	7·6	11·2	7·7	1·3	0·1	0·0
Malawi	0·0	0·0	0·0	0·0	0·0	0·2†	0·2

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	1980–84	1985–89	1990–94	1995–99	2000–04	2005–09	2010–12
(Continued from previous page)							
Malaysia	44·9*	14·9*	7·9*	23·3*	57·9	71·8*	36·5
Maldives	10·7*	10·1*	9·1*	9·0*	31·8	46·9*	48·3
Mali	0·5	0·5	0·1†	0·0	0·0	0·0	0·0
Malta	87·9	87·8	89·6	90·5	90·2	90·7	86·1
Marshall Islands	0·0	1·9*	5·1*	5·4*	1·5	2·4*	0·9
Mauritania	..	..	..	..	..	..	..
Mauritius	80·7	84·4	84·5	81·7	79·9	83·8	81·7
Mexico	74·1	76·1	80·2	82·3	84·6	86·3	88·2
Micronesia, Federated States of	0·0	0·0	0·0	0·0	0·5*	0·7	0·1
Moldova	13·0*†	35·4†	60·6	79·6	86·6	91·5	93·2
Mongolia	6·4*	5·8*	7·8*	15·2*	9·0*†	3·4*†	15·3†
Montenegro	0·0	0·0	1·1*	5·9*	12·2*	22·7*	24·5*
Morocco	0·4*	0·6*	1·7*	1·9*	1·4*	10·3*	10·8
Mozambique	0·0	0·0	0·0	0·0	0·0†	0·0	0·0
Myanmar	0·0	0·0	0·0	0·0	0·0	1·6*	0·5
Namibia	..	..	..	..	..	..	..
Nepal	..	..	..	..	..	..	..
Netherlands	89·0	89·0	88·2	87·8	87·4	88·0	83·3
New Zealand	93·9	93·1	92·8	92·6	93·0	94·4	62·7*
Nicaragua	0·1*	7·3*	45·3	49·7	64·7	73·3	73·4
Niger	..	..	..	..	..	..	..
Nigeria	0·0	0·0	0·0	0·0	0·0†	0·0†	0·0
North Korea	..	..	..	..	..	..	..
Norway	78·4	74·2	84·8	87·1	87·6	87·7	87·6
Occupied Palestinian territory	0·0	0·0	0·0	7·7	32·2	45·9	30·0
Oman	0·0	0·0	0·0	0·0	1·3*	28·8	32·0
Pakistan	0·0	0·0	0·0	0·0	0·0	0·0†	0·1
Panama	76·0	78·4	42·8*	39·5*	74·3	81·6	53·8*
Papua New Guinea	5·5	1·1*	0·5*	0·1	0·0	0·0	0·0
Paraguay	59·7	58·5	47·8*	50·4	59·4	63·3	53·7
Peru	63·3*	41·6*	43·4*	47·6	54·4	57·3	49·9
Philippines	49·5	48·6	53·4	69·0	70·3	45·6*	20·6
Poland	83·3	83·2	82·9	69·1*	70·7	83·1	79·6
Portugal	82·0	79·8	78·6	78·4	75·4*	71·0	75·3
Puerto Rico	88·9	89·2	89·7	88·1	84·2	76·8	69·9
Qatar	2·2*	4·9*	7·6*	11·8*	7·7†	45·9	59·0
Romania	88·3	87·9	87·7	85·7	84·9	86·7	81·9
Russia	54·5	55·4†	65·4†	70·1†	70·4	70·6	71·1
Rwanda	..	..	..	..	..	..	..
Saint Lucia	58·0*	47·6*	70·7	78·9	80·2	69·0	28·2
Saint Vincent and the Grenadines	20·5*	49·8*	27·3*	47·1	76·1	84·6	68·6
Samoa	3·3*	0·7	0·1	0·0	0·0	0·0	0·0
São Tomé and Príncipe	5·9*	9·6*	4·0*	0·8	0·1	0·0	0·0
Saudi Arabia	0·0	0·0	0·0	1·2*	20·8	37·9	44·9
Senegal	..	..	..	..	..	..	..
Serbia	0·0	0·0	0·0	13·9*	66·7	84·8	88·6
Seychelles	15·5*	42·1*	22·8*	10·8*	23·7*	44·9	34·2*
Sierra Leone	..	..	..	..	..	..	..
Singapore	91·7	91·7	90·4	89·0	85·1†	74·9†	66·5†
Slovakia	10·8*	10·8*	28·1*	76·8	88·8	90·1	75·8*
Slovenia	2·3*	52·0	85·2	89·2	89·4	89·9	75·1*

