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Indonesia's Sample Registration System in 2018: A work in progress

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Abstract

Background
The Indonesian national Sample Registration System (SRS) is a source of vital statistical information. This article describes the design of the SRS along with an analysis of its performance during its inception period from 2014 to 2017.

Methods
The SRS was assessed according to the following criteria: sample size utilisation, population coverage, and mortality recording procedures/data management. International standard mortality indicators by age, sex, and cause, along with an assessment of data quality, were estimated for 2016.

Results
The SRS covers a population of 8.6 million in 128 sub-districts (103 rural and 25 urban). Births and deaths are continuously recorded by local community health centres and causes of death are ascertained through verbal autopsy methods. From 2014 to 2017, mortality data completeness ranged from 55-72%, with cardiovascular diseases, diabetes, and chronic obstructive lung diseases, along with tuberculosis and transport accidents, being recorded as leading causes of death. However, as a result of the low level of completeness, total mortality indicators for the SRS population are questionable.

Discussion
As of 2018, system strengthening initiatives to increase data reliability and utility and thus to improve SRS performance and enhance its sustainability are being implemented by a collaboration of academic institutions. It is intended that lessons from the Indonesian SRS can guide vital statistics development programs in other settings.

Keywords

Mortality; causes of death; vital statistics; sample registration systems; Indonesia

Introduction

Reliable vital statistics on births, deaths, and causes of death are essential for population health assessments, the evaluation of health programs, and overall health policy. The optimal source of such data is the national civil registration and vital statistics (CRVS) system (Mahapatra et al., 2007; Mills, Abouzahr, Kim, Rassekh, & Sarpong, 2017). Currently, vital statistics are

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required to monitor and measure progress towards targets articulated in the United Nations Sustainable Development Goals for 2030, which includes 14 indicators for which mortality data are essential (GBD SDG Collaborators, 2016; Mills et al., 2017).

Indonesia ranks fourth among the world's countries in terms of population size yet lacks a functional nationwide CRVS system to serve as a reliable data source of vital statistics for regular measurement of fertility and mortality indicators (Mahapatra et al., 2007). As a result, mortality estimates for Indonesia are based on mortality models and predictions which are not considered adequate for health policy and program evaluation (Boerma, Victora, & Abouzahr, 2018; Rao, 2013).

Routine population health assessment in Indonesia is essential because of the ongoing demographic, epidemiological, and health transitions in the country. Although there was a general decline in fertility from 1970 to 2000, the total fertility rate has remained above the net replacement rate since then, and this has fuelled a sustained high level of population growth (Jones, 2015). Rapid improvements in child survival combined with the modernization of health care have increased life expectancy and have also added to population growth. Also, while Indonesia remains among the countries experiencing high levels of some diseases, such as tuberculosis, recent mortality estimates indicate a general decline in the burden from infectious diseases with a concomitant gradual rise in non-communicable diseases (Rao et al., 2010). In this current transitional environment, there is an urgent need for routine and reliable vital statistics to track trends in mortality by age, sex, and cause.

The Indonesian national CRVS system is still under development. An initial wave of activities involving the collection and analysis of data on mortality and causes of death to meet the critical need for vital statistics was conducted from 2005 to 2011 in several pilot project sites (Rao et al., 2011; Rao et al., 2010). Subsequently, in 2014, Indonesia launched the national Sample Registration System (SRS) in a representative set of population clusters (Pratiwi & Kosen, 2013). The objectives of this article are to describe the design characteristics of the Indonesian SRS and to present a critical analysis of the performance of the SRS in terms of the availability and quality of mortality statistics for 2016.

SRS Goals and Objectives

A description of the design features of the SRS helps place the data quality evaluation study into context. The overall goal of the Indonesian SRS is to develop a routine, reliable and nationally representative data source for compiling vital statistics. The specific objectives of the SRS are to generate reliable annual measurements of key population health indicators including crude birth and death rates, infant and under-five mortality rates, and life expectancies, as well as to implement standard international guidelines for the ascertainment and coding of causes of death (World Health Organization, 2012). The SRS is designed to continuously record births, deaths, and causes of death in a nationally representative population sample. In 2012, The National Institute of Health Research and Development (NIHRD), Ministry of Health, Indonesia was nominated to lead the implementation of the SRS in collaboration with the Directorate General of Population Administration, Ministry of Home Affairs. A joint decree from both ministries mandating inter-sectoral collaboration for the registration of births, deaths and causes of death in Indonesia, was issued in 2010 (Ministry of Home Affairs & Ministry of Health: Indonesia, 2010). In the initial phase from 2013 to 2015, the SRS received partial funding support from the Global Fund for AIDS, Tuberculosis, and Malaria (GFATM). Since 2016, the operational budget for SRS implementation has been provided by the Indonesian National Development Planning Agency (BAPPENAS). Currently, the SRS is also supported by a technical partnership between Indonesian and Australian academic institutions.

