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Total Excess Mortality Surveillance for Real-Time Decision-Making in Disasters and Crises

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Abstract

Crises such as Hurricane Maria and the coronavirus disease 2019 (COVID-19) pandemic have revealed that untimely reporting of the death toll results in inadequate interventions, impacts communication, and fuels distrust on response agencies. Delays in establishing mortality are due to the contested definition of deaths attributable to a disaster and lack of rapid collection of vital statistics data from inadequate health system infrastructure. Readily available death counts, combined with geographic, demographic, and socioeconomic data, can serve as a baseline to build a continuous mortality surveillance system. In an emergency setting, real-time Total, All-cause, Excess Mortality (TEM) can be a critical tool, granting authorities timely information ensuring a targeted response and reduce disaster impact. TEM measurement can identify spikes in mortality, including geographic disparities and disproportionate deaths in vulnerable populations. This study recommends that measuring total, all-cause, excess mortality as a first line of response should become the global standard for measuring disaster impact.

There are 2 approaches for mortality reporting in a disaster or crisis: event-attributable death counts and estimating total excess mortality (TEM). TEM reports the additional number of deaths within a period compared with the expected number of deaths (the counterfactual should the event not have happened) within a period, encompassing all causes of death. Neglect in timely TEM estimation of disaster mortality results in delayed action by authorities and their ability to define mitigation measures and prevent mortality in manmade and natural disasters and in health crises such as the coronavirus disease 2019 (COVID-19) pandemic. Estimating disaster mortality includes deaths directly attributable to the forces of a disaster and indirect deaths which have been precipitated by unsafe or unhealthy conditions pre-, during, and post-disaster.[1] Globally, there is a lack of a standardized approach for estimating disaster mortality.[2] Use of event-attributable death counts as a method to measure impact has also been criticized as being flawed and heterogenic during crises such as Hurricanes Katrina and Maria, and the pandemic. The effort to characterize the overall impact of Hurricane Maria in Puerto Rico (PR) caused political strife and misguided responses until findings from a specific report commissioned on the disaster's impact were communicated to the public. All because the lack of a standardized approach for estimating disaster mortality.[3,4] The COVID-19 pandemic presents another example of the challenges, delays, and heterogeneity in the estimation at the jurisdiction, national, and global levels of it's true impact.[5]

In epidemiology "Total Mortality" (TM)—known as "all-cause mortality"—is an indicator that reflects the overall result of the social, environmental, and health-care conditions in a population. The measurement of total mortality may be the simplest and most accessible indicator to identify progress in treatments, hospital performance, societal health, and human security performance. It is used as a benchmark for best practices for public health and health-care planning.[6] TM varies by socioeconomic status with known gradients within societies. It is used by media and analysts for their reporting and is measured by several national and regional systems for disease-specific surveillance, but frequently omitted in actual policy-making.[7–11]

Excess mortality from a disaster or crisis is estimated through various statistical methods including calculation of a mortality ratio, which compares "observed" deaths rates in the disaster-affected population to the "expected" death rate during the same time period in previous years.[12]

Estimation of excess mortality includes various methods for the establishment of a counterfactual: the death rate of the population in the absence of the event. This can be established using weekly or monthly mortality data for the previous 3, 5, or more years. The regression model used to estimate the difference between observed deaths and the "expected" counterfactual mean can account for demographics, displacement, seasonal mortality trends, and other assumptions.[11]

World Health Organization's (WHO) Vital Strategies includes a rapid TEM surveillance method that estimates trends and excess mortality based on the expected age-specific mortality rates as observed in previous years, and the difference with the observed rates.[13] It can be carried out at the national, facility, or even community level.[11] PAHO, the WHO Regional Office for the Americas, provided tools to support the development of countries' capacities to conduct the analysis, estimating the baseline from the historic average.[14–16] European Union member countries implemented a procedure for excess mortality estimation after the Influenza A (H1N1) pandemic of 2009.[17] This model is based on the linear trends of 5-y mortality, correcting for information delays, using large age groupings, and considering a Poisson to predict mortality in a given time frame with and without seasonality. Poisson Regression models are used for modeling rare or infrequent events where the outcomes are count data, discrete data with nonnegative integer values occurring during a timeframe.[18] Individual countries have adapted their own methods. In the United States (US),[19] the Center for Disease Control and Prevention (CDC) uses over dispersed Poisson modeling, based on Farrington's algorithm,[20] adjusting for seasonality, and considering lag in information.