(Table continues on next page)

	1980–84	1985–89	1990–94	1995–99	2000–04	2005–09	2010–12
(Continued from previous page)							
Solomon Islands	..	..	..	..	..	..	..
Somalia	..	..	..	..	..	..	..
South Africa	3·6*	1·8*	7·8*	46·9	63·2	70·5	50·0*
South Korea	9·5*	44·7	75·2	80·0	82·2	85·8	81·5
Spain	84·3	84·2	84·9	86·1	87·0	87·7	83·0
Sri Lanka	72·4	60·8	32·5	35·1*	17·6*	29·0*	10·9
Sudan	..	..	..	..	..	..	..
Suriname	53·4	58·7	57·9*	49·5	63·7	68·1	43·7
Swaziland	..	..	..	..	..	..	..
Sweden	80·4	71·7	85·3	88·5	89·4	89·5	74·1*
Switzerland	76·9	63·5	60·8	55·9	52·2	51·6	43·4*
Syria	18·4*	13·3*	2·6	0·3	0·0	22·1†	12·1
Taiwan	10·5*	10·5*	10·4*	10·4*	10·4*	26·5*	67·3
Tajikistan	12·2*	30·7	41·1	36·9	30·2	20·0*	6·0*
Tanzania	0·0	0·0	0·0	0·0	0·0	0·0	0·0†
Thailand	53·3	47·2*	37·8*	47·7	48·3	51·2*	21·4
The Gambia	..	..	..	..	..	..	..
Timor-Leste	..	..	..	..	..	..	..
Togo	..	..	..	..	..	..	..
Tonga	2·3*	1·6	1·2*	0·3	4·6*	6·0	1·2
Trinidad and Tobago	81·3	80·9	83·1	85·1	87·2	86·2	40·7
Tunisia	4·0*	3·0*	3·1*	4·6*	3·0	0·4	0·1
Turkey	2·3*	6·9*	14·1	18·7	22·4	24·6*	41·0
Turkmenistan	11·1*†	32·7†	55·9	53·6*	20·6*	5·9*	1·3
Uganda	..	..	..	..	..	..	..
Ukraine	20·9*†	39·0†	51·1	53·2	54·2	49·1*	47·1*
United Arab Emirates	0·0	1·2*	1·4*	1·4*	1·7*	1·4	0·3
UK	90·2	90·9	90·9	90·1	90·4	90·8	91·3
USA	90·8	90·2	90·1	89·5	90·3	91·0	75·4*
Uruguay	85·7	85·4	77·7*	80·2	76·5*	53·6	41·5
Uzbekistan	13·3*	37·0	50·8	48·9	45·5	36·1*	8·7
Vanuatu	..	..	..	..	..	..	..
Venezuela	81·8*	74·5	75·4*	73·7*	88·1	91·2	60·7*
Vietnam	..	..	..	..	..	..	..
Yemen	..	..	..	..	..	..	..
Zambia	..	..	..	..	..	..	..
Zimbabwe	0·0	0·5*	8·0	9·7	2·0	2·7	2·3

*All-causes only (at least 1 year in current period). †Index computed without garbage (at least 1 year in current period).

Table: **5-year annual average vital statistics performance index (VSPI) scores, by country or territory, 1980–2012**

Global scorecard for CRVS systems

There is substantial interest in understanding whether, and by how much, CRVS systems globally have progressed over the past few decades.[22] Setel and colleagues,[41] in referring to the many people, mostly in Africa and Asia, who are born and die without ever being registered, identify what they term a "scandal of invisibility" arising from the stagnation of civil registration systems. UNICEF's first global estimates of birth registration date from 2000 and show that birth registration increased only slightly between 2000 and 2010, from 58% to 65%.[15] Similarly, figure 2 suggests that overall progress in death registration coverage has been modest, with only a 2·4% increase in the past 30 years; however, a noticeable improvement has been made in the quality of CRVS systems, with more deaths registered in systems likely to produce better quality data, including more extensive use of the ICD.[42]

