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Research Article

International completeness of death registration

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Ariel Karlinsky[1]

Abstract

BACKGROUND
Death registration completeness, the share of deaths captured by countries' vital registration systems, vary substantially across countries. Estimates of completeness, even recent ones, are outdated or contradictory for many countries.

OBJECTIVE
We derive the most up-to-date and consistent estimates of death registration completeness in as many countries as possible.

RESULTS
Death registration is complete in Europe, North America, and other developed countries. In developing countries, completeness varies by region. While some have complete death registration, many countries completeness ranges from 40% to 75%. Regionally, Africa has lowest death registration completeness, and in many countries no registration data was located. In Latin America and Asia, several countries have improved their registration compared to previously available estimates.

CONTRIBUTION
This paper presents the publicly available International Completeness of Death Registration (ICDR) dataset: https://github.com/akarlinsky/death_registration. ICDR contains the annual amount of deaths registered and death registration completeness in 193 countries from 2015 to 2019.

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1. Introduction

When a death occurs, how likely is it to be registered? The answer varies considerably across regions, economic development level, and countries. Reliable information on deaths and completeness of death registration is vital for countries, international organizations, and civil society, as it informs their decisions in all venues, especially health and population matters. Without sufficient and well-understood data, the effect of policies and interventions cannot be understood properly. Moreover, for countries to understand whether they are on the path to achieve many of the Sustainable Development Goals (SDG 2020), such as mortality reduction and fighting communicable diseases, reliable monitoring systems must be established and their performance tested. The importance of civil vital registration systems was further emphasized in SDG goal 17.19.2, which states that by 2030, countries should achieve "100% birth registration and 80% death registration" (WHO 2017). Many other SDGs rely on civil vital registration systems (Makinde et al. 2020). WHO (2017) further emphasizes that the preferred source to check the progress of 17.19.2 is "civil vital registration systems," followed by censuses. The recent SCORE assessment tools (WHO 2021c) strengthened this by including "full birth and death registration" as one of its main indicators.

Completeness of death registration is estimated by dividing the number of registered deaths in the same period (year) by the number of expected deaths. Expected deaths in each country-year is derived using various information sources and methods, such as censuses, surveys, and vital registration systems (see Rao, Mswia, and Setel (2020) for a recent review). The most prominent and recent international sources for the number of expected annual deaths are the United Nations' World Population Prospects (WPP 2022), Institute of Health Metrics and Evaluation's Global Burden of Disease (GBD 2020), and the World Health Organization's Global Health Estimates (GHE 2021b). These sources construct a full demographic simulation dynamic with all demographic components simultaneously from the past (e.g, 1950) until today by using information from censuses, surveys, demographic surveillance sites, vital registration etc. and adjustments by using model life tables, statistical relationships between child mortality and adult mortality, and more.[2] Based on these and other sources, several recent studies estimate the completeness of death registration in several countries (Mikkelsen et al. 2015; Adair and Lopez 2018; Johnson et al. 2021).[3]

Internationally, the two most widely used sets of direct death registration completeness estimates are the UN Statistical Division's Demographic Yearbook (UNSD 2021) and

[2] The methodological reports of the most recent WPP revisions, 2019 and 2022, provide a detailed description of this estimation process. The former also has a detailed discussion and example of Senegal as an illustration for deriving expected deaths in countries with deficient vital registration.

[3] Another method, which we will not discuss here, is to ask respondents in large household surveys or censuses both about deaths and registration of deaths. See Saikia, Kumar, and Das (2023); Zimbabwe National Statistics Agency (2023) for two recent examples of a survey in India and a census in Zimbabwe.

GBD (2020).[4] However, some UNSD completeness estimates are opaque, listed at "Less than 90%" (is it 40%, 50% or 75% complete?). Additionally, in some countries, even recent estimates are based on outdated data and analyses. For example, in Bolivia, UNSD estimate is from 2000 and GBD is from 2003. In other cases, the latest estimate may be fairly recent (2015 for Peru), yet still outdated due to significant reforms instituted since then, such as Peru's modernization of its death registration system (Vargas-Herrera et al. 2018). Some of the completeness estimates are contradictory, with large differences between sources. For example, UNSD estimate the completeness of death registration in Lebanon from 2007 at "90% or more," while GBD contains no estimate for it at all. In Saudi Arabia, UNSD estimate completeness at "90% to 99%," while GBD estimate is 43%.