SRS Sampling Plan

Indonesia hosts a national population of approximately 260 million people, residing in 32 provinces, that can broadly be divided into 7 geographic/administrative regions. There are marked variations in population density across the 17,000 islands that comprise the Indonesian archipelago, and about 300 distinct ethnic groups. Such marked diversity poses several challenges in establishing a representative sample of the national population. Moreover, due to the relatively rare occurrence of vital events (births and deaths), as well as the nature of the administrative resources required for vital event registration and statistical compilation, there is a need to select population clusters as primary sampling units to achieve efficiency in implementing birth and death registration operations. The sub-district (*kecematan*) was nominated as the primary sampling unit since it is the most peripheral administrative unit in Indonesia with a defined border within urban or rural areas, and is served by one or more Community Health Centres (*puskesmas*) (National Institute for Health Research and Development (NIHRD), 2015).

Sample Size and Distribution

The total sample size of the SRS population was set as 3% of the Indonesian national population of approximately 260 million according to the 2011 Population Census. A systematic stratified sampling approach was used to select a representative sample of 103 rural and 25 urban sub-districts distributed across 30 provinces of Indonesia (National Institute for Health Research and Development (NIHRD, 2015). The total population coverage of the SRS is approximately 8.6 million as per the Central Bureau of Statistics (*Badaan Pusak Statistik*) data sourced from the Village Potential Survey (*Pendataan Potensi Desa*) conducted in 2014 (Badan Pusat Statistik [Statistics Indonesia], 2014).

Figure 1 displays the geographical distribution of the SRS sites. It can be seen that there is a high concentration of sites in the densely populated provinces in Java, and relatively fewer clusters in the low population density provinces in Sumatra, as well as in Kalimantan and Eastern Indonesia. The dispersal of SRS sites across the various major and minor islands in the Indonesian archipelago poses particular challenges in terms of data management and technical field support, as experienced during SRS operations from 2014 to 2017.

Figure 1: Geographical distribution of Indonesian SRS field sites, 2014-2018

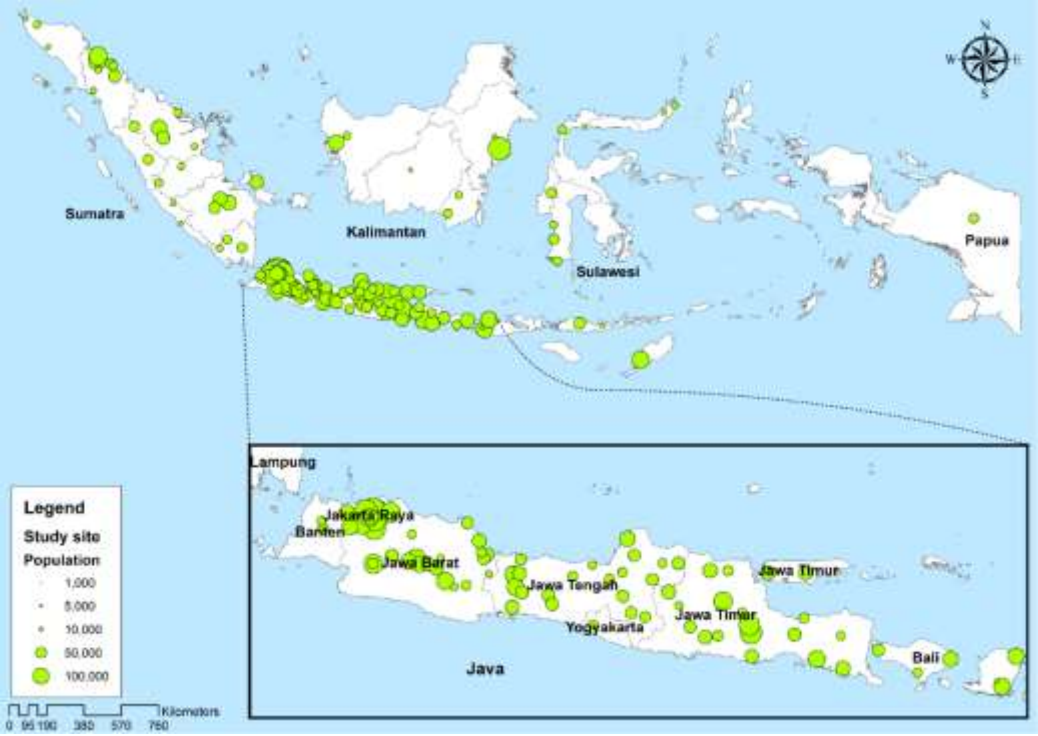


Table 1 provides descriptive characteristics of the SRS sample across the 7 regions of Indonesia. Overall, the ratio of urban to rural population coverage in the SRS closely approximates the national population ratio of 55% urban to 45% rural in 2014. The region comprising East Java, Bali, and Nusa Tenggara covers the largest SRS population and exhibits the highest median population cluster size. Overall, the large numbers of health centres, villages and urban wards in each region provide a useful perspective on the scale and magnitude of SRS operations. In particular, the population clusters in Kalimantan and Eastern Indonesia are scattered over large areas or involve multiple islands, and this adds to the administrative and technical challenges in data collection and compilation on a routine, ongoing basis.