In the early 1980s, CRVS systems worldwide collectively registered around 16·4 million deaths annually (36·2% of all deaths). By 2005–09, this number had increased to 20·5 million deaths a year (about 38·6% of estimated global deaths during that period). A much smaller proportion of the registered deaths in 2005–09 were recorded by the weaker systems (ie, the low and very low

categories in figure 2 and appendix); their proportion more than halved between the early 1980s and 2000–04. As a result of system improvements in some countries, increasing numbers of deaths were registered by systems classified as high and very high, especially after 1995 (figure 2). Between 1980–84 and 2005–09, the proportion of deaths registered by more developed systems increased from half to two-thirds of registered deaths, confirming that quality of data generated by CRVS systems is improving globally. The apparent increase in the proportion of deaths registered by the weaker systems since 2005 is almost wholly a result of the large increase in death registration in India, from 52% of all deaths in 2001 to 67% in 2010.[43] Thus, although CRVS systems globally have made only modest progress in death registration, more of these deaths are now registered by satisfactory and well functioning systems. This trend could well continue; the potential of ICT to improve efficiency and quality of vital registration in countries with weaker systems is only beginning to be appreciated.[44,45]

Although computerisation has profoundly affected operation of CRVS systems in developed countries, the global decline in annual death registration between 2005–09 and 2010–12 is mainly a result of late dissemination of mortality data in some countries with very-high-performing systems. This delay is probably related to lengthy coronial inquiries into the causes of some deaths, which can slow finalisation of the mortality dataset.

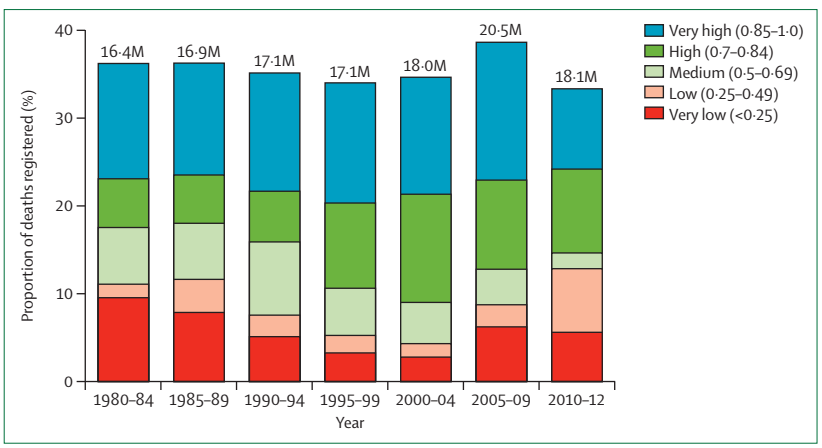

Figure 2: **Registered deaths worldwide according to CRVS system development between 1980 and 2012**
The five different colours in each bar represent the country groupings according to the quality of their CRVS systems. The vertical axis shows the annual average proportion of all deaths that were registered in the period indicated on the horizontal axis.

Intervention strategies to improve CRVS systems

Policies to strengthen CRVS systems would benefit from an improved understanding of how some countries have made substantial progress. Figure 3 shows different growth patterns in the VSPI, and the three most influential data quality components that contributed—completeness, quality of cause-of-death reporting (ie, amount of garbage coding), and detail of cause-of-death list—for selected countries, chosen to represent five different patterns of change.

CRVS performance growth in several countries, such as Moldova, which had complete death registration in the 1980s, was mostly achieved by introduction of more detail into the list used to report causes of death, a fairly simple intervention with great public health relevance. The steady improvement in the VSPI in Brazil, however, was achieved by more complex interventions aimed to increase the completeness of death registration and train doctors in correct cause-of-death certification, leading to a continuous decrease in garbage coding. For Kyrgyzstan, CRVS system improvement in the first two decades was wholly due to efforts to register more deaths, followed in 2000 by introduction of a much more detailed cause-of-death list, increasing policy utility of data. In South Africa, improvements began in the 1990s with concerted efforts to register more deaths, followed in 1993 by introduction of cause-specific data. In Turkey, only slow improvements in death registration were evident until implementation of comprehensive government reforms to strengthen the CRVS system during the past decade led to increased completeness of death registration, reduced garbage coding, and increased detail in the cause of death list.