Recent contributions to the methods for calculating excess mortality in disasters include the estimation of the impact of Hurricane Maria in PR. Investigators observed the departure of the mortality rate from baseline, accounting for seasonality, age, sex, date, and socioeconomic status. Statistical modeling using over-dispersed log-linear regression of mortality and mortality risk after Hurricane Maria showed prolonged excess mortality compared with baseline and extending 6 mo after the storm, with an increasing mortality rate in older men and low-income populations.[1,21] The investigators chose over-dispersed log-linear regression over "Poisson regression because the number of monthly deaths is greater than its mean, violating a basic condition of the Poisson model. Over-dispersed log-linear models produce the same models but different assessments of uncertainty compared with Poisson regression."[19] Another study on excess mortality due to Australian bushfires found that bushfires caused 417 excess deaths from October 2019 to February 2020.[22] Additionally, the worldwide demand for real-time excess mortality data to understand the COVID-19 pandemic's true impact on the world population prompted efforts to produce estimates. Notable examples of COVID-19 death toll estimates are those developed by The Economist and the Institute for Health Metrics and Evaluation (IHME).[7,8]

The Economist uses a machine learning approach based upon official excess mortality data and over 100 national indicators that seem to correlate with excess deaths in over 80 countries where data are available. This includes official deaths, scale of COVID-19 testing and the results of antibody surveys.[7] IHME researchers developed excess mortality estimates for 191 countries. They created a database of available all-cause weekly or monthly mortality data, correcting for time lags in reporting and underreporting of deaths. They excluded weeks with heat waves where excess mortality might be overestimated owing to the large increase in mortality observed from extreme heat during the pandemic. Expected mortality was calculated using an ensemble model (which reduces the spread of dispersions in predictions) to predict deaths in the absence of the COVID-19 pandemic for the years 2020 and 2021. For locations where weekly or monthly all-cause mortality data were not available, a statistical model was developed to capture the relationship between key COVID-19-related covariates (eg, seroprevalence, infection detection ratio) and other population level disease metrics, and excess mortality.[8] One of several limitations mentioned by the authors is that their estimates are based on all-age mortality data, male and female data combined.[8]

This study describes the challenges of using different approaches (namely cause-specific mortality) to assess event impact and provide recommendations on how to integrate TEM into day-to-day surveillance systems.

Assessing Disaster or Crisis-Related Mortality and Its Impact on Decision-Making

The following sections address challenges to mortality surveillance and build on Noe's main challenges to disaster-related mortality surveillance, with added consideration on the use of TEM.[23]

i. Defining disaster-related deaths by using cause-specific mortality

Relying on death certificate attribution for official mortality counts raises challenges in terms of the criteria for attribution used by the physician certifying the death and accounting for indirect mortality. To date, the international community has not agreed on a definition of disaster-related deaths, owing in part to the lack of standard methodology in the certification of deaths in disasters and in attribution of mortality.

The Technical Guidance for Monitoring and Reporting the Global Targets of the Sendai Framework for Disaster Risk Reduction (SFDRR) acknowledges the challenges in mortality attribution.[24,25] Member states have the flexibility to use their national methodology to measure deaths related to a disaster, without a strong guidance or approach. The report highlights that cause of death (CoD) is frequently not recorded as associated with a disaster. The SFDRR recommends that for monitoring and reporting deaths for Target A, countries focus on direct causes of death, which are easier to attribute, rather than using excess mortality which would include indirect deaths resulting from complications from chronic diseases, sidestepping the attribution of premature mortality relating to disasters.[22]

The CDC released guidance in 1999 and 2017 on death certification in disasters, based on CDC's uniform disaster mortality case definitions with a pathway to determine attribution,[26,27] Although codes for disaster related mortality exist in the International Classification of Diseases (ICD-10), there is little or no training on certifying deaths occurring in disasters. And "currently no published standardized methodology exists for analyzing disaster-related mortality data".[2] Additionally, the definition of indirect deaths is still contested in the medical community.

ii. Capturing information in a timely manner

Delays in capturing cause-specific mortality information are a recurring theme in the literature.[28] In non-emergency settings, all information is filled by corresponding agencies/individuals such as the funeral director, the attending physician, and medical examiners in cases of non-natural deaths, and should be available through the national Civil Registration and Vital Statistics (CRVS) system in a timely manner.[29] Although the "report" of a death is rapidly available, details on the death certificate, including codes for the CoD can take weeks to process. For TEM estimation, the only information required is a death event, age, sex, location, date, and ideally race and socio-economic status.