Table 1: Descriptive characteristics of the Indonesian SRS sample population in 2017 SRS field operations

No	Region	Provinces	No. of SRS sites	Total population in SRS sites	Median cluster population size (range)	Health centres	Villages / urban wards
I	North Sumatra	Aceh, Kepulauan Riau, Riau, North Sumatra	15	753,093	33,260 (9,539-255,046)	25	218
II	West & South Sumatra	West Sumatra, Jambi, South Sumatra, Bengkulu, Lampung, Bangka Belitung	15	600,508	38,756 (10,655-86,437)	24	173

No	Region	Provinces	No. of SRS sites	Total population in SRS sites	Median cluster population size (range)	Health centres	Villages / urban wards
III	Jakarta & Kalimantan	Jakarta, Banten, West /South/ Central & East Kalimantan	15	1,580,672	103,564 (9,216-259,982)	57	125
IV	West Java	West Java	22	1,8328,814	93,947 (22,399-175,641)	39	234
V	Central Java	Central Java, Yogyakarta	21	1,324,753	64,542 (30,829-119,230)	32	292
VI	East Java, Bali, Nusa Tenggara	East Java, Bali, West / Central Nusa Tenggara	29	2,121,140	75,915 (10,129-166,713)	54	413
VII	Eastern Indonesia	North /Central/West Sulawesi, South-east Sulawesi, North Maluku, Papua	12	379,211	35,262 (3,769-125,340)	21	120
	Total		**128**	**8,598,191**		**252**	**1,575**

The SRS is designed to implement data collection and compilation through the network of institutions under the Ministry of Health at the district and sub-district level, utilizing personnel from these offices as well as from community health centres. Until 2017, the SRS focussed exclusively on the collection of information relating to deaths and causes of death, but from 2018 onwards, has also been compiling data on births. At the village level, information on deaths is routinely sourced by the government midwife (*bidan desa*) from a network of local informants including the village administrator (*kepala desa*) , neighbourhood/community associations (*rukun tetangga/rukan warga*), and community health volunteers (*kader*). Each month, the *bidan desa* completes a death report form which records the name, age, gender, date of death, and address of all identified persons who have died, and this is then submitted to the local *puskesmas*. On a periodic basis, trained local paramedics visit the households of deceased individuals to interview the principal caregivers of the deceased, using an international standard questionnaire adapted to the Indonesian context (National Institute for Health Research and Development (NIHRD), 2012). The aim of the interview, termed a 'verbal autopsy' (VA), is to record information on the symptoms and events during the terminal illness, along with relevant details of previous medical history and health care received. Informed consent is obtained from all respondents (Gouda et al., 2017). Completed VA questionnaires are analysed by trained physicians who assign cause(s) of death according to prescribed guidelines (National Institute for Health Research and Development (NIHRD), 2008b).

The VA data are then submitted by each *puskesmas* to the local district health office, where they are compiled by the district SRS coordinator to the central SRS team at the NIHRD in Jakarta, where the VA data quality and assigned causes of death are reviewed and coded according to the principles of the WHO ICD-10 (National Institute for Health Research and Development (NIHRD), 2008a). The compiled dataset at the national level is then aggregated into summary statistical tables of deaths by age, sex, and cause. SRS data are analysed routinely to develop international standard mortality indicators (World Health Organization, 2015b). In order to derive proportionate mortality rankings of leading causes by sex and age, causes of death are aggregated in the WHO Mortality Tabulation List 1, which comprises of 103 categories of grouped ICD codes (World Health Organization, 1993a).

Regarding the quality assurance aspects of the SRS, prior to the induction of the SRS program in a sub-district, dissemination activities were conducted in each village/urban ward to inform community leaders and local officials of the purpose and mechanisms of the SRS, and to encourage community support and participation in SRS activities. Also, all SRS field staff at village, health centre and district level received induction training in their functions, with onsite supervision and refresher training programs as required. Each year, coordination meetings are also convened at the national and district level by NIHRD staff to monitor SRS implementation, and these are attended by the district, health centre and local administration officials from sub-districts and villages as feasible. These coordination meetings are designed to review the quantity and timeliness of mortality reports from each SRS site, assess logistical issues in SRS implementation with regard to budget and human resources, and nominate future targets and priorities for the program.

Study Methods

SRS data for 2016 were first analysed at regional and national levels to derive standard mortality indicators including life expectancy at birth, levels of child mortality (risk of dying before age 5 years), adult mortality (risk of dying between ages 15 and 59 years), and life expectancy at age 60 years for males and females. SRS indicators were assessed for plausibility in comparison with estimates from international sources and were considered to be implausible if there marked differences were found. The data were also analysed for proportionate mortality by cause for each sex, as well as evaluated for the plausibility of the age-sex distributions of specific causes, in comparison with what is known of the natural history of mortality patterns for these causes (Rao, Lopez, Yang, Begg, & Ma, 2005).