This study presents the International Completeness of Death Registration (ICDR) dataset. ICDR was created by hand-collecting death registration data from 193 countries in 2015–2019 to provide the most up-to-date and reliable estimates of the completeness of death registration in one single source. ICDR is freely and publicly available at https://github.com/akarlinsky/death_registration.

2. Materials and methods

Many sources were used to construct the ICDR dataset. We build on our previous work, the World Mortality Dataset (WMD) (Karlinsky and Kobak 2021), which contains weekly or monthly death counts from 127 countries and territories from 2015 to 2023. The data from the WMD are official counts published or provided by the responsible institutions in these countries: national statistics offices, civil registries, ministries of health, and others (henceforth referred to as NSOs). A detailed list of sources for each country in WMD is available at https://github.com/akarlinsky/world_mortality. Inclusion criteria in WMD require some information to be available for 2020 and at least a monthly time format. As this paper focuses on the 2015–2019 period, data from WMD was supplemented by (1) annual number of registered deaths in countries that are in WMD, but weekly/monthly data is not available for all 2015–2019;[5] and (2) official registered number of deaths, hand-collected for countries not in WMD. Similarly to the WMD, the sources for most additional countries are official reports from the NSOs. Additionally, we obtained death registration data for some countries from the civil registration vital systems midterm questionnaire, UNSD yearbook, the UN's special collection of deaths by month, WHO's Mortality Database, and the research literature (UNESCAP 2021; United Nations, Department of Economic and Social Affairs, Population Division 2021; UNdata 2021; WHO 2021d; Zeng et al. 2020; Stoneburner and Greenwell 2017). In cases we were unable to locate

[4] Table S9 in the appendix of Vos et al. (2020) contains direct estimates of death registration completeness.

[5] For example, WMD has Algeria's monthly data from 2018. We added annual data for 2015–2017 from Algeria's demographic yearbooks to ICDR dataset.

the information ourselves, we contacted NSOs for it. The extensive list of sources for all countries not from the WMD is provided in the References section.

In cases where information for some country was found in more than one source, priority was given to figures published by the country itself or with a more direct attribution. For example, in Bangladesh 2018, the number of deaths in the UNSD yearbook is over 820,000; but this is contradicted by the figure in the civil registration vital systems midterm questionnaire of about 196,000, which is more plausible.[6]

The annual amount of registered deaths in each country for 2015–2019 was contrasted with the annual expected number of deaths. As discussed in the introduction, there are three prominent international datasets containing estimates of total/expected deaths by country-year: World Population Prospects (WPP 2022)[7], Global Burden of Disease (GBD 2020), and Global Health Estimates (GHE 2021b). The estimates in these sources are derived from a variety of sources and use many methods, a detailed discussion of which is outside the scope of this work. It is important to note that the three different estimates are mostly similar, especially when vital registration systems are complete. However, the estimates sometimes differ significantly. For example, the estimate of total deaths in the United Arab Emirates in 2019 is 13,552 (WPP), 20,932 (GHE), and 29,113 (GBD). Large disagreements reflect the fact that the underlying information in such countries might be problematic, and differences are driven by modeling as well as methodology and selection of data sources. ICDR provides for each country-year a confidence score defined as the ratio between the min and max completeness estimates, provided there are at least two sources for expected deaths. The confidence score ranges from 0% (lowest agreement) to 100% (full agreement). As with all such measures, it reflects the agreement between available data sources and not true uncertainty. In simple terms, if all sources and methods for a specific country-year are 'wrong' but similar, the confidence score will be high even if in reality it should be low.

