International Conference on Social Science and Humanity
Homepage : https://proceeding.antispublisher.or.id/index.php/icossh/index
Email : admin@antispublisher.com

e-ISSN : 3063-9611
ICOSSH, Vol. 3, No. 5, 2026
Page 159-171
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Gap Analysis of Indonesian Mortality Data in the Digital Era Based on Completeness, Cause-of-Death Availability, Timeliness, and Data Usability

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DOI : https://doi.org/10.61796/icossh.v3i4.663

Sections Info

Article history:
Submitted: August 23, 2026
Final Revised: September 11, 2026
Accepted: October 16, 2026
Published: November 23, 2026

Keywords:
Mortality data
Underlying cause of death
Completeness
Icd
Data usability

ABSTRACT

Objective: *This study aims to analyze the gaps in Indonesian mortality data across seven dimensions: completeness, cause-of-death availability, timeliness, granularity, comparability, interoperability, and data usability.* ***Method:*** *An evaluative secondary analysis design was employed, examining publicly available mortality data sources, with national and international mortality publications and datasets serving as the units of analysis. The analysis was conducted through data source inventory, core mortality variable extraction, indicator availability matrix construction, dimensional scoring, cross-source comparison, and the development of a mortality data gap factor tree.* ***Results:*** *The results indicate that while Indonesian mortality data are accessible through national channels and international estimates, they do not yet possess a uniform variable structure capable of supporting detailed epidemiological mortality analysis. Major gaps include limited ICD-based underlying cause-of-death data, inconsistent granularity by age, sex, region, period, and cause of death, methodological discrepancies across sources, publication delays, and suboptimal interoperability and data usability for decision-making. The factor tree identifies four primary problem clusters: data input completeness, cause-of-death certification and coding, digital system integration, and data utilization for analysis and policy.* ***Novelty:*** *Strengthening Indonesia's digital mortality data requires minimum dataset standardization, medical certification of cause of death, ICD coding, cross-source validation, system integration, and a comprehensive, timely, comparable, and actionable national dashboard.*

INTRODUCTION

Mortality data constitute a critical foundation within any health system, as deaths not only signify the endpoint of a disease trajectory but also reflect the quality of prevention, early detection, clinical care, and health system responsiveness to priority health challenges. Robust mortality information must capture the number of deaths, time of occurrence, demographic characteristics, geographic region, and the underlying cause of death classified according to international standards. The World Health Organization (WHO) defines the underlying cause of death (UCOD) as the disease or injury that initiated the train of morbid events leading directly to death, while the International Classification of Diseases (ICD) serves as the standard instrument to ensure cause-of-death comparability across regions and time periods [1], [2]. Within vital statistics systems, complete registration of deaths and causes of death underpins health planning, program evaluation, development indicator monitoring, and disease burden estimation [3], [4]. Without comprehensive mortality data disaggregable by cause of death, health policies risk relying heavily on modeled estimates or proxy indicators rather than empirical evidence derived from routine national registration.

Digital health transformation offers significant opportunities to accelerate the recording, collection, integration, and utilization of mortality data. Ideally, a digital system links mortality records across healthcare facilities, electronic medical records (EMRs), medical certificates of cause of death (MCCOD), civil registration, disease surveillance, and health program reporting. The WHO Mortality Database exemplifies international mortality data standards, compiled by country, year, age, sex, and ICD-coded causes of death reported by national authorities [5]. Similarly, the WHO Global Health Estimates provide mortality estimates disaggregated by country, age, sex, and cause of death; however, these estimates must be interpreted cautiously where death registration remains incomplete or cause-of-death quality is constrained [5], [6]. In Indonesia, the availability of the 2020 Population Census Long Form (Long Form SP2020), the Indonesia Vital Statistics Report, the Indonesia Health Profile, and international estimation sources demonstrates progress in mortality data availability, yet variable structures across these sources remain insufficiently uniform to support granular epidemiological mortality analysis [7]–[9].