Aside from issues in quality reporting, a crisis or disaster can negatively impact the CRVS system's functioning and the country's capacity to accurately count deaths for an indeterminable length of time. Post Hurricane Maria, the only medical examiner's office (PR Institute of Forensic Sciences) suffered from a backlog of autopsies due to infrastructural damages and a severe shortage of pathologists and other human resources. This interrupted the completion/revision of final death certificates, lowering the official death count. In the case of epidemics or pandemics, such as the cholera outbreak in Haiti, country capacity to test and report cases can also result in a lengthy process due to overwhelmed laboratories, shortages in reagents and personnel.[30,31]

During the COVID-19 pandemic, measuring excess mortality using deaths from all causes helped overcome reporting and testing variations between countries, providing a summary measure of the total impact of the crisis and allowing comparability between countries.[32] Considering that timely mortality reports are essential to mounting an effective response in disasters/crises, this approach is also less liable to interruptions in death reporting due to delays in processes for determining specific causes of death, as described following Hurricane Maria.

Building TEM surveillance systems in advance requires strengthening CRVS systems by: linking them to real-time "death reports", integrating these into epidemiologic surveillance, routinely measuring mortality trends and incorporating an alert system for mortality peaks. It should be noted that, when trying to identify the overall impact of Hurricane Maria, it took approximately 11 mo to estimate TEM because a system was not yet existent. Results allowed researchers to identify social and geographic locations with the highest vulnerabilities. Advancing on this experience, during the COVID-19 pandemic, countries, states, and some cities estimated their TEM, in the best scenarios within 2-4 wk, but usually within 3 to 6 mo. with little consideration of its use to identify and target specific vulnerable groups at the local level.[33] This resulted in delayed actions by governments to mitigate the impact of the crisis, leading to higher mortality rates.[34]

iii. TEM and cause-specific mortality for public health decision-making and communication of impact

Lessons from the literature show that the counting of disaster-related deaths can lead to underestimations of the true mortality burden after a disaster or in a crisis, and directly affect government response efforts and actions.[35] The use of excess mortality can provide governments with more accurate information on the impact of the disaster/crisis, using timely, readily available information and used to guide decision-making, allocation of resources, and crisis and risk communication. While accurate, timely estimation of mortality in a disaster or crisis is crucial for appropriate mitigation and response efforts, these estimates are of little use if they are not communicated effectively to the audiences that need this information, namely governments, disaster managers, and the public.[36]

There are no established guidelines for communication on mortality following disasters or crises.[2] The lack of consensus on how to convey this information to diverse stakeholders is problematic given that mortality figures are key to understanding a disaster's magnitude and impact,[6,37] as well as the rapidly evolving circumstances and effects of disasters occurring over longer time periods, such as those occurring during the COVID-19 pandemic and the extended recovery period following Hurricane Maria. Government capacity to effectively communicate risk must begin with the communication of *impact*, and mortality estimates are key indicators for determining and interpreting true levels of disaster impact.

Guidelines for disaster mortality communication should be established and integrated into Crisis and Emergency Risk Communication (CERC) training for government leaders, public health practitioners, and spokespersons. The consequences of this gap came into focus following Hurricane Maria when delays in mortality reports and mishandling of the situation by communicators contributed to major controversy and public backlash. Development of such guidance is complicated by a lack of research in this area, especially to elucidate how public audiences comprehend mortality estimates and interpret them in relation to risk mitigation.[34,38,39]

Changing Global, National, and Local Practice: Six Recommendations to Build Total (All-Cause) Excess Mortality Surveillance Systems

The following recommendations were developed based on findings from the literature on the challenges of using cause-specific mortality and the benefits of using TEM for rapid decision-making.

1. Use total excess mortality as the minimum standard for mortality surveillance in a disaster/crisis

Total, all-cause, excess mortality as the indicator for emergency response helps to provide a quick picture of the impact of a disaster/crisis.