In order to limit the effect of such disagreements on our estimates, the final estimate for expected number of deaths in each year was obtained as the mean of the three estimates. However, the public availability of the ICDR dataset allows researchers to use any one of these estimates, some other function thereof, or another estimate of expected deaths entirely. See section 3 for further discussion on this.

A few small changes were conducted to the registration data in order to merge it with the number of expected deaths. WMD provides separate death registration counts for Transnistria and Kosovo, while the three sources of expected number of deaths count

[6] The source of the UNSD figure is from Bangladesh's Sample Vital Registration Survey, derived as the product of the survey crude death rate and population count – making it essentially an expected number rather than the registered number of deaths. After alerting the UN, the UNSD yearbook now mentions that the "Data are estimates from Sample Vital Registration System (SVRS 2019)" for Bangladesh.

[7] Taken from the medium fertility variant time series.

Transnistria as part of Moldova. For this study, we joined them so that the completeness rate for Moldova would not be downward-biased.[8] For Kosovo, out of the three expected deaths sources, only WPP provide separate estimates for it, with the other sources counting it as part of Serbia. ICDR provides a separate estimate for completeness in Kosovo and Serbia (based only on WPP as denominator). After these modifications, we provide data for a total of 193 countries: 127 from WMD and the rest from the additional sources discussed above.

Finally, using the above-mentioned sources and methods, we estimate death registration completeness for each country c and year t, which is defined as:

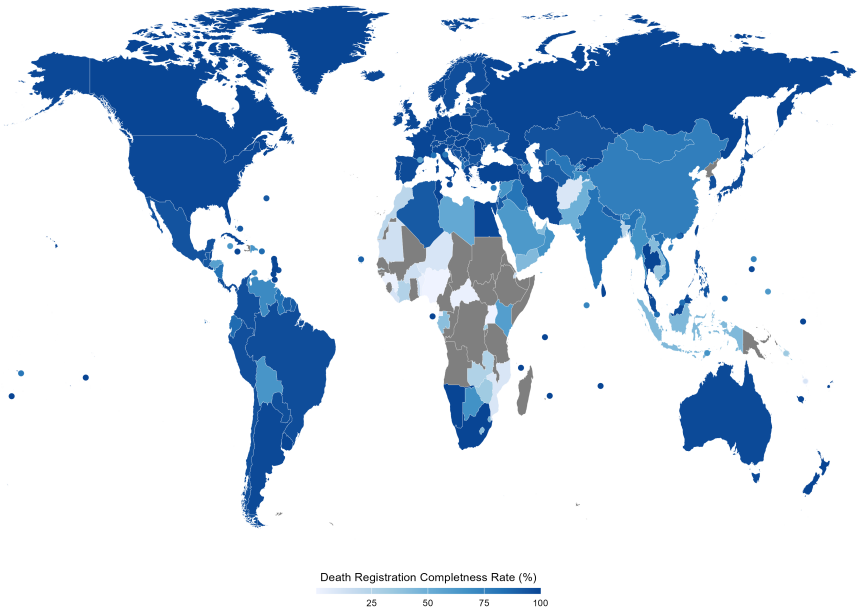
$$\text{Death Registration Completeness (\%)}_{c,t} = \frac{\text{Registered Deaths}}{\text{Expected Deaths}}_{c,t} = \frac{\text{Registered Deaths}}{AVG(\text{WPP, GBD, GHE})}_{c,t}.$$

3. Results

The full list of the 193 ICDR countries and the death registration completeness estimates are provided in https://github.com/akarlinsky/death_registration, where ICDR is made available in a machine-readable, longitudinal format, along with the underlying values for the number of registered and expected deaths. Figure 1 shows a map of the completeness rate in the latest available year for each country. Darker shades denote higher completeness.

[8] While this corrects for the data issue, the state issue remains as Moldova exerts no de-facto control over Transnistria, such that joining them together does not allow for proper assessment of their independent vital registration systems.

Figure 1: Death registration completeness by country



Notes: Small countries and territories as circles. Gray denotes no registration data.