See Online for appendix

Monitoring and strengthening CRVS system performance: challenges and opportunities

By application of the composite VSPI indicator to the GBD mortality database, we have assessed the performance of CRVS systems in 148 countries or territories during the past three decades. Global progress in death registration has been disappointingly slow, with completeness of death registration only 2·4 percentage points higher at present (38·6%) than in 1980. Some encouraging signs suggest that systems are improving, with more than two-thirds of registered deaths reported by reliable systems, compared with 50% in 1980s, and with fewer deaths (outside India) recorded by the weakest systems.

Compared with other assessment approaches, such as expert audit and self-assessment, the VSPI has several advantages: the VSPI is objective, replicable, uses available data, and can generate comparable scores over time and between countries. Moreover, available data can be used for retrospective analyses to show how CRVS systems have improved over time. Annual time-series of scores for VSPI and its six components provide the evidence needed to inform technical and policy dialogue about priority interventions to strengthen CRVS systems. These characteristics suggest that the VSPI has an important role in monitoring of national CRVS improvement strategies, and in any global accountability framework for CRVS strengthening, such as that called for as part of the so-called data revolution[6] to monitor progress with global development goals.

However, our study has several potentially important limitations. First, and perhaps most notably, the VSPI in its current form is wholly based on mortality data and does

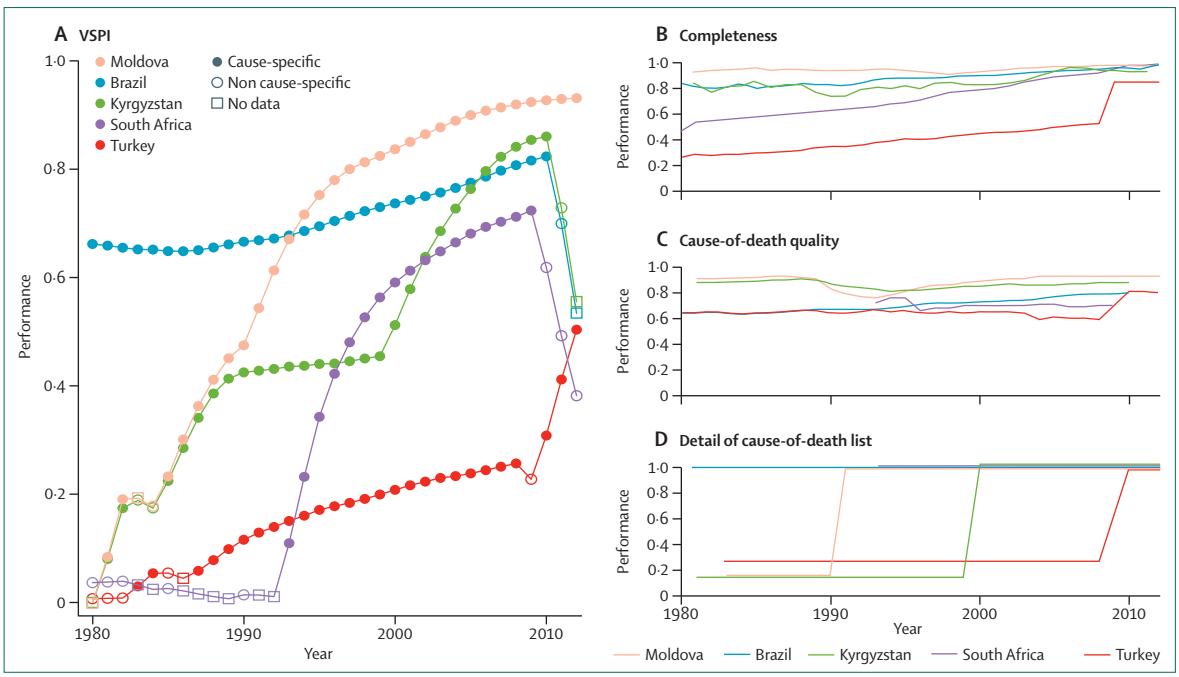

Figure 3: **Annual vital statistics performance index (VSPI) and selected quality components for Brazil, Kyrgyzstan, Moldova, South Africa, and Turkey, between 1980 and 2012**

