Enhancing COVID-19 Mortality Surveillance in Latin America and the Caribbean through All-Cause Mortality Surveillance

Guidance document
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1. PURPOSE AND TARGET AUDIENCE

The purpose of this document is to provide guidance to countries of Latin America and the Caribbean (LAC) on improving COVID-19 mortality surveillance. The document expands on methods for the analysis of all-cause mortality as one of the proposed approaches to contribute to the evaluation of the true burden of the COVID-19 epidemic in countries in Latin America and the Caribbean.

This document is addressed to national health authorities, including epidemiological surveillance and public health emergency teams involved in the COVID-19 epidemic response, as well as other professionals or institutions involved in surveillance, such as epidemiology departments, and mortality monitoring, such as national institutes of statistics.

2. INTRODUCTION

As part of the International Health Regulations (IHR), Member States must have the capacity to detect, assess, notify and report diseases or health events that could constitute public health events of international concern. In the context of the COVID-19 pandemic, a single approach may be insufficient to provide the necessary information to guide public health action. Countries may therefore use a combination of surveillance strategies in addition to the COVID-19 case reporting, such as monitoring deaths from all causes, or deaths among patients with severe acute respiratory illness.

Mortality surveillance for COVID-19 can provide information to:
- Monitor the severity of the COVID-19 epidemic at all administrative levels.
- Assess and estimate the mortality burden due to COVID-19 by combining/triangulating all data sources available.
- Measure the impact of the COVID-19 pandemic on all-cause mortality
- Detect changes in mortality trends by geographic areas (alerting, or confirming, COVID-19 spread to new areas).  
- Examine individual and ecological risk factors for increased mortality due to COVID-19, including those related to existing inequities in health.
- Measure and compare the impact of different public health measures implemented (e.g., non-pharmaceutical mitigation measures, or new treatment approaches, etc.).

The accurate measurement of the mortality attributable to COVID-19 can be challenging, for the following reasons:

1. This includes COVID-19 deaths and other deaths occurring during outbreaks for example, due to delays in accessing health services, interrupted health services, or over extended health services impacting on patient care.
2. Preciseness of estimates may be an issue for areas with small populations and small number of deaths.
- COVID-19 case reports rely on access to health services and testing, resulting in substantial diagnostic uncertainty for COVID-19 where testing is low.
- Cases captured by the COVID-19 incident management surveillance system may differ from cases in the community and underrepresent the true burden of the epidemic. Especially where there are existing socioeconomic, cultural, or gender-related barriers to health services in specific geographic areas or affecting populations in situations of vulnerability.
- Reporting of deaths due to COVID-19 may also be affected by under-reporting and incorrect reporting of deaths and cause of death. While WHO has established international standards, there is still limited experience in countries with the certification and coding of COVID-19 deaths. In addition, among the elderly, assessing the cause of death is typically complicated by the presence of multiple comorbidities adding to the diagnostic difficulty.

The geographic and population coverage of COVID-19-specific mortality surveillance can be improved by using additional surveillance approaches such as all-cause mortality surveillance to provide additional information on the burden and extent of the outbreak during the course of the pandemic and to capture additional impact on health due to side effects of the outbreak (e.g., increases in malnutrition, poor access to health services, etc.). For example, Figure 1 uses data from the Civil Registration System of Brazil to show increases in all-cause cumulative deaths from January to May 2020, mainly in the State of Amazonas.

Figure 1. Total deaths in Amazonas and Pará States in Brazil, January-May 2020 compared to 2019.

Source: Portal da Transparencia, Registro Civil do Brasil. Central de Informações do Registro Civil - CRC Nacional. Available at: https://transparencia.registrocivil.org.br/especial-covid

Specifically, conducting all-cause mortality surveillance through the recording of all weekly deaths and comparing this number to established threshold values could provide more detailed information on changes in mortality; it could also improve local information on COVID-19 spread and burden, and complement other COVID-19 surveillance efforts. Lastly, verbal autopsy or laboratory surveillance of cadavers at select sites could be embedded within an all-cause mortality surveillance system.
3. COVID-19 MORTALITY SURVEILLANCE SUBSYSTEMS

A. COVID-19-specific mortality surveillance
All LAC countries following IHR requirements should provide to extent possible support to WHO-coordinated response activities, including for COVID-19-specific mortality surveillance. This surveillance system includes deaths from confirmed, and probable COVID-19 cases. Those include patients with COVID-19 where “death” was the outcome reported following hospitalization, residence in nursing homes or other long-term social/medical establishments, or patients attending a sentinel surveillance site for respiratory illnesses.

B. SARI sentinel mortality surveillance
Since the 2009 A(H1N1) influenza pandemic, LAC countries have made significant investments and efforts to strengthen the surveillance of severe acute respiratory infections (SARI) surveillance. Sentinel sites across the region, systematically collect, analyze and report epidemiological and virologic information on a weekly basis to guide public health action. The outcome of the hospitalization is typically reported for SARI patients, including death. Thus, this system can be used to capture death following a severe acute respiratory infection in patients who may not have had a test result to confirm or exclude COVID-19 as the cause of death. Currently, LAC countries have leveraged existing national influenza surveillance systems and public health laboratories for epidemiological and virologic surveillance for COVID-19. Both COVID-19 case reporting and the complementary sentinel SARI surveillance use existing reporting channels to notify national-level authorities of all COVID-19 deaths.