The data quality evaluation component of the study estimated the completeness of death reporting, which is defined as the proportion of deaths reported to the SRS out of the total estimated deaths that were expected to occur in the sample population. Completeness was estimated using two methods. In one method, the expected deaths in a population cluster were first estimated by applying a crude death rate of 6.4 per 1,000, as per the WHO Global Health Observatory estimates for Indonesia in 2015 (World Health Organization, 2015a). Subsequently, the completeness of death reporting in each cluster was calculated as the proportion of reported to expected deaths in that cluster. In the second method, an alternate completeness measure was estimated at the national level, using an indirect demographic technique known as the 'Brass Growth Balance method'. This method is based on demographic assumptions of constant fertility and mortality rates for the study population in the 2-3 decades preceding the assessment, as well as an absence of migration into or from the study population (United Nations, 1983). The quality of assigned causes of death was assessed using a simple measure, i.e. the proportion of deaths that are assigned codes that belong to the chapter titled, "Symptoms and Ill-defined conditions" in the ICD-10 (World Health Organization, 1993b).

The evaluation study also conducted qualitative reviews in several SRS sites from 2016 to 2017, to foster an understanding of the practical issues and challenges in the field implementation of SRS operations. The qualitative methods included focus group sessions with *puskesmas* staff, key informant interviews with district health office SRS coordinators, and observational analyses of field procedures.

Results for 2016

The SRS recorded a total of 30,633 deaths in 2016, with an estimated overall completeness of 55.7%. Table 2 shows low levels of completeness across all regions, with marked variations ranging from 22% for females in Eastern Indonesia to 69% for males in Central Java. Completeness is marginally higher for males in all regions. At the national level, the alternate completeness estimate from the Brass Growth Balance technique demonstrates even lower levels at 44% for males and 51% for females (data not shown). The summary mortality indicators demonstrate the impact of low completeness in terms of implausibly higher life expectancies than the modelled estimates for Indonesia, as well as implausibly low levels of both child and adult mortality. Another key feature from the SRS data is the narrow differential (less than 2 years) in life expectancy at birth between males and females for all regions. Data from other Asian countries demonstrate relatively higher mortality rates in males, resulting in comparatively higher life expectancies (of at least 4-5 years) in females (World Health Organization, 2015a). All these findings indicate the implausibility of the summary mortality indicators from the SRS presented in Table 2.

Table 2: Summary regional & national mortality measures from observed SRS data* for 2016, compared with international mortality estimates for Indonesia

	Males				**Females**			
Region	**Estimated completeness**	**Life expectancy at birth**	**Child mortality****	**Adult mortality*****	**Estimated completeness**	**Life expectancy at birth**	**Child mortality**	**Adult mortality**
1. North Sumatra	46	82.8	14.7	111.9	38	87.9	12.8	86.8
2. West & South Sumatra	55	79.2	10.8	105.8	52	79.6	10.1	100.2
3. Jakarta & Kalimantan	42	88.2	7.3	95.1	36	87.5	7.1	79.8
4. West Java	53	80.8	11.6	112.5	50	79.9	12.2	98.6
5. Central Java	69	79.9	12.0	105.7	68	80.2	11.7	84.3
6. East Java, Bali, Nusa Tenggara	68	78.8	10.3	113.0	63	80.5	7.9	94.0
7. Eastern Indonesia	24	97.8	5.6	58.8	22	97.3	6.5	43.1
National Sample	55	**80.9**	**10.3**	**105.9**	51	**81.6**	**9.6**	**88.6**
WHO Global Health Observatory 2015	–	**67.1**	**31.0**	**205.5**	–	**71.2**	**24.0**	**145.7**
IHME Global Burden of Disease, 2015	–	**69.6**	**29.2**	**204.0**	–	**73.3**	**21.1**	**133.0**

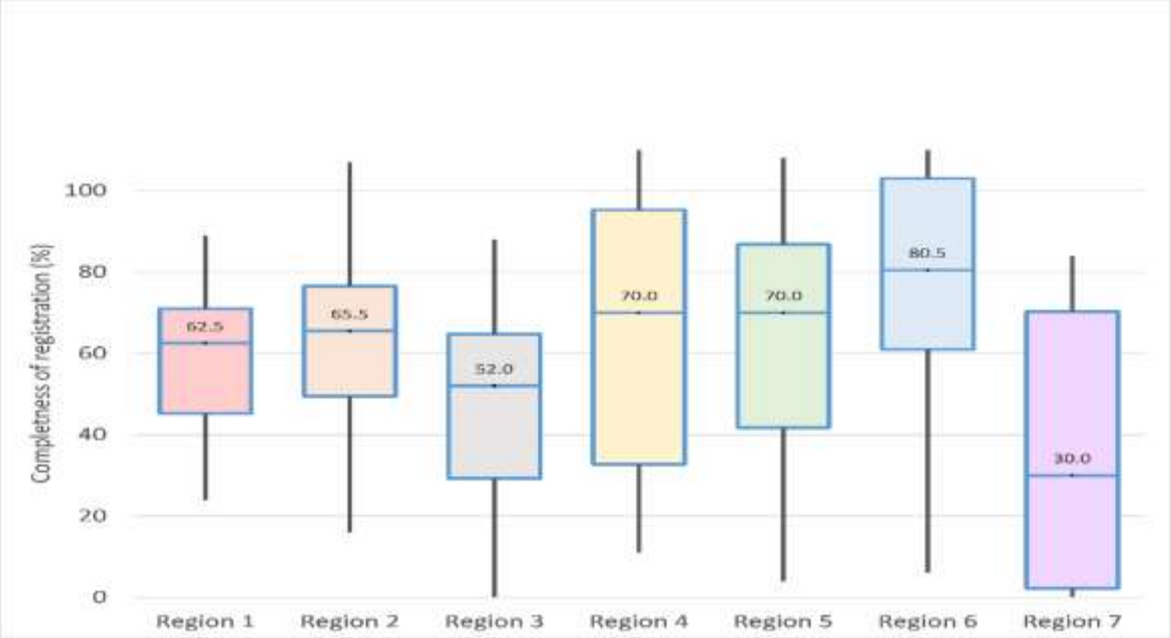
**Mortality measures from SRS data are not adjusted for under-reporting of deaths*