TEM surveillance during the COVID-19 pandemic is now considered a thorough and trustworthy approach to measure the impact of mortality by the pandemic. TEM data overcome inaccurate counts due to: (i) misdiagnosis or under-reporting of COVID-19 related deaths; (ii) disruption of care for unattended health conditions due to an overwhelmed health system[40,41]; (iii) care-seeking hesitation; (iv) the prioritization of COVID-19 patients over those with other ailments. Although cause-specific mortality provides deep insights on the impact of a disaster or crisis, the information presented above demonstrates that it is better used in the postdisaster setting.

2. Pre-establish baseline mortality with regular surveillance for real-time use during crisis

To allow timely response to an emergency, a continuous mortality surveillance system based on initial death "reporting" should be established in advance at the national and local levels. Once a disaster or crisis strikes, the model would already be in place to identify real-time spikes in mortality and a departure from baseline. There is opportunity for creating a continuous statistical model for overall, local, and national mortality surveillance. This simplified approach can even be used in low- and middle-income countries, where national capacity to evaluate cause-specific mortality may be limited, but the establishment of a baseline mortality surveillance system is feasible.

3. Structure the baseline (counterfactual) mortality on previous mortality and the demographic composition of the population

The counterfactual to predict expected deaths should be built in advance at all levels and include data on all-cause mortality considering seasonal patterns as well as the size of and changes to the population.[19] Key demographic variables include population age structure, sex, date, location, race, and socioeconomic status. Events which have a major effect on mortality such as natural disasters, heat waves, and armed conflict, etc.,[29] should also be considered.

4. Mandate an integrated information system between departments of civil registration and epidemiologic surveillance

Establishing shared data systems between the CVRS and the epidemiologic surveillance departments, to promote continuous data analysis, assures timeliness of TM information. Analysis for TEM only requires the use of the "initial report of death" (including sections 1-24 of the US Standard Death Certificate) to identify peaks, affected population groups, and geolocation to support the immediate response.

5. Develop mortality impact communication protocols for crisis management

For mortality surveillance to inform crisis and disaster planning and policies, as well as decision-making by government and public health leadership, risk, and impact communication must be prioritized, including the communication of disaster mortality. Differentiate risk communication from impact communication to the different target groups and prepare for effective support to policy-makers and communicators so objective situation awareness is supported, and informed decisions.

6. Benchmark and monitor Total Excess Mortality to identify critical public health needs locally, regionally, nationally, and globally

Given the heterogeneous codification of mortality between countries (as observed in COVID-19, being dependent on the differential testing and diagnosis confirmation rates), establishing TEM as the indicator to compare mortality between national jurisdictions and between countries will show the overall impact on population and social systems performance, independent of the diagnostic resources, helping to identify regions and populations requiring immediate attention.

Conclusions

Based on the literature from disasters and crises such as the COVID-19 pandemic, and the challenges identified from using cause-specific mortality to estimate impact, this article calls for the use of a TEM surveillance system for real-time use in public health response to target actions in crises and disasters.

Current practice for measuring mortality in a disaster, man-made or from natural causes, is not yet standardized at the global level. Challenges include the contested definition of deaths attributable to a disaster and the health systems infrastructure to rapidly collect high-quality vital statistics data. Obstacles include low capacity for disease surveillance, poor integration of CRVS systems to epidemiologic surveillance, major upheavals in a country owing to disasters or armed conflict, or local practices. These hardships have led to an underestimation of natural disasters impact such as Hurricane Maria in Puerto Rico, and of the COVID-19 pandemic.

To overcome these challenges, techniques have been developed to estimate mortality rates in the absence of detailed mortality data.[42] Establishing TEM surveillance systems requires political will on the part of government officials and policy-makers to standardize national practice, and communication between key government agencies that produce demographic data, and public health authorities that systematize, analyze, and use the data to guide interventions.

Accurate estimation of TEM that identifies age, sex, date, race, socio-economic, or geographic location of the most affected populations can inform the development of effective policies and interventions to prevent deaths and contribute to world knowledge. This will provide added value to a routine medico-legal procedure, improve surveillance systems, and improve decision-making at all levels of governance. Through "real-time" readily available data, measuring TEM will contribute to the protection of the population's health and safety in a disaster or crisis.