C. COVID-19 mortality from existing national vital registration systems
A well-functioning national vital registration (VR) system registers all deaths and classifies causes of death reported in death certificates using the WHO standardized International Statistical Classification of Diseases (ICD). Despite the well-documented benefits of VR systems, it is estimated that globally, two-thirds of deaths are never registered. In LAC, the population coverage, quality and timeliness of these vital statistics systems vary between countries and under-registration of deaths is a major challenge in many countries. Some population groups may also be underrepresented; for example, indigenous groups may face barriers to registration systems. Even when deaths are registered, reporting might not be timely, and there may be inaccurate and misclassified underlying cause of death on death certificates, for example, associated with limited competencies of those certifying the death, or coding errors may occur.

Deaths due to **ICD-10 codes U07.1 and U07.2** (laboratory confirmed and suspected deaths due to COVID-19) (see Annex 2) and **codes J10-J18** (for pneumonia and influenza deaths) are currently being recorded. Nevertheless, the quality of ascription and coding of the underlying cause of death, as well as the completeness and timeliness of the information may be challenges for opportune data use, for example, for outbreak response.
D. All-cause excess mortality surveillance

Monitoring all-cause mortality and comparing observed deaths to expected values is a strategy with increasing applications globally. Excess mortality has been used in monitoring the impact of influenza epidemics, heat waves, other events impacting population health, and currently in the COVID-19 pandemic.3, 4, 5, 6, 7, 8, 9

All-cause excess mortality surveillance can be a reliable and comprehensive measure of the overall impact of COVID-19 mortality. Timely detection of an excess mortality may be particularly valuable in settings with limited testing for SARS-CoV-2. This surveillance allows national authorities to better assess the burden of COVID-19 without relying exclusively on molecular testing and in doing so, including a much larger proportion of their population.

Weekly counting of all deaths in a defined area (with minimal disaggregation for example by age group, sex, residence and place of death) and its comparison to threshold values can be used as an early warning system to monitor the extent and severity of COVID-19 outbreaks. It can also guide the allocation of health care resources and response to other needs. Rapid increases in COVID-19 cases can lead to changes in the use of the health system or its failure. For instance, resources and priority may be reallocated away from routine care, resulting in an increase in mortality from other causes or from lack of access to intensive care. Moreover, public health measures such as lockdowns and fear of infection in hospitals, may delay urgent care and contribute to increased adverse health outcomes. Countries may consider several potential sources for counts of deaths and scope of the method:

**Vital registration systems with cause of death adscription:** National vital registration systems that collect and code cause of death could be one of the sources for monitoring of all deaths. Coverage, precision, and timeliness are important factors to consider when using this source of data for counting deaths.

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3 Preliminary estimate of excess mortality during the COVID-19 outbreak — New York City, March 11–May 2, 2020. MMWR Morb Mortal Wkly Rep 2020;69:603–605. DOI: [http://dx.doi.org/10.15585/mmwr.mm6919e5](http://dx.doi.org/10.15585/mmwr.mm6919e5)


Civil registration of deaths: These refer to death registration systems such as those carried out by townships or municipalities. In most countries, a civil registration system is used to record statistics on vital events such as births, deaths, marriages, divorces, and fetal deaths. This government administrative system creates a permanent record of each event. In some cases, they are linked to the abovementioned vital registration systems but in others they function as separate systems. Civil registration can provide preliminary information on the number of deaths without providing the cause of death. Surveillance based on civil registration of deaths can provide useful information in a timely manner and be used to reconcile data from vital statistics and other surveillance systems.

Community-based recording of deaths: In areas where deaths are likely to go unreported, or where coverage of death reporting is suboptimal, community efforts may leverage existing systems for counting deaths. For example, in some areas, community leaders have been able to, to keep a record of all births to create a register of children eligible for vaccination, this register is used by the Expanded Program on Immunization (EPI) to facilitate community engagement and catch-up vaccination of missed children. The same type of list – this time for deaths – could be a useful tool to assess all-cause mortality in areas where reporting is subpar. Use of technology such as mobile devices can also facilitate this type of recording.

Facility-based recording of deaths: Facility-based all-cause mortality surveillance aims to collect information on all deaths occurring at a health facility, with the optional collection of cause of death information where feasible. This approach typically relies on selecting sentinel sites, chosen for representativeness or feasibility purposes. Sites report daily or weekly deaths, with minimal disaggregation (i.e., age group and sex) and analysis includes comparing figures to threshold values.

4. HOW TO CONDUCT ALL-CAUSE MORTALITY SURVEILLANCE TO INFORM COVID-19 RESPONSE

We now describe the steps in setting up or enhancing COVID-19 mortality surveillance focusing on using all-cause mortality surveillance from vital registration systems, civil registries, sentinel health facilities, and/or community-based reporting).

All-cause mortality captures the net effect of all the factors contributing to an increase or decrease in deaths (for example, less road traffic deaths, lower pollution). In the absence of mortality-inducing unusual events such as natural disasters, all-cause mortality is the most reliable and comprehensive measure of the overall impact of COVID-19 mortality. In order to determine the additional number of deaths occurring in relation to (and not just due to) COVID-19, we must estimate “excess” mortality.