In order to analyze the results, it's useful to contrast them with previously reported, direct estimates of death coverage from United Nations, Department of Economic and Social Affairs, Population Division (2021), and Vos et al. (2020).[9] Table 1 presents this comparison for some selected countries.

[9] Vos et al. (2020) also has indirect estimates of death registration completeness, produced by predicting completeness as a function of socio-development index, even for countries without any registration data. See Lozano et al. (2018), appendix section 17.19.2c for details. ICDR provides actual registration data, we thus contrast it with only direct estimates.

Table 1: Death registration completeness: Direct estimates by source for selected countries

Country	ICDR	GBD	UNSD
Albania	84% (2019)	71% (2010)	75–89% (2016)
Algeria	92% (2019)	31% (2006)	less than 90% (2001)
Bahrain	76% (2019)	83% (2014)	90% or more (2015)
Bhutan	70% (2019)	None	None
Bolivia	65% (2019)	38% (2003)	less than 90% (2000)
India	82% (2019)	4% (1994)	78.1% (2016)
Indonesia	44% (2019)	None	None
Iraq	81% (2019)	76% (2014)	70–79% (2019)
Kenya	60% (2019)	None	38.9% (2018)
Kuwait	78% (2019)	83% (2012)	90% or more (2001)
Lebanon	73% (2019)	None	90% or more (2007)
Namibia	100% (2019)	None	70% (2008)
Oman	66% (2019)	79% (2010)	80–89% (2018)
Pakistan	49% (2018)	None	None
Peru	96% (2019)	64% (2015)	50–74% (2015)
Saudi Arabia	63% (2018)	43% (2010)	90–99% (2017)
United Arab Emirates	42% (2019)	67% (2007)	100% (2017)

Notes: Completeness estimate (Year of estimate). ICDR = International Completeness of Death Registration; GBD = Global Burden of Disease; UNSD = UN Statistical Division.

First and foremost, ICDR covers 26 countries that neither GBD nor UNSD contain direct estimates for, such as Indonesia, Ivory Coast, and Bhutan. Second, ICDR contains many more up-to-date estimates: Out of the 193 countries in ICDR, the latest year of data is more recent than both GBD and UNSD for 164 countries, such as Algeria, Azerbaijan, and Peru.[10] Comparing ICDR estimates to existing ones reveals some surprising results. Algeria's is estimated at 92% completeness, while UNSD and GBD estimate completeness at "Less than 90%" and 31%, respectively, and both estimates are outdated (2001 and 2006). Bolivia is estimated at 65%, while UNSD and GBD estimate completeness at "Less than 90%" and 47%, respectively. Again, both estimates are outdated (2000 and 2003). Bhutan is estimated as 70% complete based on the vital statistics report for 2019, released on 2021, which is the first it has issued (National Statistics Bureau 2021). We were also able to obtain registered death counts from Indonesia and estimate completeness at 44%, while neither GBD nor UNSD have any direct estimate.

For most of Africa, we were unable to obtain counts of registered deaths, and they thus have no estimate in ICDR. For those that did, some African countries have the lowest estimated registration completeness: Nigeria and Uganda are at less than 1% completeness; countries such as as Liberia, Morocco, Ivory Coast, and Rwanda are less than 40% complete. ICDR's estimate for Kenya is much higher than that from UNSD, and for Botswana it is quite similar. ICDR estimates virtually complete death registration

[10] ICDR contains more up-to-date estimates than UNSD for 164 countries and all countries for GBD.

in Egypt, Tunisia, South Africa, and few more. A surprising and possibly false result is the essentially complete rate for Namibia. This is probably due to an unreasonably low estimate for the annual number of expected deaths in all three sources. In fact, Namibia's own NSO in its vital statistics report estimates the expected number of deaths for 2017 at over 25,000 (Namibia Statistics Agency 2020), which would yield a much more reasonable completeness rate of 76%. This further supports the need to provide the raw counts of registered deaths, which ICDR does, so that researchers and practitioners can estimate completeness independently if they wish. Further discussion on this is in the Limitations section.