Different improvement trends in (A) the VSPI and the three most influential data quality dimensions that contributed: (B) completeness, (C) quality of cause of death reporting (ie, amount of garbage coding), and (D) cause-of-death list detail, for selected countries, chosen to represent five different civil registration and vital statistics (CRVS) improvement patterns.

not take into account the completeness and quality of birth data. Future research should focus on development of a comparable assessment framework for birth statistics based on a similarly comprehensive database of country birth registration outcomes, as has been assembled for mortality. Second, although the GBD study has made every effort to identify all available national vital statistics, some data have probably been missed for several countries because of restrictive national dissemination policies. If these data were included, scores for the data quality components might show a different picture. Third, the method used by Phillips and colleagues[8] used a simulation to determine weights to compute the VSPI. The underlying basis of the simulation was to measure the effect of progressively decreasing the level of each component of the index on cause-of-death accuracy at the population level, assessed by comparison with standard cause-of-death distributions from the GBD study. Incorrect specification of the cause -of-death pattern estimated for the GBD will affect the magnitude and functional form of VSPI weights for the various components. Fourth, the VSPI does not consider every factor that could potentially affect data quality. Several country studies, for example, have identified systematic diagnostic misclassification patterns,[46–51] but this information cannot be readily incorporated into the measure.

The poor CRVS performance for many countries during the most recent (2010–12) period, including countries with satisfactory systems such as Canada, Iceland, and New Zealand, is mostly due to lack of the most recent vital statistics. Data availability, although a crucial performance component of any CRVS system, is likely to be an organisational issue or a result of deliberate policies to restrict data dissemination rather than a reflection of country concern for data quality. Whatever the reasons, outdated vital statistics are unlikely to fulfil their intended policy purposes.

Countries and development partners alike will be keen to understand whether a minimum set of conditions need to be met to rapidly improve a country's CRVS system. Our findings suggest that rapid progress is indeed possible, and the specific component analysis suggests that efforts to improve completeness of registration, report causes of death in more detail (eg, age and sex, and more detailed cause-of-death lists), and to strengthen cause-of-death certification practices in countries are likely to have the greatest immediate benefit for CRVS improvement strategies.[46,47] Deliberate policies to ensure vital statistics are compiled and widely disseminated within 2 years of the reference year will also greatly improve their value. Underlying all of these efforts is a need for governments and those who operate the CRVS system in countries, including statistical clerks, registrars, doctors, and data analysts, to all understand the crucial importance of reliable and timely vital statistics for national development. Targeted awareness campaigns to rapidly improve knowledge and understanding are needed at several levels to emphasise the health service benefits

that result from policies based on improved death and cause-of-death reporting. Such interventions should be given much higher priority in national CRVS strategic improvement plans. Committed leadership from organisations such as WHO and the UN and its Regional Commissions is essential to ensure that countries receive practical guidance, based on the most up-to-date scientific evidence, about how to improve their CRVS systems, and that they are made aware of the many means and technical support now available to assist them.[1,3,4,20,46]

Conclusions

Our analysis confirms that, in countries with sustained and informed government commitment, substantial progress in CRVS systems can be achieved in a fairly short period of time, especially when new ICT technologies are applied; however, without such purposeful policies, only incremental changes in CRVS system performance can be expected. Knowledge generated from vanguard countries that have made substantial progress with their systems in a short period of time should be shared with others. In this respect, the demise of the Heath Metrics Network, which in its final years effectively took on the role of CRVS knowledge broker, is especially regrettable, and an alternative global leadership mechanism to support countries is urgently needed, as argued by Abouzahr and colleagues[2] in this Series.