Excess mortality is defined as the reported number of deaths\(^{10}\) minus the expected number of deaths during that period. The expected number is devised from past mortality trends. Excess deaths are not

\(^{10}\) Reported deaths (observed) may be subject to adjustments for reporting delays or under-registration. They would be deaths “estimated” to have occurred.
defined by the number of deaths where COVID-19 is the cause, other factors can contribute to excess mortality.

Regardless of the data source for all deaths counts, performance indicators including coverage, completeness and timeliness of each system should always be considered when conducting this surveillance and analyzing the data.\textsuperscript{11}

**Box 1. Steps in setting up all-cause mortality surveillance**

<table>
<thead>
<tr>
<th><strong>Step 1. Establish a working group and plan surveillance</strong></th>
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<tbody>
<tr>
<td>- Engage the relevant stakeholders and establish a working group on all-cause mortality surveillance</td>
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<tr>
<td>- Identify and assess the existing surveillance systems and data sources that can be leveraged for mortality surveillance</td>
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<tr>
<th><strong>Step 2. Improve existing systems and/or develop new ones for collection of information on all weekly deaths</strong></th>
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<tbody>
<tr>
<td>- Enhance reporting of deaths and analysis from existing systems: Vital Registration death certification and/or civil registration</td>
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<tr>
<td>- Establish or enhance surveillance sites for facility and/or community-based surveillance</td>
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<tr>
<th><strong>Step 3. Conduct analysis for excess all-cause mortality</strong></th>
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<tbody>
<tr>
<td>- Review data quality</td>
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<tr>
<td>- Compile observed deaths and historical data and determine expected mortality levels (number of deaths, range and threshold values)</td>
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<tr>
<td>- Continuously collect data and report on daily/weekly basis. Continuously manage, analyze and interpret data</td>
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<tr>
<td>- Calculate excess deaths and range</td>
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<td>- Use findings and provide feedback to actors of the system at all levels</td>
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</table>

**STEP 1. Define a working group and conduct a rapid review of existing mortality information systems to decide on data sources and plan analysis**

A working group including the epidemiological surveillance teams at the ministry of health, and other experts from key institutions such those in charge of vital statistics, should start by listing all systems that record deaths. This review should consider all systems that can provide information on the total number of deaths during a predefined period. Also, the review must examine the following characteristics of the systems:

- System coverage (geographical, place of death: institutional and in the community, other variables).
- Possible disaggregation by subnational administration levels, age, sex, and ethnicity.

• The subpopulations under surveillance, with a focus on marginalized and hard-to-reach groups or populations of geographically remote areas.
• Data timeliness, i.e., when data become available for use at the national and subnational levels.

National authorities should decide which systems to enhance and/or develop to improve monitoring and reporting of all deaths during the COVID-19 outbreak for appropriate analysis and decision making.

**STEP 2. Improve existing systems and/or develop new ones for collection of information on all weekly deaths**

When strengthening existing systems or developing new systems to capture deaths, the main elements to consider are:

• Simplicity (“less is more”): identify which systems are already in place and those that can be rapidly expanded. Harmonize all reporting and feedback loops and avoid developing new reporting channels or new training mechanisms if established mechanisms can be built upon.
• Sensitivity: the ability to capture a health event, or how well does the registration system capture a health event (i.e., death in the case of all-cause mortality surveillance and COVID-19 deaths in the case of COVID-19-specific mortality surveillance).
• Timeliness: the timeframe to make data available for decision-making at the central level. The target should be for the institution in charge of surveillance and response to receive information at least on a weekly basis.
• Consistency: a consistent reporting structure aligned with international recommendations.
• Acceptability: strong support from participating areas and communities, including gender and cultural sensitivity.

**Collection of deaths from existing vital registration death certification systems or civil registration systems**

• Weekly reported number of deaths (ideally disaggregated by age group, sex, place of residence, place of death and ethnicity) are required in a timely manner (with the shortest delay possible). Alternatively, adjustments for reporting delays can be conducted. Other variables should be encouraged such as ethnicity.
• Analysis can be done at national or subnational and local levels.
• Identifying each step of the death registration process, timelines, main actors, and possible delays, biases or information loss is important for implementing measures to improve the coverage of deaths, such as with the use of novel technologies to improve completeness and timeliness, and understand the quality of the data and possible correction measures.
• Reviewing data validation and quality control processes/measures to ensure the local and central levels can conduct weekly analysis with improved data completeness and timeliness.
• Where cause of death is available, a similar but more specific analysis for each relevant cause of death can be conducted to gain better insights into causes of excess mortality.
**Sentinel facility-based surveillance**

- Facility-based all-cause mortality surveillance aims to collect information on all deaths occurring at a health facility, with the optional collection of cause-of-death information where feasible.
- Health officials may choose to expand the sentinel surveillance network to increase geographic representativeness, or to overrepresent vulnerable/hard-to-reach populations.
- Facility based all-cause mortality surveillance could be built on existing networks of sentinel hospitals, such as SARI sentinel surveillance hospitals.
- If process does not yet exist or has been interrupted since the start of the COVID-19 in-country, a line list of deaths with four variables (sex, age, district or township of residence, ethnicity) can be completed each day and submitted weekly to the district or central-level authorities for compilation, review, and analysis.
- National-level authorities must calculate pre-epidemic levels of mortality, using data from the last 3–5 years from all sentinel facilities or from vital registration systems. The information should be stratified by age and sex.
- The strengths of facility-based surveillance include:
  - Its infrastructure makes it continuously available.
  - In principle, all deaths are medically certified.
  - It can measure cause of death.
  - It is a by-product of patient management.
- The limitations include:
  - Will not include cases that do not make it to hospital eg. sudden cardiac death.
  - Persons may not attend health facilities due to fear of contracting the SARS-CoV2.