***Child mortality = risk of dying between birth and age 5 years*

****Adult mortality = risk of dying between 15 and 59 years*

A more detailed comparison of reporting completeness both within as well as across the Indonesian regions is presented in Figure 2. The plots indicate a very wide range of reporting performance in each region. However, the median value of reporting completeness is above 60% for SRS sites in five of the seven regions. Also, in all regions, there were some SRS sites that had achieved estimated completeness rates above 75%. These findings suggest that there are successes in implementation in each region. At the same time, all regions include SRS sites with very low estimated completeness (<20%), which severely limits the overall utility of the data in developing reliable mortality estimates.

Figure 2: Variations in SRS site-specific estimated death registration completeness within and across the Indonesian regions, 2016



Annual graphs were compared over the period of 2014 to 2016, and there were similar variations of reporting completeness across all regions. However, on closer examination of the trends in SRS site-specific completeness measures, the actual reporting performance for individual sites showed marked variations. Several SRS sites performed well with high completeness rates in one year, but with low completeness in other years. This variation within sites results in a relatively low proportion of sites (20%) which have consistently high or low reporting. Across 128 study sites while only 24 (18.7%) had completeness rates over 75% in all three years, it was also observed that over half of all clusters had achieved completeness of 75% in at least one of the three years, indicative of the potential to improve SRS performance through an innovative and strategic approach.

Causes of death

The second key SRS output of interest is the data on causes of death. Table 3 displays the leading causes of death observed from the SRS data for 2015 and 2016. While there is consistency over time in terms of the rank and magnitude of the five leading causes of death, this is not so for several lower ranked conditions, such as diseases of the liver; kidney diseases; intestinal infections, and nutritional & metabolic disorders. Overall, the leading causes of death are dominated by non-communicable diseases, but the marked under-reporting of child deaths could have biased these findings.

In terms of data quality, there are relatively low proportions of deaths coded to the category of ill-defined conditions. This indicates that the field verbal autopsy interviews collect adequate information on the medical history of the deceased, as well as on symptoms and clinical events during the terminal illness, for the reviewing physician to be able to formulate specific diagnoses of cause(s) of death. Also, over two-thirds of all cases in both years were assigned multiple causes of death, for which specific ICD rules needed to be applied to select and code the underlying causes. For injury deaths, sufficient information was available to identify both external causes as well as the specific bodily injuries suffered by the deceased (data not shown).

We identified that the sex and age-specific distributions were plausible for deaths from specific causes. As per expectations, mortality from diarrhoea and pneumonia was highest among children below five years whereas mortality from non-communicable diseases particularly cerebrovascular disease, ischaemic heart disease, and chronic obstructive lung disease increased exponentially with age, and road traffic accident deaths were highest in adult males aged 15 to 60 years. Also, there were no incorrect assignments of causes by gender due to errors in coding. All these findings indicate the plausibility of the reported causes of death, and hence the face validity of the VA methods employed in the Indonesian SRS. Further studies need to be undertaken to empirically assess data reliability and content validity of causes of death determined through verbal autopsies.

Table 3: Leading causes of death recorded in Indonesian SRS during 2015 and 2016

Rank	2015		2016	
	Cause	%	**Cause**	%
1	Cerebrovascular disease (I60-I69)	20.4	Cerebrovascular disease	19.9
2	Ischaemic Heart Disease (I20-I25)	13.2	Ischaemic Heart Disease	13.3
3	Diabetes mellitus (E10-E14)	7.8	Diabetes mellitus	7.9
4	Hypertensive diseases (I11-I13)	6.2	Hypertensive diseases	5.8
5	Chronic lung diseases (J40-J47)	5.7	Respiratory tuberculosis	5.6
6	Respiratory tuberculosis (A15-16)	5.3	Chronic lung diseases	5.1
7	Diseases of the liver (K70-K76)	2.8	Diarrhoea / Intestinal infections	4.2
8	Transport accidents (V01-V99)	2.6	Other heart disease (I26-I51	3.4
9	Diarrhoea/intestinal infections (A00-A09)	2.5	Ill-defined conditions (R00-R99)	2.9
10	Pneumonia (J12-J18)	2.1	Transport accident	2.6
11	Breast cancer (C50)	1.0	Nutritional & metabolic disorders*	2.5
12	Falls (W00-W19)	0.9	Kidney disease (N00-N98)	2.2
13	Peptic ulcer (K25-K27)	0.8	Diseases of the liver	2.0
14	Viral hepatitis (B15-B19)	0.7	Perinatal conditions (P00-P96)	1.9
15	Dengue fever (A90-A91)	0.6	Pneumonia	1.8
	All other causes	26.3	All other causes	18.9
	Total Deaths	25,228	**Total Deaths**	30,633