Mortality data quality cannot be evaluated merely by the presence of aggregate death counts; rather, it must be assessed by its capacity to answer epidemiological questions. The *completeness* dimension reflects the extent to which deaths are captured within the system; *cause-of-death availability* indicates the presence of ICD-codable underlying causes of death; *timeliness* measures the speed at which data become available for monitoring; and *granularity* determines the capacity to disaggregate data by age, sex, region, time, and cause of death [2], [4]. *Comparability* is vital because data derived from civil registration, surveys, programmatic profiles, and global estimates often employ differing definitions, coverage, and calculation methodologies [6], [10]. Furthermore, *interoperability* and *data usability* are increasingly indispensable in the digital era, as mortality data remain underutilized if systems are disconnected, lack clear metadata, are published in non-machine-readable formats, or cannot be directly applied to health policy planning and evaluation [11], [12].

Previous studies indicate that mortality data gaps persist across many countries, particularly regarding death registration completeness and cause-of-death accuracy. Implementation research on Civil Registration and Vital Statistics (CRVS) in Indonesia demonstrates that while CRVS represents the optimal source for birth, death, and cause-of-death statistics, system strengthening requires improvements in reporting procedures, cause-of-death determination, institutionalization, and local capacity [13]. Studies on medical certification of cause of death further reveal that certification errors, reliance on ill-defined conditions, and improper selection of the underlying cause of death substantially degrade the accuracy of mortality statistics [14], [15]. Globally, the Global Burden of Disease (GBD) study and WHO Global Health Estimates offer valuable benchmarks for understanding mortality patterns by cause, age, sex, and location; nevertheless, both rely on statistical modeling that synthesizes disparate sources and therefore cannot fully substitute for a complete, routine national death registration system [6], [10].

Indonesia's mortality data gap must be understood not solely as an issue of publication availability, but as a challenge of variable alignment, informational depth, and cross-source linkage. Long Form SP2020 provides demographic mortality indicators and descriptive mortality analyses, but it is not designed as a routine, ICD-based

underlying cause-of-death system [7]. The Indonesia Vital Statistics Report has begun strengthening the integration of population administration, census/survey, and health data, yet utilizing it for cause-specific mortality analysis still requires standardized cause-of-death variables and coding [8]. The Indonesia Health Profile presents annual programmatic data and health indicators, but its reporting format does not consistently align with epidemiological needs regarding underlying cause of death, age, sex, region, and reporting period [9]. Conversely, international sources such as WHO Global Health Estimates and GBD offer broader cause-of-death coverage, but methodological differences relative to national data create challenges when comparing trends and establishing local data-driven priorities [6], [10].

These gaps directly impair the health system's ability to detect shifts in disease and mortality patterns. When underlying causes of death are inconsistently available, analyses of mortality attributable to non-communicable diseases, communicable diseases, injuries, maternal and neonatal causes, and specific risk factors lose precision. When granularity across age, sex, region, and reporting period is non-uniform, identifying high-risk populations and priority regions becomes constrained [2], [7], [9]. When national data, programmatic reports, and international estimates are not fully comparable, policymakers face conflicting figures that are difficult to reconcile for program implementers and the public [6], [10], [14]. In the digital era, publication delays and poor interoperability further diminish the utility of mortality data for early warning, trend surveillance, and rapid decision-making on priority health threats [11], [12], [16].
Strengthening Indonesia's digital mortality data ecosystem requires an analytical approach rather than a mere inventory of sources. Mortality data sources must be evaluated through a multidimensional matrix encompassing *completeness*, *cause-of-death availability*, *timeliness*, *granularity*, *comparability*, *interoperability*, and *data usability* to systematically pinpoint strengths and weaknesses. Presidential Regulation No. 39 of 2019 on One Data Indonesia (*Satu Data Indonesia*) underscores the necessity of data standards, metadata, interoperability, and reference codes as pillars of high-quality government data governance [11]. Concurrently, population administration legislation provides the legal mandate for vital event registration [17], while electronic medical record regulations reinforce the digitalization of clinical data capable of supporting cause-of-death documentation in healthcare facilities [16]. Consequently, digital mortality challenges cannot be resolved simply by deploying new dashboards; they require minimum variable standardization, medical certification of cause of death, ICD coding, cross-source validation, system integration, and actionable data utilization mechanisms [4], [18].