A standard methodology should be followed to improve the data quality and reliability of reported facility data, with a defined minimum set of data to be recorded weekly (Table 1).

**Table 1. Example of line list of deaths at a facility with minimal recording of variables, additional variables can be included depending on feasibility**

<table>
<thead>
<tr>
<th>Facility name and place:</th>
<th></th>
<th></th>
<th></th>
<th>District, township of usual residence</th>
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</thead>
<tbody>
<tr>
<td>Week:</td>
<td>Sex</td>
<td>Age at death</td>
<td>Ethnicity</td>
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</tr>
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<td>1.</td>
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<td>2.</td>
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<td>3.</td>
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**Community-based surveillance**

- Community-based surveillance is a reporting mechanism whereby community leaders or other trusted community members (e.g., community health workers, traditional birth attendants, traditional healers, village leaders, religious leaders, teachers, political cadres, cemetery official, coffin
makers), keep a tally of the number of deaths that occur in their area during a specific period of time. In some countries in LAC, non-health professionals can report deaths and complete the death certificate, such as mayors and other community leaders.

- Community surveillance of mortality is important where a significant proportion of deaths are not reported within existing VR systems, or when some populations are systematically under-reported. This is more common among deaths occurring outside a health facility. The proportion of under-reported deaths may increase during an epidemic if hospital capacity is exceeded and some patients cannot be admitted or do not present to the hospital.
- The focus is on all-cause mortality counts, with the addition of information on the specific cause of death where feasible.
- Governments may want to select communities for surveillance in order to reflect the presence of high-risk or vulnerable populations (e.g., internally displaced populations/refugees, slums/informal settlements, food-insecure populations, etc.) or other areas of concern. In practice, time and financial constraints may force selection based on feasibility.

Regardless of how community sites are selected, certain conditions favor the success of the effort, including:

- The presence of at least one community health care worker whose routine duties include reporting incident births and deaths to pre-established local levels.
- Surveillance area boundaries that are contiguous with an administrative unit for which historical and current population and mortality figures are available or can be derived or estimated; or areas where data can be reconciled with health facility data.

**STEP 3. Conduct analysis for excess all-cause mortality**

Mortality surveillance teams must consider all attributes of the reported data including completeness, timeliness and where applicable quality of cause of death, and pay special attention to changes that may have occurred in the system over time (e.g., in system coverage and sensitivity) in order interpret the analysis results adequately and avoid misinterpreting surveillance artefacts.

**a. Data quality review**

Reviewing the coverage, completeness, timeliness and accuracy of the data allows users to understand the reference population for the data, identify patterns that may deviate from prior trends. These deviations allow users to interpret data more adequately, probe more specifically in the reporting system of select location, identify bottlenecks and propose solutions to local authorities.
Review data for coverage:

- Issues: When the coverage rate reaches 100%, all geographical units have submitted their mortality report for the period in question. When the coverage rate falls below the threshold (e.g., 90%), the dataset is incomplete and may produce biased results. Specifically, mortality rates in some locations may seem lower than in neighboring areas or when compared to the same location in previous years. In the context of a pandemic, these deviations from previous trends can cause the area to be removed from the prioritization list for resources. Also, limited information does not allow authorities to detect excess deaths, which in turn allows SARS-CoV-2 to move unchecked in the area.

- Action points:
  - Assess the degree of coverage: are all geographical units in a country reporting mortality data through their vital registry, SARI sentinel surveillance system and COVID-19 reporting mechanism? If not, work with local authorities to address any issues in the reporting system (e.g., poor internet connectivity, poor capacity for data collection, training for additional data collectors/extractors, etc.).
  - Disaggregate data by administrative level and geographical unit, and identify the silent units (i.e., those units that have not submitted any reports for 2+ weeks. They are different from units that report 0 deaths [to be discussed in the next section]).
  - Disaggregate data by population subgroup (e.g., ethnic/linguistic, hard-to-reach, migrant/refugee, etc.), and identify the silent groups (i.e., those groups for whom no mortality report has been submitted; they are different from groups who report 0 deaths [to be discussed in the next section]).
  - Disaggregate data by month and assess whether there is a period when specific geographical units or groups did not submit their mortality report. Work with local authorities to understand the bottleneck and develop strategies to either: a) remove the difficulty; or b) submit reports despite unfavorable conditions.

Review data for completeness of reporting:

- Issues: When the completeness rate reaches 100%, geographical units have submitted all data points for the period in question. When the completeness rate falls below the threshold (e.g., 90%), the dataset appears complete, but incorporates missing data points that may skew the analyses. As a result, mortality rates in some locations may seem lower than in neighboring areas or when compared to the same location in previous years. Or the pandemic may seem to affect some groups or areas more than others, when there is no difference in the mortality rate. In the context of a pandemic, limited information does not allow authorities to determine the characteristics that put specific persons at higher risk of death. Consequently, early signs, symptoms and risk factors are not recognized, and prognosis worsens.