Europe's vital registration is essentially complete across the board, with Andorra's completeness estimate standing out as the lowest in Europe, and in contrast to United Nations, Department of Economic and Social Affairs, Population Division (2021), which estimate it at "90% or more." This might be due to the long time since that estimate was derived (2005) or the difficulty in establishing a reliable estimate for the expected number of deaths in such a small country (about 78,000 residents).[11] Another country that stands out is Ukraine, which ICDR estimate at about 93%. This is likely due to the annexation of Crimea by Russia in 2014, such that deaths that occur there are not registered by Ukraine, while all sources for the expected number of deaths consider it part of Ukraine.

The countries of the Persian Gulf: Bahrain (76%), Iraq (81%), Kuwait (78%), Oman (66%), Qatar (56%), Saudi Arabia (63%), and United Arab Emirates (42%) have relatively low estimated death completeness rates, with the exception of Iran (complete coverage). This is also in contrast to United Nations, Department of Economic and Social Affairs, Population Division (2021), which estimate it as complete (Qatar, Saudi Arabia, and the UAE) or close to 90% (Bahrain, Kuwait, and Oman), with roughly similar high completeness estimates from Vos et al. (2020). This might be due to the large numbers and share of noncitizens in these countries, which have a very different demographic composition than the rest of the population, especially in terms of age – which the expected death estimates from WPP, GBD, and GHE might not be taking into account properly. Many of these countries provide separate registered death counts for citizens and noncitizens. Unfortunately, neither of the sources for expected number of deaths contain separate estimates by citizenship status as they provide an estimate of the total number of deaths that occur in the country, regardless of citizenship. Thus, the analysis in ICDR is conducted on the total number of deaths (citizens and noncitizens).

In the rest of Asia, several countries' completeness estimate is lower than 50%, such as Afghanistan, Bangladesh, Laos, and Pakistan, while several countries have completeness estimates higher than 90% or complete, such as the Philippines, Thailand, Malaysia, Kazakhstan, and Sri Lanka.

[11] Note that GHE do not provide estimates for countries with populations smaller than 900,000.

In the Americas, ICDR contains estimates for all countries (except Haiti). North America's vital registration is complete, while several countries in Latin America have relatively low completeness rates with Honduras, the Dominican Republic and Bolivia having the lowest estimated completeness in the analyzed time period, at less than 65%.

4. Limitations

We set to create ICDR to provide reliable death registration completeness estimates for as many countries as possible. Compared to this goal, ICDR has several limitations. We were unable to locate information on the registered deaths counts for many countries and have chosen to treat such instances as missing rather than 0% complete since the data might exist, but it is not shared. Some countries have completeness of death registration estimates as arises from surveys or censuses. These were not included as information on vital registration is essentially missing. We have tried to make sure that the death counts we use are based on vital registration and not estimates from other sources – but some misattribution is possible.

Another limitation is the uncertainty embodied in the expected number of deaths as derived from WPP, GBD, and GHE. Estimates of the expected number of deaths is complex (see Rao, Mswia, and Setel (2020) and discussion in Section 1). Some gauge of the uncertainty in the expected number of deaths is the disagreement between the three sources. The ratio, or difference, between the highest and the lowest expected number of deaths is sometimes substantial. For example, in Botswana 2019, GBD estimates about 21,000 deaths, which is 22% higher than WPP (17,500). Such disagreement is reflected in ICDR's confidence score (see Section 1). A partial remedy for this limitation is to use more local knowledge on demographic processes. In many countries, NSOs have their own estimates of total/expected number of deaths. Collecting such estimates systematically is beyond the scope of this work, but a few examples are in order: Namibia's local estimate is much higher than all three sources, India's local estimate of 8.3 million deaths in 2019 is lower than all three, and so is Botswana's local estimate of 16,500. Thus, using the local number of expected deaths would result in lower completeness estimates for Namibia and higher completeness estimates for India and Botswana. The availability of the raw number of death registrations in ICDR allows such adjustments, while other sources only providing the final completeness estimate cannot.