We draw five broad conclusions from this analysis. First, the policy utility of CRVS systems in some countries could be rapidly and easily enhanced by simple organisational and technical decisions to improve clarity and cause-of-death detail reported for deaths already captured by the system. A good example is use of more detailed cause-of-death lists to report vital statistics, which is likely to be wholly within the provenance of epidemiologists in countries. Second, country CRVS systems would benefit substantially from technical leadership and advice about implementation of established and cost-effective methods for birth and death registration, data collection, and analysis, especially exploitation of ICT advances for registration and data management. Third, technical leadership needs to be accompanied by targeted and comprehensive awareness programmes to ensure that organisations entrusted with acquisition, processing, dissemination, and use of vital statistics are fully aware of their utility for public policy, something that has previously received very little attention. Fourth, because governments are custodians of CRVS systems, much more effort is needed to ensure that governments fully understand the policy value of good quality information about births and deaths, and invest in their sustainability. Fifth, CRVS strengthening efforts will benefit greatly from a monitoring and accountability strategy based on a metric that is comprehensive, objective, mostly costless, and able to detect minor changes across several measures of data quality and availability. The index we propose can be readily calculated from available data and used by global and regional partners to monitor progress. Indeed, if the momentum of CRVS system strengthening is to be maintained, and accelerated, then such comparable, objective evidence about progress (or lack of progress) and why it matters will need to be given much more prominence in global policy debates.

Contributors

LM and ADL developed the original concept and outline on the basis of initial input from the group. LM prepared the manuscript. DEP carried out all of the statistical calculations. All authors provided feedback and reviewed the final paper.

Declaration of interests

We declare no competing interests.

References

1 WHO, University of Queensland, HMN. Strengthening civil registration and vital statistics for births, deaths and causes of death: resource kit. Geneva: World Health Organization, 2013.

2 Abouzahr C, de Savigny D, Mikkelsen L, et al. Civil registration and vital statistics: progress in the data revolution for counting and accountability. *Lancet* 2015; published online May 11. http://dx.doi.org/10.1016/S0140-6736(15)60173-8.

3 Abouzahr C, Stein C, Chapman N, et al. A development imperative: civil registration and vital statistics systems in the Asia-Pacific region. *Asia Pac Popul J* 2014; **29:** 2014.

4 WHO, University of Queensland. Improving the quality and use of birth, death and cause-of-death information: guidance for a standards-based review of country practices. Geneva: World Health Organization, 2010. http://whqlibdoc.who.int/publications/2010/9789241547970_eng.pdf (accessed April 7, 2015).

5 Abouzahr C, de Savigny D, Mikkelsen L, et al. Towards universal civil registration and vital statistics systems: the time is now. *Lancet* 2015; published online May 11. http://dx.doi.org/10.1016/S0140-6736(15)60170-2.

6 United Nations. A new global partnership: eradicate poverty and transform economies through sustainable development. Report of the High-Level Panel of Eminent Persons on the Post-2015 Development Agenda. United Nations: New York, May, 2013.

7 UN ESCAP. Ministerial conference on civil registration and vital statistics in Asia and the Pacific. E/ESCAP/MCCRVS/1.2. Bangkok, Thailand: UN Economic and Social Commission for Asia and the Pacific, Nov 28, 2014.

8 Phillips DE, Lozano R, Naghavi M, et al. A composite metric for assessing data on mortality and causes of death: the vital statistics performance index. *Popul Health Metr* 2014; **12:** 14.

9 Gaete-Darbo A. Appraisal of vital statistics in Latin America. *Milbank Memorial Fund Quart* 1964; **42:** 86–117.

10 Danel I, Bortman M. An assessment of LAC's vital statistics system: the foundation of infant and maternal mortality monitoring. Health, Nutrition and Population Program. Discussion Paper. Washington DC: The World Bank, May, 2008.

11 UNICEF Mozambique, Métier Research. Implementation of the Birth Registration National Action Plan; Final Report. Maputo, Mozambique: United Nations Children's Fund, May, 2008.

12 UNICEF Bangladesh. Birth registration: a vehicle for child rights promotion. Dhaka, Bangladesh: United Nations Children's Fund Bangladesh, May, 2002.

13 UNICEF Cote d'Ivoire. Birth registration determinants based on multiple indicator cluster survey data (MICS, 2006). Abidjan, Cote d'Ivoire: UNICEF Cote d'Ivoire, 2007.

14 UNICEF Ghana. Assessment of the birth registration system in Ghana. Accra, Ghana: United Nations Children's Fund Ghana, 2008.

15 UNICEF. Every child's birth right: inequities and trends in birth registration. New York: United Nations Children's Fund, 2013.

16 UNICEF Madagascar and Ministry of Interior of the Government of Madagascar. Evaluation of the implementation and suggested guidelines for the scaling-up of the EKA programme for birth registration including the computerisation of the civil registry; final Report. Antananarivo, Madagascar: United Nations Children's Fund Madagascar, March, 2009.