This study is designed to analyze Indonesian mortality data gaps in the digital era by evaluating the availability, structure, comparability, and usability of open mortality data sources. Rather than assessing individual-level mortality records, this paper evaluates mortality publications and datasets as the units of analysis using the seven-dimensional framework (*completeness*, *cause-of-death availability*, *timeliness*, *granularity*, *comparability*, *interoperability*, and *data usability*). This approach aligns with strengthening submissions to the WHO Mortality Database as an ICD-based reference [5] and operationalizing One Data Indonesia principles [11]. The findings yield a source evaluation matrix, dimensional gap scores, and a factor tree of Indonesian mortality data gaps to guide national mortality data system reform.

RESEARCH METHODS

This study employed an evaluative secondary analysis design, utilizing publicly accessible Indonesian mortality data sources and publications—both national and international estimates—as the units of analysis. The evaluated sources comprised Statistics Indonesia (BPS) publications (Long Form SP2020 and the Indonesia Vital Statistics Report), the Indonesia Health Profile, WHO Global Health Estimates, the WHO Mortality Database, the Global Burden of Disease (GBD) study, and other relevant open-access mortality repositories.

Data collection involved source inventory, coverage identification, extraction of core mortality variables, and construction of an indicator availability matrix. Evaluated variables included total death counts, underlying cause of death, ICD codes, age, sex, geographic region, reporting year, data collection methodology, publication format, and analytical readiness for epidemiological research.

Assessment was conducted across seven dimensions: *completeness*, *cause-of-death availability*, *timeliness*, *granularity*, *comparability*, *interoperability*, and *data usability*. Each dimension was scored on an ordinal scale from 0 to 3:

- **0:** Not available
- **1:** Available, very limited
- **2:** Partially or moderately available
- **3:** Well available / optimal

The resulting scores were compared across sources and synthesized into an evaluation matrix and a mortality data gap factor tree illustrating core bottlenecks across data input, cause-of-death certification and coding, digital system integration, and data utilization for analysis and policy.

RESULTS AND DISCUSSION

Results

A. Inventory and Dimensional Evaluation of Mortality Data Sources

The inventory demonstrates that Indonesian mortality data are available across multiple channels, each differing in function, coverage, and informational depth. BPS's Long Form SP2020 excels in depicting demographic mortality indicators, such as mortality by population characteristics and demographic mortality estimates. The BPS Indonesia Vital Statistics Report strengthens the integration of administrative and vital statistics, though it has not yet established a consistent framework for detailed, ICD-based underlying cause-of-death analysis. The Indonesia Health Profile provides programmatic health indicators and selected priority mortality metrics, yet its structure remains largely aggregated by health program. Conversely, WHO Global Health Estimates, the WHO Mortality Database, and GBD offer broader cause-of-death profiles, but function primarily as modeled estimates or international benchmarks rather than primary national records derived from routine civil death registration.

Table 1. Inventory of Analyzed Mortality Data Sources

Data Source	Primary Data Characteristics	Key Strengths	Key Limitations
Long Form SP2020 (BPS)	Population census-based mortality data	Strong for demographic mortality indicators and population characteristics	Not designed as a routine ICD-based underlying cause-of-death system
Indonesia Vital Statistics Report (BPS)	Vital statistics compiled from administrative and statistical sources	Advances the strengthening of national vital statistics	Cause of death and ICD coding are not yet consistent core structures
Indonesia Health Profile	Annual health program reporting data	Strong for programmatic, service delivery, and selected priority mortality indicators	Not all deaths are disaggregated by UCOD, age, sex, region, and period
WHO Global Health Estimates	Modeled mortality estimates by cause, age, sex, country, and year	Strong for international benchmarking and cause-specific mortality	Model-based estimates; dependent on underlying national data quality
WHO Mortality Database	Country-reported, ICD-coded mortality data	Serves as the international reference standard for cause-of-death data	Data availability depends on national reporting and registration quality
Global Burden of Disease (GBD)	Modeled estimates of disease burden and mortality by cause and risk factor	Highly robust for trend analysis, risk factor attribution, and global comparison	Statistical estimation model; does not replace national death registration