- Action points:
  - Examine the dataset: are certain data points missing? Are the data gaps occurring at random or focused on select variables? Are gaps occurring in data from specific groups or geographical units? Discuss these patterns with local authorities to understand any constrains in death notification or data reporting.
Review data for **timeliness**:  
**Issues:**  
- There is always a time lag between a death and its notification to the competent authorities (physician or vital registry). If the death occurs in a health care facility, the lag may last a few hours. If the death occurs in the community, the lag may last hours, days, or weeks, depending on the frequency of communication between the community and the local authorities. This delay impacts mortality surveillance, since the number of deaths in a specific geographical unit or among a specific subgroup may be under-reported for weeks.  
- The central level expects that updated datasets be submitted routinely by a certain date (e.g., second week of the month; Friday at 3 pm, etc.), so that the analyses can report the most up-to-date information. Timeliness of information is especially important during an outbreak, when decisions must be made quickly. Any delay in reporting means that decisions are formed based on outdated information.

**Action points:**  
- Calculate the average delay between the event (i.e., death) and the first notification to local authorities, first overall and then for individual geographical units. Use consistent units of measure (e.g., hours, days, weeks) so the lag time can be compared across geographical units. Identify any outliers, and whether these delays occur consistently. Discuss possible action with the authorities of that unit to improve timeliness of death notification.  
- Use timeliness indicators (e.g., proportion of reports received on time vs. received late vs. not received) for each geographical unit, to establish the timeliness trend of each. Discuss possible action with the authorities of that unit to improve timeliness of reporting.  
- Analysis of reporting dates. Analysis of reports by time between day of death and day of reporting. Recent weeks may have partially missing data due to reporting delays. Average and median reporting time should be calculated. Analysis disaggregated by different variable may be useful to understand if a certain subgroups of deaths present greater delay (i.e. community deaths versus hospital deaths).

Identify **duplicate values**:  
**Issues:** Duplicate observations occur when the same information is entered twice in a dataset by mistake. For example, the same data points are entered twice (or more) for one person at one time. This error inflates the number of observations and distorts the data patterns we are trying to discern.  
**Action points:**  
- Identify duplicated reports using key variables such as unique ID (recommended), or a combination of name, sex, and date of birth (and other variables when available).  
- Eliminate all duplicate values from the database.
Repeat the de-duplication process every time an updated dataset is received.
Assess the reporting system to identify the juncture where the observations were duplicated (e.g., aggregation at the subnational level, different timelines for data flow, multiple entry points for the same information), and streamline the process to avoid duplicate information in the future.

Review data for accuracy:
- **Issues:** Even with 100% coverage, completeness and timeliness, the dataset may include incorrect information. This may be due to poor capacity of the data collection, difficulty extracting data from the medical records, communication challenges, or data entry errors. These inaccuracies can seriously bias the mortality trends under review, and create fictitious hotspots where none are, while ignoring true outbreaks.
- **Action points:**
  - Compare historical data (3–5 years prior) with current mortality estimates. Is there any significant variation between years? Is the current trend higher or lower compared to previous years? Higher mortality may be a warning for excess deaths due to COVID-19. Lower mortality may indicate bottlenecks in the notification or reporting systems.
  - Triangulate the information of one variable using other variables in the dataset to assess the veracity of the information (e.g., validate the number of deaths reported in a specific location by calculating the number of death certificates submitted; validate the number of persons who died in a health facility by ensuring that this number is smaller than the total number of deaths reported in that location, etc.).
  - Assess the epidemiological situation of an area compared to that of its neighbors. Do we notice a dearth of deaths in one location, while its neighbors are hot spots? Do we notice little to no deaths in a specific subgroup, while other groups in the same area report high mortality rates?
  - Compare frequency tables of the current dataset with those from a previous dataset. Do we see sudden variations in the mortality trends? If yes, can we explain them given the context and the information in the other variables?
  - Conduct trend analysis by sex, place of death and residence. This process can identify systematic differences in reporting for some deaths, such as evidence that community deaths are underreported in a greater degree than deaths occurring in a facility, or there may have greater reporting delays if differences only appear for certain weeks.

**b. Compile observed deaths**
The first key data element for mortality surveillance is the **weekly number of deaths due to any cause**. Given the need for timely information, national surveillance institutions will probably be conducting analyses using crude preliminary data, with the understanding that figures may be updated over time. Achieving a good balance between the quality of the information and its timeliness is essential to inform public health decision-making.
Since the observed daily number of deaths may vary widely within small geographic areas or for sentinel health facilities, using the aggregate weekly number provides more robust analysis. For that purpose, daily deaths should be aggregated by epidemiological weeks.

Corrections for delays in reporting can also be made for more accurate results. The basic assumption is that the proportion of deaths registered over a defined period is proportional to the number of days when the administration is open. The average reporting delay should be ascertained and for those days in which reporting delays may have produced an undercount of observed deaths, these can be adjusted based on reporting from previous weeks. Figure 2 shows data for the United States, with both corrected (for underreporting) and not corrected weekly reported deaths. For weeks after April 1, both corrected and uncorrected number of deaths appear over the threshold with the exception of the last two weeks (corresponding to weeks ending on 2 and 9 May 2020) where only corrected deaths are over the threshold.