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References

1. **CDC.** A reference guide for certification of deaths in the event of a natural, human-induced, or chemical/radiological disasters. NVSS vital statistics reporting guidance. Report No.1, October 2017. Accessed February 9, 2023. https://stacks.cdc.gov/view/cdc/49294
2. **Issa A, Ramadugu K, Mulay P, *et al.*** Deaths related to Hurricane Irma — Florida, Georgia, and North Carolina, September 4–October 10, 2017. *MMWR Morb Mortal Wkly Rep.* 2018;67(30):829-832. doi: 10.15585/mmwr.mm6730a5
3. **Santos-Burgoa C, Goldman A, Andrade E, *et al.*** Ascertainment of the estimated excess mortality from Hurricane Maria in Puerto Rico. Global Health Faculty Publications. Published online August 28, 2018. Accessed September 16, 2022. https://hsrc.himmelfarb.gwu.edu/sphhs_global_facpubs/288
4. **Andrade EL, Barrett ND, Edberg MC, *et al.*** Mortality reporting and rumor generation: an assessment of crisis and emergency risk communication following Hurricane María in Puerto Rico. *J Int Crisis Risk Commun Res.* 2020;3(1):15-48. doi: 10.30658/jicrcr.3.1.2
5. **Stokes AC, Lundberg DJ, Bor J, *et al.*** Excess deaths during the COVID-19 Pandemic: implications for US death investigation systems. *Am J Public Health.* 2021;111(S2):S53-S54. doi: 10.2105/AJPH.2021.306331
6. **Baghdadi Y, Bourrée A, Robert A, *et al.*** Automatic classification of free-text medical causes from death certificates for reactive mortality surveillance in France. *Int J Med Inform.* 2019;131:103915. doi: 10.1016/j.ijmedinf.2019.06.022
7. **Checchi F, Roberts L.** Interpreting and using mortality data in humanitarian emergencies. Published online 2005. Accessed September 16, 2022. https://odihpn.org/wp-content/uploads/2005/09/networkpaper052.pdf
8. **The Economist**. The pandemic's true death toll. Published online 2022. Accessed September 8, 2022. https://www.economist.com/graphic-detail/coronavirus-excess-deaths-estimates
9. **IHME.** COVID-19 projections. Institute for Health Metrics and Evaluation. Published 2022. Accessed September 24, 2022. https://covid19.healthdata.org/
10. **CDC.** Total deaths. Published 2022. Accessed March 24, 2022. https://www.cdc.gov/nchs/fastats/deaths.htm
11. **EUROMOMO**. Rationale on mortality monitoring. EUROMOMO Published 2022. Accessed March 24, 2022. https://euromomo.eu/graphs-and-maps/
12. **WHO**. WHO COVID-19 excess mortality estimation methodology. Published online October 2021. Accessed November 8, 2022. https://cdn.who.int/media/docs/default-source/world-health-data-platform/who-covid-19-excess-mortality-methods-summary-october-2021.pdf?sfvrsn=5dc0de38_3&download=true
13. **World Health Organization**. Revealing the toll of COVID-19: a technical package for rapid mortality surveillance and epidemic response. Published