Based on the seven-dimensional assessment, the most pronounced gaps occur in *cause-of-death availability*, *granularity*, *comparability*, and *interoperability*. National sources exhibit strengths in geographic coverage and programmatic relevance, yet not all provide standardized ICD-coded underlying causes of death. Conversely, international sources offer more comprehensive and cross-nationally comparable cause-of-death data, but rely

on estimation models that do not directly reflect national civil registration capacity. Evaluative scoring indicates that no single source achieves optimal performance across all dimensions, necessitating cross-source triangulation when utilizing Indonesian mortality data.

Table 2. Dimensional Evaluation Scores of Mortality Data Sources

Data Source	Completeness	Cause of Death	Timeliness	Granularity	Comparability	Interoperability	Data Usability	Total
Long Form SP2020 (BPS)	2	1	1	2	2	1	2	**11**
Indonesia Vital Statistics Report (BPS)	2	1	2	2	2	1	2	**12**
Indonesia Health Profile	2	1	2	2	1	1	2	**11**
WHO Global Health Estimates	2	3	2	3	3	2	3	**18**

Data Source	Completeness	Cause of Death	Timeliness	Granularity	Comparability	Interoperability	Data Usability	Total
WHO Mortality Database	2	3	2	3	3	2	3	**18**
Global Burden of Disease (GBD)	2	3	2	3	3	2	3	**18**

Table 3. Key Gaps by Evaluation Dimension

Dimension	Key Findings	Implications for Mortality Analysis
Completeness	Death counts appear across multiple sources, but do not consistently reflect complete routine civil registration	Mortality rate estimates may vary across data sources
Cause-of-death availability	ICD-based underlying causes of death are inconsistently available in national sources	Cause-specific mortality analysis relies heavily on international estimates
Timeliness	Data are published periodically, but do not support rapid or real-time surveillance	Suboptimal for rapid public health response to shifting mortality patterns
Granularity	Disaggregation by age, sex, region, and cause of death is non-uniform	Limits identification of high-risk groups and priority geographic areas

Dimension	Key Findings	Implications for Mortality Analysis
Comparability	Methodologies differ across census, vital statistics, programmatic data, and global estimates	Cross-source trend comparisons require cautious interpretation
Interoperability	Linkages among civil registration, health facilities, and programmatic systems are weak in open publications	Cross-source validation and unified mortality dashboard integration are suboptimal
Data usability	Data are published, but not consistently in machine-readable formats ready for secondary analysis	Policy application requires substantial preprocessing and data cleaning

B. Factor Tree of Indonesian Mortality Data Gaps

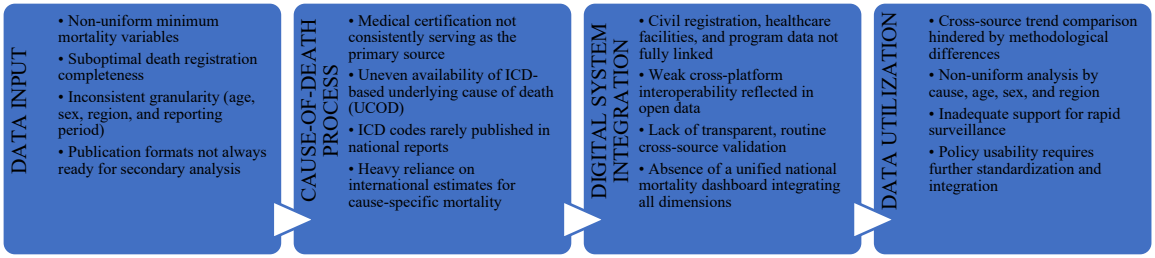

Figure 1. Factor tree of Indonesian mortality data gaps.