**Figure 2. Example of all-cause mortality surveillance in the United States, with and without accounting for reporting delays.**


c. **Define expected deaths**

Expected all-cause mortality levels should be calculated for comparison with the observed weekly number of deaths for the periods of interest (see Figures 1 and 2). Comparing mortality for all available weeks during the year is recommended over comparing only the specific weeks of interest.
The expected all-cause mortality can be developed by using historical weekly data from the previous 3–5 years. Several options are available as summary measures for the point estimate of the expected mortality:

- The median of the previous 3–5 years of mortality data for each geographical level of analysis (or health facility) and epidemiological week. Expected values by age and sex should also be calculated for stratified analysis.
- Regression models, such as a GLM Poisson model corrected for over-dispersion, or time series models. In addition to many statistical packages, there are programs with built-in prediction functions that can support these calculations. Use of regression models should be explored when statistical expertise is available.

Special attention should be given to events occurring during years that could have affected mortality in an important manner (e.g., natural disasters like a strong hurricane season in Caribbean islands; other disease outbreaks; famine; important population movements; etc.). In this case, national authorities should decide whether those years should be excluded from the analysis. Also, consider whether there have been systematic efforts to increase reporting of deaths. These activities may result in surveillance artifacts.

Countries with incomplete vital registration can adjust their mortality data. Users can take the number of historical deaths, and divide it by the estimate of total deaths from a reliable source (such as the UN World Population Prospects reports). This will provide the percent completeness. That percentage can be used as the annual adjustment factor for the expected deaths. Where needed, users can apply this adjustment to observed deaths as well. However, prior investments may have been made to improve completeness, and the COVID-19 epidemic may have affected death registration adversely or positively. Therefore, completeness for observed weekly deaths may differ from the historical death count. Analysis of deaths by place of death (hospital or community), age group, or other variables, can provide information to guide corrections on completeness.

If reported mortality data are not available for previous years, the expected number of deaths can be estimated from international estimates such as the UN World Population Prospects 2019 mortality rates (i.e., applying the age-/sex-specific death rates derived from the UN World Population Prospects 2019 to the reference population stratified by age and sex). Alternatively, estimated mortality rates from the WHO,12 or the Global Burden of Disease Study (GBD),13 can be used.

If population size or structure is considered to have varied in the last 5 years, the use of death rates either crude or stratified by age, as the basis for calculating expected deaths (instead of using historic absolute number of deaths) can control for those variations over time.

12 Available at https://www.who.int/healthinfo/global_burden_disease/en/
13 Available at http://ghdx.healthdata.org/gbd-2017
Lastly, if the use of historical observed cases or mortality rates are not feasible, the first set of observations from the newly established all-cause surveillance system can be used to track levels and trends from that point forward.

The range for expected deaths can be the 95% confidence intervals if using regression models or averages, or the 25 and 75 percentiles when using medians of the historical data for the weekly expected death values.

d. Indicators

**Excess deaths**
The absolute number of excess deaths is calculated as:

\[
\text{Excess mortality} = \text{observed deaths (with or without adjustments)} - \text{expected deaths}.
\]

To obtain the range of excess deaths, there are several options:

- The **lower end of the range** of excess death estimate is calculated as: the number of observed deaths minus the upper range of the expected deaths (i.e., upper bound of the 95% CI of the expected deaths; or the 75th percentile of the historical data).
- The **upper end of the range** of excess death estimation is calculated as: the p25 of the historical number of deaths; or the lower bound of the 95% CI of the expected deaths when using regression models.

**Alert threshold for excess deaths**

Once the expected baseline data are obtained, different methods can be used to establish alert or a “high level” threshold. Options for considering high levels of excess deaths include:

- The 75th percentile of the historical data, when using medians for the expected death point value.
- The upper limit of the 95% confidence interval, when using regression models or averages for the weekly expected point values for deaths.

Similarly, a lower level of the threshold can also be established. Sensitivity and specificity of the different threshold methods can be assessed using historic data.

**Figure 3** and **Figure 4** show examples of weekly observed, expected deaths and the threshold area from Spain’s daily mortality surveillance project and pooled mortality data from 24 countries as per Europe’s Euromomo collaborative network.

The basic recommended indicators are depicted in **Table 2**, and an example of a summary table in **Table 3**. Disaggregation by sex and age groups and other variables: geographic areas, ethnicity, etc. should be carried out where possible. When conducting surveillance for smaller population sizes, disaggregation may produce overly imprecise values and caution must be conducted when drawing conclusions.
Table 2. Summary indicators of interest

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excess mortality</td>
<td>Excess mortality = weekly observed deaths – weekly expected deaths</td>
</tr>
<tr>
<td>Range for excess mortality</td>
<td></td>
</tr>
<tr>
<td>Upper end</td>
<td>Upper end = weekly observed deaths – p25 weekly expected deaths</td>
</tr>
<tr>
<td>Lower end</td>
<td>Lower end = weekly observed deaths – p75 weekly expected deaths</td>
</tr>
<tr>
<td>Percent excess</td>
<td>Percent excess: (weekly observed deaths – weekly expected deaths) / weekly expected deaths</td>
</tr>
<tr>
<td>Deaths over the threshold</td>
<td>Deaths over the threshold: weekly observed deaths – upper threshold value</td>
</tr>
<tr>
<td>Percent over the threshold</td>
<td>Percent over the threshold: (weekly observed deaths - upper threshold value) / upper threshold value</td>
</tr>
</tbody>
</table>

Table 3. Example of weekly output table for each geographical unit under analysis

<table>
<thead>
<tr>
<th>Ethnic group</th>
<th>Observed deaths in week (number)</th>
<th>Expected deaths in week (number)</th>
<th>Absolute difference</th>
<th>% difference (A–B)/B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;65 years</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥65 years</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethnic group 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethnic group 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Where feasible, disaggregation by sex AND age group and further disaggregation within age groups may be valuable.
Figure 3. Weekly observed deaths (black) and expected deaths (blue) and threshold area for excess deaths (blue band) in Spain by epidemiological weeks November 2019-April 2020.