17 UNICEF. Good practices in integrating birth registration into health systems: case studies from Bangladesh, Brazil, the Gambia and Delhi, India. New York: United Nations Children's Fund, 2009.

18 UNICEF Fiji. Birth registration in the Pacific. Suva, Fiji: United Nations Children's Fund Pacific Office, 2005.

19 UN Department of International Economic and Social Affairs. Statistical Office. Handbook of Vital Statistics Systems and Methods. Vol II: Review of national practices. Series F, No. 35. New York: UN, 1985. http://unstats.un.org/unsd/publication/SeriesF/SeriesF_35v2E.pdf (accessed April 13, 2015).

20 WHO, University of Queensland School of Population Health. Rapid assessment of national civil registration and vital statistics systems. Geneva: World Health Organization, 2010. http://whqlibdoc.who.int/hq/2010/WHO_IER_HSI_STM_2010.1_eng.pdf (accessed April 13, 2015).

21 Ruzicka LT, Lopez AD. The use of cause-of-death statistics for health situation assessment: national and international experiences. *World Health Statistics Quart*, 1990; **43:** 249–58.

22 Marapatra P, Shibuya K, Lopez AD, et al, and the Monitoring of Vital Events (MoVE) writing group. Civil registration systems and vital statistics: successes and missed opportunities. *Lancet* 2007; **370:** 1653–63.

23 Rao C, Lopez AD, Yang G, Begg S, Ma J. Evaluating national cause-of-death statistics: principles and application to the case of China. *Bull World Health Organ* 2005; **83:** 618–25.

24 Mathers CD, Fat DM, Inoue M, Rao C, Lopez AD. Counting the dead and what they died from: an assessment of the global status of cause of death data. *Bull World Health Organ* 2005; **83:** 171–77.

25 Wang H, Dwyer-Lindgren L, Lofgren KT, et al. Age-specific and sex-specific mortality in 187 countries, 1970–2010: a systematic analysis for the Global Burden of Disease study 2010. *Lancet* 2012; **380:** 2071–94.

26 Mikkelsen L. Improving civil registration and vital statistics: lessons learnt from the application of HIS Hub tools in Asia and the Pacific. Working paper No. 24. Brisbane: University of Queensland School of Population Health, Health Information Systems Knowledge Hub, 2012. http://www.uq.edu.au/hishub/wp24 (accessed April 7, 2015).

27 Mikkelsen L. Rapid assessment of vital statistics systems: evaluation of the application of the WHO/HIS Hub tool in 26 countries in the Asia–Pacific region. Working paper No. 10, Brisbane: University of Queensland School of Population Health, Health Information Systems Knowledge Hub, 2012. http://www.uq.edu.au/hishub/wp10 (accessed April 7, 2015).

28 Mikkelsen L. Assessing the quality of vital statistics systems: lessons from national evaluations in Sri Lanka and the Philippines. Working paper No. 08. Brisbane: University of Queensland School of Population Health, Health Information Systems Knowledge Hub, 2009. http://www.uq.edu.au/hishub/wp8 (accessed April 7, 2015).

29 Gamage S, Rampatige R, Samarakoon J, Ranadheera S, Mikkelsen L, Aung E. Assessing the production, quality and use of national vital statistics: a case study of Sri Lanka. Documentation Note No. 01. Brisbane: University of Queensland School of Population Health, Health Information Systems Knowledge Hub, 2009. http://www.uq.edu.au/hishub/dn1 (accessed April 7, 2015).

30 Aung E, Cajita J, Hufana L, et al. Assessing the production, quality and use of national vital statistics: a case study of Philippines. Documentation Note No. 02. Brisbane: University of Queensland School of Population Health, Health Information Systems Knowledge Hub, 2009. http://www.uq.edu.au/hishub/dn2 (accessed April 7, 2015).

31 UNICEF. A passport to protection. A Guide to birth registration programming. New York: United Nations Children's Fund, 2013.

32 WHO. World health statistics 2012. Geneva: World Health Organization, 2012. http://www.who.int/gho/publications/world_health_statistics/2012/en/ (accessed April 13, 2015).

33 UN DESA, Statistics Division. Population and vital statistics report, ST/ESA/STAT/SER.A/259, ISBN: 978-92-1-161568-5. New York: United Nations, 2013. http://unstats.un.org/unsd/demographic/default.htm (accessed April 7, 2015).