ICDR includes only national-level counts of registered deaths for national-level estimates. However, national-level registration completeness may obscure significant heterogeneity within countries. For example, death registration completeness across the states of India ranges from 100% in Delhi, Gujarat, Karnataka, Kerala, and more, down to 52% complete in Bihar and 21% in Manipur, according to India's civil registration report (2021). In some countries, only some regions have functioning vital registration, such

that the NSOs report these figures as the total known registered counts. For example, in Djibouti, only the capital region of Djibouti-Ville, which contains about 66% of the total population, reports registered deaths. In Benin, the civil registration report explicitly states that the number of registered deaths is available only for "some communities," resulting in a national completeness estimate of about 2.5% in 2019. In incomplete vital registration systems, differences in death completeness are known to occur on many dimensions, such as urban/rural, sex, age, income, and more (Basu and Adair 2021; Adair et al. 2021).

Deaths that occur outside health facilities remain a challenge for many vital registration systems. For example, Burkina Faso's and Liberia's registration figures pertain only to deaths that occur in hospitals or basic health facilities.

Some of the countries analyzed here were under severe political difficulties or civil war during 2015–2019; examples include Libya, Syria, and Yemen. In these countries, the registered number of deaths reflect both the toll of civil conflict and the fact that some regions are not reporting registrations to the central government. For example, during the entire analyzed period, there was no reporting on registered deaths from the Aleppo governorate in Syria.

5. Summary and outlook

This study is a data description of the ICDR dataset, which currently contains the latest completeness of death registration in 193 countries from across the globe. ICDR is a live dataset: Possible sources are checked regularly, and information is added to the ICDR at the public repository at https://github.com/akarlinsky/death_registration.

Death registration completeness is a key measure and input into vital registration performance estimates, monitoring of SDGs, proper governance, and state capacity (similar to Lee and Zhang (2017)'s census accuracy measure). There are other important properties of death registration systems that are outside the scope of this work. These include the timelines of registration, (i.e., the amount of time that passes between occurrence of death and its registration); the share of deaths that are registered with cause-of-death information (WHO 2021a), sex, and age (Mikkelsen et al. 2015); proper attribution of cause of death and a low share of "garbage cause of death codes." For example, while Egypt's death registration is complete, it has a high share of garbage codes (Iburg et al. 2020). These dimensions of vital registration should be the focus of more research, especially in countries that have achieved complete or close to complete registration. In countries with incomplete registration, emphasis should be placed on strengthening basic vital registration as a necessary first step.

The period we have analyzed here is the five-year period prior to 2020, the year COVID-19 began to spread. The effect of COVID-19 and government-mandated measures to combat its spread on vital registration systems and the completeness rate is yet unclear.

On the one hand, many vital registration systems "were either disrupted or discontinued" (Centre of Excellence for CRVS Systems 2021; Pacific Community 2021), which might lower completeness rates in 2020 and onward. On the other hand, governments might have put more resources into monitoring both general and COVID mortality, suggesting a possible upward shift in completeness. It should be noted that estimating completeness during COVID by contrasting registered with expected deaths in 2020, for example, is not valid. This can be easily seen by many countries having more deaths than expected in 2020 and onward – this is excess deaths and not "above 100%" completeness. Thus, death registration completeness during COVID might be better studied using censuses and surveys (Saikia, Kumar, and Das 2023; Zimbabwe National Statistics Agency 2023).

An additional dimension of vital registration and dissemination that should be emphasized is the frequency of the published data. Excess mortality estimates, crucial to our understanding of COVID-19 (Beaney et al. 2020; Islam et al. 2021; Karlinsky and Kobak 2021; Adair, Lopez, and Hudson 2020) as well as other disasters and pandemics, requires high-frequency mortality data, such as weekly or monthly. Annual number of registered deaths counts are better than no registration data, but their application to excess mortality estimates is limited since many of these events do not conform to annual timelines or last for a long duration. It is vital that countries publish high-frequency mortality data in the future, preferably by date of occurrence, just as they report periodical estimates of unemployment, prices, and various other measures.

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