* *E00-E07, E15-E34, E50-E88*

Qualitative assessment of SRS performance

The qualitative reviews conducted during the evaluation identified key local factors that affect data quality, including a high turnover of field verbal autopsy staff and physician reviewers, inadequate local coordination between health staff and other key informants, absence of field supervision, and irregular availability of funds for local activities. In addition, the centralised mechanisms for data computerization precluded the potential for efficient local data compilation and monitoring as a tool to enable immediate local follow up of data reports not submitted by primary sampling units. Also, the wide geographical distribution of the SRS sites limits the potential of the NIHRD to effectively provide technical and administrative support across the country. Finally, the challenges in introducing and managing addition and change in routine institutional practices for reporting vital events and data compilation were recognized by the SRS management team, and it was agreed that a strategic approach to the institutionalisation of SRS procedures was required in order to strengthen the SRS.

Discussion

The Indonesian SRS is a critically important infrastructure component in facilitating the availability of routine, timely and reliable vital health-policy statistics. During its inception period (2014-2017), the SRS has institutionalised procedures for data collection, processing, compilation, and analysis across the 128 SRS sites. The system has also supported the training and establishment of field experience among registration staff, verbal autopsy interviewers and physician certifiers of causes of death, and data managers and data analysts, all of whom serve as a critical mass of human resources for national vital statistics development. In addition, the decision to align the Indonesian SRS with local civil registration practices is an important strategic step, which will assist in scaling up operations to increase national CRVS coverage in contrast to similar sample registration systems in India, China and Bangladesh, which function as processes independent of civil registration (Rao & Kelly, 2017).

Despite these strengths in system design and the robust nature of system inputs, the key limitation of the SRS is that it has not yet been able to generate reliable vital statistics. Although the SRS has generated annual data on deaths by age, sex, and cause since 2014, these data are biased due to the relatively low estimated levels of completeness throughout this period, dropping from 72% in 2014 to 55% in 2016. The evidence presented on low mortality reporting completeness for 2016 in Figure 2 and the impact of incomplete data in terms of the implausible mortality measures for 2016 presented in Table 2 are indicative of the systemic weaknesses in current SRS field operations. Preliminary information for 2017 demonstrates similarly low levels of completeness.

Strengthening the Indonesian SRS in 2018-2019

To address the issues affecting data quality, several initiatives have been launched in 2018 to strengthen the SRS. Firstly, the Indonesian government (BAPPENAS) has accorded a national priority status for the transition and scaling up of the SRS program and for it to be integrated with the national CRVS system during the period 2017-2024 (Government of Indonesia, 2017). This has been accompanied by a specific action to commit an enhanced local budget for field SRS operations. The government is also actively promoting collaboration between the Directorate General of Population Administration (Ministry of Home Affairs, which operates the CRVS system, and the Ministry of Health at all levels as per the joint ministerial decree published in 2010).

In addition to these administrative initiatives, a technical partnership has been established between NIHRD and a network of Australian and Indonesian university public health departments, supported by a governmental bilateral development partnership, to provide technical assistance to the SRS. This academic collaboration to support this aspect of health information system development follows a specific recommendation from a commissioned report on mortality reduction in Indonesia (Joint Committee on reducing maternal and neonatal mortality in Indonesia, 2013). From 2018-2019, the collaboration will implement a data quality assurance program comprising tools for local data computerization and monitoring, local capacity building activities, and the conducting of specific field studies on data quality. Training workshops to improve data management are being conducted for staff from province and district health offices as well as from community health centres. University staff are being trained in data quality evaluation, field supervision, and on-site technical support within their regions, and in developing technical reports on regional vital statistics. It is envisaged that the implementation of decentralised data management with local technical support will have a significant impact on SRS performance and the quality of SRS outputs from 2018 to 2019.

A key component of the SRS quality assurance program is the computerisation of data entry, management, processing, and analysis. The SRS team has developed a low cost, user-friendly data entry program based on the Census and Survey Processing System (CSPro) public domain software package made available by the United States Census Bureau (United States Census Bureau, 2018). Data entry is being decentralised to community health centres and district health offices with the software capturing essential variables on identity, address, vital dates, causes of death, and selected mortality risk factors. Following computerization, data are to be imported into a customised database with tools to monitor reporting compliance, timeliness and data quality from villages, urban wards, and health centres, as well as across district health offices and regions. These tools will be used for close monitoring, field supervision, and quality control. The data management package also generates outputs compatible for processing with automated ICD coding programs for the selection of underlying causes of death (IRIS) as well as aggregated data that are compatible with international software for descriptive analysis of mortality indicators by age, sex and cause (World Health Organization, 2014). In addition to these enhancements in SRS management and quality control, specific research studies will be conducted from 2018 to 2019 to evaluate completeness of reporting of births and deaths using dual-record linkage mechanisms and studies to measure the validity of causes of death assigned from verbal autopsies, using standard international methods (Polprasert et al., 2010; Prasartkul, Porapakkham, Vapattanawong, & Rittirong, 2007; Rao & Kelly, 2017; Yang et al., 2006). These empirical assessments of potential bias will be used to adjust SRS data for 2018 and 2019 and to develop reliable national mortality estimates for Indonesia. Qualitative findings from these research studies will also be used to modify SRS procedures that potentiate such data bias thereby promoting improved SRS data in the future.