Source: Centro Nacional de Epidemiología (ISCIII). Vigilancia de los excesos de mortalidad por todas las causas. MoMo. Situación a 14 de abril de 2020. Available at: https://www.isciii.es/QueHacemos/Servicios/VigilanciaSaludPublicaRENAVE/EnfermedadesTransmisibles/MoMo/Paginas/MoMo.aspx

Figure 4. Weekly number of deaths 2016-2020 in 24 European countries participating in the EuroMOMO collaborative network

Source: https://www.euromomo.eu/bulletins/2020-18/
When underlying cause of death data is available

If cause-of-death data are available, additional analyses could be conducted by underlying cause of death such as COVID-19, influenza and pneumonia, coronary heart disease, severe acute respiratory failure, respiratory failure unspecified, shock/sepsis, others and stratifying by age group, sex, location. It is important to know the historical mortality pattern and the leading causes of death could be analyzed as a reference and as quality indicators ill-defined causes of death and garbage code should also be considered.

For example, in New York City during 11 March–2 May 2020, a total of 32,107 deaths were reported to New York City Department of Health and Mental Hygiene; of these deaths, 24,172 (95% confidence interval = 22,980–25,364) were found to be in excess of the seasonal expected baseline. Included in the 24,172 deaths were 13,831 (57%) laboratory-confirmed COVID-19-associated deaths and 5,048 (21%) probable COVID-19-associated deaths, leaving 5,293 (22%) excess deaths that were not identified as either laboratory-confirmed or probable COVID-19-associated deaths (Figure 3). The 5,293 excess deaths not identified as confirmed or probable COVID-19-associated deaths might have been directly or indirectly attributable to the pandemic.

Figure 5. Number of laboratory-confirmed and probable COVID-19-associated deaths and total estimated excess deaths — New York City, 11 March–2 May 2020

5. CONCLUSIONS

Reliably measuring excess deaths can help provide a comprehensive and timely estimate of the true overall impact of the COVID-19 pandemic in a population. This is facilitated by the existence of civil registration and vital statistics systems that capture all, or the majority of, deaths in a timely manner. For systems leveraged to conduct all-cause mortality surveillance to provide valid findings, countries should have a good understanding of their completeness and quality in order to avoid biased estimates. All-cause mortality surveillance along with information from the incident management system and the robust sentinel networks for the surveillance of respiratory viruses in LAC should contribute to optimal decision-making for the prevention and control of COVID-19.

6. AVAILABLE TOOLS

While countries can use Excel or other analytical programs for analysis, Vital Strategies has produced the Web Excess mortality calculator, available at: https://preventepidemics.org/covid19/resources/excess-mortality/. This tool is useful for producing analysis and graphs and has the added value, that changes can easily be made in the formulas inserted in the tool where desired.

7. LIMITATIONS

The main limitation of all-cause mortality surveillance and analysis of excess mortality is that the extent to which an overall increase in deaths is attributable to COVID-19 cannot be fully ascertained without further analysis of the underlying cause of death. Other limitations include small number of deaths in localities with small populations, so estimates may be imprecise. As with other methods, quality of the data, for example, level of under-registration, will affect the validity of the results and their application.

8. ADDITIONAL BIBLIOGRAPHY

- CRVS technical guide Guidance for assessing and interpreting the quality of mortality data using ANACONDA. Available at: https://crvsgateway.info/file/10084/56
• Mortality statistics: a tool to improve understanding and quality. Available at: https://getinthepicture.org/sites/default/files/resources/Mortality%20statistics%20tool%20to%20improve%20understanding%20and%20quality_0.pdf

• Verbal autopsy standards: ascertaining and attributing causes of death. Available at: https://www.who.int/healthinfo/statistics/verbalautopsystandards/en/
ANNEX 1. SENTINEL LABORATORY SURVEILLANCE OF CADAVERS: WHEN SHOULD IT BE PERFORMED?

This strategy may allow countries to assess the burden of mortality that is due to COVID-19. If testing resources are scarce, countries should make a decision on what surveillance strategy to use, for example cadavers should receive a test only when: a) there is a need to assess the case fatality ratio due to COVID-19; or b) there is suspicion of COVID-19 infection in a community or healthcare setting where no previous cases have been reported.

In the first instance (i.e., need to assess the case fatality rate due to COVID-19), Member States can use sentinel surveillance sites to limit the number of assays used on cadavers, while still maintaining the representativeness of their population. Finally, this strategy can be used where there is a sudden, unexplained decline in the number of COVID-19 related deaths, in order to assess whether testing and reporting protocols are being implemented correctly.

In the second instance (i.e., suspicion of COVID-19 infection in a community or healthcare setting where no previous cases have been reported), Member States should consider testing the first cadavers who displayed symptoms related to COVID-19.