The factor tree (Fig. 1) illustrates that Indonesian mortality data challenges stem from four root clusters: data input, cause-of-death certification and coding processes, digital system integration, and data utilization. On the input side, gaps arise from non-uniform minimum variables and incomplete event capture. On the process side, limitations in medical certification of cause of death and ICD coding prevent consistent availability of underlying causes of death. Within digital systems, insufficient interoperability restricts data linkage across healthcare facilities, civil registration offices, and programmatic reporting. On the output side, published data are not fully ready for trend analysis, regional benchmarking, priority setting, or actionable policy dashboards.

Discussion

The findings demonstrate that Indonesia's mortality data gap extends beyond mere source availability to encompass variable completeness, underlying cause-of-death availability, cross-source comparability, and readiness for epidemiological analysis. This aligns with the international conceptual framework of the underlying cause of death, which positions the initiating disease or injury as the focal point for understanding mortality pathways, requiring mortality systems to move beyond aggregate death counts

[1], [2]. Within vital statistics frameworks, robust mortality intelligence must originate from a complete, continuous CRVS system capable of disaggregating deaths by age, sex, geography, time, and cause [3], [4]. AbouZahr et al. [19] emphasize that strengthening national mortality statistics must begin with a systematic assessment of data completeness, reliability, validity, and policy relevance. Similarly, Hart et al. [20] underscore that accurate and timely cause-of-death data are vital for guiding health programs and policies, requiring targeted interventions across hospitals, physician training, monitoring, and institutional recording culture. Consequently, low scores in *cause-of-death availability* and *interoperability* indicate that Indonesia must transition from aggregate mortality reporting toward a standardized, interconnected, and actionable cause-of-death data architecture.

Cross-source comparison reveals that Long Form SP2020, the BPS Indonesia Vital Statistics Report, and the Indonesia Health Profile hold distinct value as national sources due to their alignment with Indonesia's administrative context, programmatic needs, and policy frameworks. Long Form SP2020 provides strong demographic mortality indicators, whereas the BPS Vital Statistics Report demonstrates progress toward integrating administrative, census, survey, and health records [7], [8]. The Indonesia Health Profile remains essential for tracking annual health program indicators, although programmatic metrics do not always equate to ICD-coded underlying cause-of-death records disaggregated by age, sex, region, and period [9]. Conversely, WHO Global Health Estimates, the WHO Mortality Database, and GBD excel in presenting cause-specific mortality disaggregated by age, sex, location, and year, yet remain contingent upon input data quality and statistical modeling assumptions [5], [6], [10]. As demonstrated by the GBD 2021 Causes of Death Collaborators [21], global models can generate granular estimates across 288 causes of death and subnational locations, but such approaches rely on synthesizing diverse data sources and statistical covariates. Therefore, national and international sources should be interpreted as complementary informational layers rather than mutually exclusive substitutes.

The gap factor tree confirms that Indonesian mortality data limitations are rooted in four interconnected domains: data input, certification and coding processes, digital integration, and policy utilization. This resonates with Rao et al. [13], who found that strengthening Indonesia's CRVS system requires reforming reporting workflows, cause-of-death determination, institutionalization, and local capacity. Regarding *completeness*, Adair and Lopez [22] stress that death registration completeness must be routinely measured so governments understand the proportion of actual deaths captured by civil registries. Furthermore, Adair et al. [23] demonstrate that CRVS data quality can vary across demographic strata, including sex differentials in registration completeness and cause-of-death accuracy. These insights reinforce that input gaps are not merely administrative hurdles; they directly bias mortality rate estimates, trend interpretations, risk-group identification, and geographic priority setting.