34 Murray CJL, Rajaratnam JK, Marcus J, Laakso T, Lopez AD. What can we conclude from death registration? Improved methods for evaluating completeness. *PLoS Med* 2010; **7:** e1000262.

35 Murray CJL, Lopez AD. The Global Burden of Disease: a comprehensive assessment of mortality and disability from diseases, injuries and risk factors in 1990 and projected to 2020. Global Burden of Disease and Injury Series, vol I. Cambridge, MA: Harvard University Press on behalf of the World Health Organization and The World Bank, 1996.

36 Naghavi M, Makela S, Foreman K, O'Brien J, Pourmalek F, Lozano R. Algorithms for enhancing public health utility of national causes-of-death data. *Popul Health Metr* 2010; **8:** 9.

37 Lozano R, Naghavi M, Foreman K, et al. Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet* 2012; **380:** 2095–128.

38 Rosling H. The joy of facts and figures. *Bull World Health Organ* 2013; **91:** 904–05.

39 Naidu S, Buttsworth M, Aumura A. Strengthening civil registration and vital statistics systems in the Pacific: the Fijian experience. Working Paper No. 35. Brisbane: University of Queensland School of Population Health, Health Information Systems Knowledge Hub, 2013. http://www.uq.edu.au/hishub/wp35 (accessed April 7, 2015).

40 Mikkelsen L, Rampatige R, Hernandez B, Lopez AD. Strengthening vital statistics systems: what are the practical interventions necessary to reduce ignorance and uncertainty about causes of death and disease burden in the Asia Pacific region? Policy Brief Vol 3. No. 2 2014. Manila: Asia Pacific Observatory on Health Systems and Policies, World Health Organization Regional Office for the Western Pacific, 2014.

41 Setel P, Macfarlane SB, Szreter S, et al, on behalf of the Monitoring of Vital Events (MoVE) writing group. A scandal of invisibility: making everyone count by counting everyone. *Lancet* 2007; **370:** 1569–77.

42 WHO. International statistical classification of diseases and related health problems, 10th Revision. Geneva: World Health Organization, 2010. http://www.who.int/classifications/icd/en/ (accessed April 13, 2015).

43 Office of The Registrar General of India. Vital statistics of India based on the civil registration system 2010. New Delhi: Government of India, 2011.

44 Lopez A, Thomason J. Civil registration and vital statistics—everybody's business but nobody's business. *Lancet* 2013; **381:** 1275–76.

45 Abouzahr C, Harbitz M, Fu H, Mitra RG. Towards a research agenda for civil registration vital statistics in the Asia–Pacific region. *Asia Pac Popul J* 2014; **29:** 99–136.

46 Rampatige R, Mikkelsen L, Prado B, Riley I, Lopez AD. Systematic review of hospital-based cause-of-death statistics: strengthening the evidence for policy makers. *Bull World Health Organ* 2014; **92:** 807–16.

47 Rampatige R, Gamage S, Peiris S, Lopez AD. Assessing the reliability of causes of death reported by the Vital Registration System in Sri Lanka: medical records review in Colombo. *HIMJ* 2013; **42:** 20–28.

48 Polprasert W, Rao C, Adair T, Pattaraarchachai J, Porapakkham Y, Lopez AD. Cause-of-death ascertainment for deaths that occur outside hospitals in Thailand: application of verbal autopsy methods. *Popul Health Metr* 2010; **8:** 13.

49 Khosravi A, Rao C, Naghavi M, Taylor R, Jafari N, Lopez AD. Impact of misclassification on measures of cardiovascular disease mortality in the Islamic Republic of Iran: a cross-sectional study. *Bull World Health Organ* 2008; **86:** 688–96.

50 Rao C, Yang G, Hu J, Ma J, Xia W, Lopez AD. Validation of cause-of-death statistics in urban China. *Int J Epidemiol* 2007; **36:** 642–51.

51 Hernández B, Ramírez-Villalobos D, Romero M, Gómez S, Atkinson C, Lozano R. Assessing quality of medical death certification: Concordance between gold standard diagnosis and underlying cause of death in selected Mexican hospitals. *Popul Health Metr* 2011; **9:** 38.