Conclusions

The Indonesian SRS is being developed to serve as a reliable source of vital statistics in the country to meet a critical information need for planned progress towards UN Sustainable Development Goals. Since 2014, the SRS has established the essential framework, procedures, and resources for field operations. However, this article demonstrates that there are considerable problems with SRS data, particularly regarding the under-reporting of deaths. These problems are largely due to limitations in field supervision, data management, and quality control of SRS operations. The quality of data also needs to be evaluated through research studies that assess the reliability and validity of reported causes of death. There is an urgent need to systematically improve the SRS from all these aspects.

To address all these issues, a comprehensive system strengthening strategy has been developed by the SRS implementing agency (NIHRD) in consultation with a collaboration including Indonesian and Australian academic partner institutions, the Indonesian Ministry of Health, and the Indonesian National Development Planning Agency (BAPPENAS). A consensus has been achieved on the methodologies of the system strengthening strategy in terms of decentralisation of data management, local technical support from academic partners, and the conducting of specific research studies to evaluate the completeness and validity of SRS data with suitable follow-up capacity building programs. This strategy is currently underway in 2018 under the technical leadership of an academic collaboration involving Indonesian universities and is expected to fill vital gaps in SRS data quality. Once established, the SRS will serve as a platform to strengthen the national CRVS system. An incremental approach to scale up the SRS will facilitate efficiencies in measuring sub-national vital indicators in Indonesia while enabling improvements towards the long-term goal of a complete and reliable national CRVS system. These lessons from the Indonesian SRS provide evidence for other developing countries on the activities and resources involved in system design and implementation as well as on the indicative lead time taken to develop routine and reliable data sources for population health assessment and epidemiology.

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References

Badan Pusat Statistik [Statistics Indonesia]. (2014). *Indonesia - Pendataan Potensi Desa 2014 [Summary of village potential]*. Retrieved from https://microdata.bps.go.id/mikrodata/index.php/catalog/599

Boerma, T., Victora, C., & Abouzahr, C. (2018). Monitoring country progress and achievements by making global predictions: is the tail wagging the dog? *Lancet*. doi: 10.1016/S0140-6736(18)30586-5

GBD SDG Collaborators. (2016). Measuring the health-related sustainable development goals in 188 countries: A baseline analysis from the global burden of disease study 2015. *Lancet, 388*(10053), 1813-1850. doi: 10.1016/S0140-6736(16)31467-2

Gouda, H. N., Flaxman, A., Brolan, C. E., Joshi, R., Riley, I. D., Abouzahr, C., …, Lopez, A.D. (2017). New challenges for verbal autopsy: Considering the ethical and social implications of verbal autopsy methods in routine health information systems, *Social Science & Medicine, 184*, 65-74. doi:10.1016/j.socscimed.2017.05.002

Government of Indonesia. (2017). *Voluntary National Review: Eradicating poverty and promoting prosperity in a changing world*. Retrieved from https://sustainabledevelopment.un.org/content/documents/15705Indonesia.pdf.

IRIS. *A computer software package for automated coding of causes of death and selection of underlying causes of death: Version 5 (MUSE)*. Retrieved May 8, 2018 from http://www.dimdi.de/static/en/klassi/irisinstitute/about-iris/index.htm

Joint Committee on reducing maternal and neonatal mortality in Indonesia. (2013). *Saving lives, saving the future*. Washington, D.C: United States National Academy Press.

Jones G. W. (2015). *The 2010 – 2035 Indonesian Population Projection: Understanding the Causes, Consequences and Policy Options for Population and Development*. Retrieved from https://indonesia.unfpa.org/sites/default/files/pub-pdf/Policy_brief_on_The_2010_%E2%80%93_2035_Indonesian_Population_Projection.pdf

Mahapatra, P., Shibuya, K., Lopez, A. D., Coullare, F., Notzon, F. C., Rao, C., … Monitoring Vital Events (2007). Civil registration systems and vital statistics: successes and missed opportunities. *Lancet, 370*(9599), 1653-1663. doi: S0140-6736(07)61308-7 [pii] 10.1016/S0140-6736(07)61308-7

Mills, S. L., Abouzahr, C., Kim, J. H., Rassekh, B., & Sarpong, D. (2017). *Civil registration and vital statistics (CRVS) for monitoring the Sustainable development goals*. Retrieved from http://documents.worldbank.org/curated/en/979321495190619598/Civil-registration-and-vital-statistics-CRVS-for-monitoring-the-Sustainable-development-goals-SDGS

Ministry of Home Affairs & Ministry of Health: Indonesia. (2010). *Joint ministerial regulation regarding the registration of deaths and causes of death* (162/menkes/PB/1/2010, Jakarta).