Gaps in certification and coding represent a critical bottleneck, as mortality data can only support cause-specific epidemiology when causes of death are accurately certified, coded according to ICD rules, and properly selected as the underlying cause of death. Gamage et al. [14] show that medical certification errors significantly compromise underlying cause-of-death accuracy, while Al-Kubaisi et al. [15] identify improper causal sequencing, listing mechanisms of death rather than underlying diseases, and recording ill-defined conditions as pervasive errors on death certificates. In a systematic review and meta-

analysis, Gamage et al. [24] establish that structured training interventions significantly improve medical certification quality, provided they are supported by continuous supervision and contextual adaptation. For out-of-facility deaths or regions lacking medical certifiers, the WHO Verbal Autopsy Standards offer a validated complementary methodology to ascertain population-level cause-of-death distributions where medical certification is unavailable [25]. Thus, digitalizing mortality reporting will remain insufficient unless paired with clinical input quality assurance, medical certification training, ICD coding capacity, and rigorous cause-of-death validation.

This study concludes that while Indonesia possesses diverse mortality data repositories, substantial gaps persist in ICD-based underlying cause-of-death availability, granularity, methodological comparability, timeliness, interoperability, and epidemiological usability. Strengthening digital mortality systems cannot be achieved merely by increasing publication volume; it requires building an end-to-end data pipeline linking death registration, medical certification, ICD coding, cross-source validation, and policy-oriented indicator utilization [2], [4], [11], [18]. A limitation of this study is its reliance on publicly available datasets and publications as units of analysis, without evaluating individual-level mortality microdata, physical death certificates, medical records, facility-level operational workflows, or subnational implementation disparities. Future research should validate this gap matrix using empirical death certificate audits, electronic medical records, civil registration microdata, and expert consensus to evaluate the mortality reporting cascade from healthcare facilities to national aggregation [13], [14], [20], [22]. Moving forward, system strengthening should prioritize establishing a national minimum mortality dataset, expanding medical certification of cause of death, scaling ICD coding training, integrating cross-sectoral platforms, deploying verbal autopsy for non-medically certified deaths, and developing a unified, timely, comparable, and actionable national mortality dashboard.

CONCLUSION

Fundamental Finding: This study concludes that Indonesia's mortality data gap in the digital era stems primarily not from an absence of data sources, but from suboptimal variable completeness, limited ICD-based underlying cause-of-death availability, publication lags, non-uniform granularity, methodological incomparability, weak interoperability, and constrained usability for epidemiological analysis. National sources—such as Long Form SP2020, the Indonesia Vital Statistics Report, and the Indonesia Health Profile—provide essential context on national mortality, yet cannot fully deliver routine, granular cause-of-death data disaggregated by age, sex, region, period, and underlying cause. International repositories—including WHO Global Health Estimates, the WHO Mortality Database, and the Global Burden of Disease—offer valuable comparative benchmarks and cause-specific estimates, but cannot substitute for a robust national civil registration and vital statistics system. **Implication:** Future strengthening efforts are recommended through: (1) establishing a standardized national minimum mortality dataset; (2) expanding medical certification of cause of death across healthcare facilities and integrating verbal autopsy for community deaths; (3) strengthening standardized ICD coding capacity; (4) enforcing system interoperability across civil registration, healthcare facilities, electronic medical records, and programmatic reporting platforms; (5) institutionalizing cross-source data validation; and (6) developing a complete, timely, standardized, and actionable national mortality dashboard to support public health planning, evaluation, and evidence-based decision-

making. **Limitation:** This study is limited by its reliance on existing national and international mortality data sources, which may differ in completeness, reporting periods, data granularity, classification methods, and estimation procedures. These variations may restrict direct comparability across sources and limit the ability to assess mortality patterns consistently at subnational levels. Furthermore, the study identifies gaps in Indonesia's mortality data systems but does not empirically evaluate the implementation or effectiveness of proposed system-strengthening interventions. **Future Research:** Future research should evaluate the feasibility and effectiveness of implementing a standardized national minimum mortality dataset that integrates civil registration, healthcare facility records, electronic medical records, and verbal autopsy data. Further studies should assess strategies for improving medical certification of causes of death, ICD coding capacity, data interoperability, and cross-source validation across different regions of Indonesia. In addition, research should develop and test an integrated national mortality dashboard to determine its effectiveness in improving data completeness, timeliness, accessibility, and utilization for epidemiological analysis and evidence-based public health decision-making.

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