- If the first suspicious deaths occur among healthcare workers (including emergency services and non-clinical staff) in a clinical or community setting, the cadavers should be tested to identify whether COVID-19 infection is present. This step is necessary to protect health workers and reduce the risk of nosocomial transmission. There are no guidelines that specify how many cadavers should test positive before the clinic’s managers assumes that COVID-19 infection is present. Nonetheless, the first positive result within a 14-day period among the same cohort of healthcare workers should be taken as strong indication that COVID-19 transmission is present (at least in clusters).
- If first suspicious deaths occur in a community, the cadavers should be tested to identify whether COVID-19 infection is present. This step is necessary to protect members of the community who may have come in contact with the deceased person and reduce the risk of community transmission. There are no guidelines that specify how many cadavers should test positive before community leaders and elected officials assume that COVID-19 infection is present. Nonetheless, the first positive result within a 14-day period in the same community should be taken as strong indication that COVID-19 transmission is present in the community.
### Resources needed to perform laboratory surveillance on dead bodies

<table>
<thead>
<tr>
<th>Personnel</th>
<th>• Dead body management teams or healthcare personnel who has been trained in nasopharyngeal sample collection from cadavers.</th>
</tr>
</thead>
</table>
| Logistics | • Phone credit  
• Vehicle, fuel and driver to carry personnel to the location of the deceased  
• Reverse cold chain materials to preserve the samples |
| Materials. | • Nonsterile, nitrile gloves  
• Heavy-duty gloves, to be worn over the nitrile gloves if there is a risk of cuts, puncture wounds, or other injuries that break the skin  
• Long-sleeved, fluid-resistant or impermeable gown  
• Plastic face shield or a face mask  
• Goggles to protect the face, eyes, nose, and mouth from splashes of potentially infectious bodily fluids  
• Since collection of nasopharyngeal swab specimens from deceased persons will not induce coughing or sneezing, NIOSH-certified disposable N-95 respirator or higher is not required |
| Personal protective equipment (PPE) | • Sterile Dacron/nylon swab. Use only synthetic fiber swabs with plastic shafts.  
• Viral transport media tube (should contain 1-3ml of sterile viral transport medium)  
• Labels and markers  
• Laboratory forms |
| Sample collection materials for the post-mortem nasopharyngeal swab (same as for a live patient) | If an autopsy is performed:  
• Materials for an upper respiratory tract (nasopharyngeal) swab  
• Materials for a lower respiratory tract (lung) swab  
• Materials to collect separate swab specimens for testing of other respiratory pathogens and other post-mortem testing, as indicated  
• Formalin to preserve autopsy tissues from lung, upper airway, and other major organs |
ANNEX 2. EMERGENCY USE ICD CODES FOR COVID-19 DISEASE OUTBREAK

The COVID-19 disease outbreak has been declared a public health emergency of international concern.

- An emergency ICD-10 code of “U07.1 COVID-19, virus identified” is assigned to a disease diagnosis of COVID-19 confirmed by laboratory testing.
- An emergency ICD-10 code of “U07.2 COVID-19, virus not identified” is assigned to a clinical or epidemiological diagnosis of COVID-19 where laboratory confirmation is inconclusive or not available.
- Both U07.1 and U07.2 may be used for mortality coding as cause of death. See the International guidelines for certification and classification (coding) of COVID-19 as cause of death following the link below.
- In ICD-11, the code for the confirmed diagnosis of COVID-19 is RA01.0 and the code for the clinical diagnosis (suspected or probable) of COVID-19 is RA01.1.
- For more information please see: https://www.who.int/classifications/icd/covid19/en/
ANNEX 3. USE OF VERBAL AUTOPSY FOR COVID-19 ASSOCIATED DEATHS

Verbal autopsy (VA) can be used to determine individuals' causes of death and cause-specific mortality fractions in areas without a vital registration system that records cause of deaths. Verbal autopsies consist of a trained interviewer using a questionnaire to collect information about the signs, symptoms, and demographic characteristics of a deceased person from an individual familiar with the deceased. A standard VA instrument paired with easy-to-implement and effective analytic methods can help bridge significant gaps in information about causes of death, particularly in resource-poor settings.

The use of verbal autopsy (VA) is the only option for determining the fraction of community deaths likely due to COVID-19 – i.e. for deaths occurring where no medical certification of cause of death is possible. It is also used in several Latin American countries in conjunction with investigations into undetermined causes of some facility deaths and bodies brought in dead or dead on arrival at emergency rooms.

There are extensive resources available for implementing the WHO verbal autopsy. A set of COVID-19-specific questions are being added to the most current version of the verbal autopsy form. These forms may be coded by physician review or by automated algorithms which are being adapted to identify deaths likely due to COVID-19.

Conducting VA can be quite challenging, expensive and time consuming. In the context of the epidemic, traditional face-to-face data collection may be difficult or impossible (due to implemented public health measures for example) and may be substituted by phone interviews. Nevertheless, VA is probably the only way to accurately describe the causes of death occurring in the community. For these reasons, weekly reports of total mortality should not be delayed by efforts to obtain a cause of death. VA findings can be reported with a lag without delaying the provision of other important epidemic intelligence.

Intercultural approaches to verbal autopsies are likely to be necessary in indigenous populations, hence medical anthropologists should be included in the study and ensuring involvement of community leaders and traditional healers in the design and interpretation of other world visions of causes of death is helpful.
ACKNOWLEDGMENTS

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