National Institute for Health Research and Development (NIHRD). (2008a). *Buku panduan penentuan kode penyebab kematian menurut ICD-10 [Guide to assigning codes for cause of death according to ICD-10]*. Jakarta: NIHRD, Ministry of Health, Indonesia.

National Institute for Health Research and Development (NIHRD). (2008b). *Menegakkan diagnosis penyebab kematian menurut ICD-10 dari data autopsi verbal: panduan untuk dokter [Diagnosing causes of death from verbal autopsy data according to ICD-10: Guide for doctors]*. Jakarta: NIHRD, Ministry of Health, Indonesia.

National Institute for Health Research and Development (NIHRD). (2012). *Pedoman Autopsi Verbal [Guidelines for Verbal Autopsy], Indonesia Sample Registration System*. Jakarta: NIHRD, Ministry of Health, Indonesia.

National Institute for Health Research and Development (NIHRD). (2015). *Indonesia Sample Registration System 2014*. Jakarta: NIHRD, Ministry of Health, Republic of Indonesia.

Polprasert, W., Rao, C., Adair, T., Pattaraarchachai, J., Porapakkham, Y., & Lopez, A. D. (2010). Cause-of-death ascertainment for deaths that occur outside hospitals in Thailand: Application of verbal autopsy methods. *Popul Health Metr, 8*, 13. doi: 1478-7954-8-13 [pii] 10.1186/1478-7954-8-13

Prasartkul, P., Porapakkham, Y., Vapattanawong P, & Rittirong, J. (2007). Development of a verbal autopsy tool for investigating cause of death: The Kanchanaburi project. *Journal of Population and Social Studies, 15*(2).

Pratiwi, E. D., & Kosen, S. (2013). Development of an Indonesian sample registration system: a longitudinal study. *The Lancet, 381*, S118. doi: 10.1016/S0140-6736(13)61372-0

Rao, C. (2013). Mortality estimates for South East Asia, and INDEPTH mortality surveillance: necessary but not sufficient? *Int J Epidemiol, 42*(4), 1196-1199. doi:10.1093/ije/dyt033

Rao, C., & Kelly M. (2017). *Overview of the principles and international experiences in implementing record linkage mechanisms to assess completeness of death registration*. Population Division: United Nations Department of Economic and Social Affairs. New York.

Rao, C., Kosen, S., Bisara, D., Usman, Y., Adair, T., Djaja, S., … Lopez, A. D. (2011). Tuberculosis mortality differentials in Indonesia during 2007-2008: evidence for health policy and monitoring. *Int J Tuberc Lung Dis, 15*(12), 1608-1614. doi:10.5588/ijtld.11.0018

Rao, C., Lopez, A. D., Yang, G. H., Begg, S., & Ma, J. (2005). Evaluating national cause of death statistics: Principles and application to the case of China. *Bull World Health Organ, 83*(8), 618-625.

Rao, C., Soemantri, S., Djaja, S., Suhardi, Adair, T., Wiryawan, Y., … Lopez, A. D. (2010). Mortality in Central Java: results from the Indonesian mortality registration system strengthening project. *BMC research notes, 3*, 325. doi: 10.1186/1756-0500-3-325

United Nations. (1983). *Manual X: Indirect techniques for demographic estimation*. New York.

United States Census Bureau. (2018). *Census and Survey Processing System*. CSPro 7.1.1: United States Census Bureau. Retrieved from https://www.census.gov/data/software/cspro.html.

World Health Organization. (1993a). Special tabulation lists for mortality and morbidity; Mortality tabulation list 1 *International Statistical Classification of Diseases and Health Related Problems - Tenth Revision. Volume 1* (Vol. 1, pp. 1207-1210). Geneva: World Health Organization.

World Health Organization. (1993b). Symptoms, signs, and ill-defined conditions. *International Classification of Diseases and Health-Related Problems Tenth Revision,* (Vol. 1). Geneva: World Health Organization.

World Health Organization. (2012). Verbal autopsy standards: The 2012 WHO verbal autopsy instrument Release Candidate 1. Retrieved from http://www.who.int/healthinfo/statistics/verbalautopsystandards/en/

World Health Organization. (2014). ANACOD: An electronic tool for analysing levels of mortality And Causes of Death. Geneva: World Health Organization. Retrieved from http://www.who.int/healthinfo/anacod/en/.

World Health Organization. (2015a). Global Health Observatory data repository - life tables by country. Retrieved from http://apps.who.int/gho/data/view.main.60750?lang=en

World Health Organization. (2015b). *World Health Statistics 2015: Indicator Compendium*. Geneva

Yang, G., Rao, C., Ma, J., Wang, L., Wan, X., Dubrovsky, G., & Lopez, A. D. (2006). Validation of verbal autopsy procedures for adult deaths in China. *Int J Epidemiol, 35*(3), 741-748. doi:10.1093/ije/dyi181