online 2020. Accessed September 9, 2022. https://cdn.who.int/media/docs/default-source/documents/ddi/rms_report_v04-(2)3cb3c4d5-d98d-4dcf-b6fc-39bdbfb1a51d.pdf?sfvrsn=4950b624_1&download=true
14. **Pan American Health Organization**. Excess Mortality Calculation. Published online 2020. Accessed September 10, 2022. https://iris.paho.org/bitstream/handle/10665.2/52308/PAHOIMSPHECOVID-19200035_Excel.xlsx?sequence=3&isAllowed=y
15. **Pan American Health Organization**. Enhancing COVID-19 mortality surveillance in Latin America and the Caribbean through All-Cause Mortality Surveillance, May 2020. Published online June 18, 2020. Accessed November 8, 2022. https://iris.paho.org/handle/10665.2/52308
16. **Pan American Health Organization**. Monitoring mortality and measuring the excess of deaths in the context of COVID019 Pandemic. Published online 2020. Accessed November 8, 2022. https://ais.paho.org/phip/mortalitymonitor/technotes.html
17. **euroMOMO**. A European algorithm for a common monitoring of mortality across Europe. Published online 2020. Accessed September 10,2022. https://www.euromomo.eu/uploads/pdf/wp7_report.pdf
18. **Hayat MJ, Higgins M.** Understanding poisson regression. *J Nurs Educ.* 2014;53(4):207-215. doi: 10.3928/01484834-20140325-04
19. **Center for Disease Control and Prevention, NCHS.** Excess deaths associated with COVID-19. Published online 2021. Accessed September 5, 2022. https://www.cdc.gov/nchs/nvss/vsrr/covid19/excess_deaths.htm
20. **Noufaily A, Enki D, Farrington P, *et al.*** An improved algorithm for outbreak detection in multiple surveillance systems. *Online J Public Health Inform.* 2013;5(1):e148. Accessed September 8, 2022. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3692796/
21. **Santos-Burgoa C, Sandberg J, Suárez E, *et al.*** Differential and persistent risk of excess mortality from Hurricane Maria in Puerto Rico: a time-series analysis. *Lancet Planet Health.* 2018;2(11):e478-e488. doi: 10.1016/S2542-5196(18)30209-2
22. **Arriagada NB, Palmer AJ, Bowman DM, *et al.*** Unprecedented smoke-related health burden associated with the 2019–20 bushfires in eastern Australia. *Med J Aust.* 2020;213(6):282-283. doi: 10.5694/mja2.50545
23. **Noe RS.** Applications: disaster-related mortality surveillance: challenges and considerations for local and state health departments. In: *Disaster Epidemiology*. Academic Press; 2018:55-63. doi: 10.1016/B978-0-12-809318-4.00007-1
24. **United Nations Office for Disaster Risk Reduction**. Technical guidance for monitoring and reporting on progress in achieving the global targets of the Sendai Framework for Disaster Risk Reduction. Published 2018. Accessed September 10, 2022. https://www.undrr.org/publication/technical-guidance-monitoring-and-reporting-progress-achieving-global-targets-sendai
25. **UNDRR**. Sendai framework indicators. Published 2022. Accessed April 25, 2022. https://www.preventionweb.net/sendai-framework/sendai-framework-indicators
26. **NCHS, CDC**. Instructions for classifying underlying and multiple causes of death. Published 2016. Accessed November 10, 2021. https://www.cdc.gov/nchs/nvss/instruction-manuals.htm#current-manuals
27. **NCHS**. A reference guide for certification of deaths in the event of a natural, human-induced, or chemical/radiological disasters. 2017. Accessed April 25, 2022. https://stacks.cdc.gov/view/cdc/49294
28. **Rosenbaum JE, Stillo M, Graves N, *et al.*** Timeliness of provisional U.S. mortality data releases during the COVID-19 Pandemic: delays are associated with electronic death registration system and weekly mortality. Epidemiology; 2021. doi:10.1101/2021.01.07.21249401
29. **Temple KM.** Death certificates: a closer look at detail. The Rural Monitor. Published August 8, 2018. Accessed April 25, 2022. https://www.ruralhealthinfo.org/rural-monitor/death-certificate-detail/
30. **Salama P, Spiegel P, Talley L, *et al.*** Lessons learned from complex emergencies over past decade. *Lancet.* 2004;364(9447):1801-1813. doi: 10.1016/S0140-6736(04)17405-9
31. **Ratnayake R, Finger F, Edmunds WJ, *et al.*** Early detection of cholera epidemics to support control in fragile states: estimation of delays and potential epidemic sizes. *BMC Med.* 2020;18(1):397. doi: 10.1186/s12916-020-01865-7
32. **Karlinsky A, Kobak D.** Tracking excess mortality across countries during the COVID-19 pandemic with the World Mortality Dataset. *eLife.* 2021;10:e69336. doi: 10.7554/eLife.69336
33. **Beaney T, Clarke JM, Jain V, *et al.*** Excess mortality: the gold standard in measuring the impact of COVID-19 worldwide? *J R Soc Med.* 2020;113(9):329-334. doi: 10.1177/0141076820956802
34. **Vestergaard LS, Mølbak K.** Timely monitoring of total mortality associated with COVID-19: informing public health and the public. *Euro Surveill.* 2020;25(34):2001591. doi: 10.2807/1560-7917.ES.2020.25.34.2001591
35. **Kung S, Doppen M, Black M, *et al.*** Underestimation of COVID-19 mortality during the pandemic. *ERJ Open Res.* 2021;7(1):00766-2020. doi: 10.1183/23120541.00766-2020
36. **Reynolds BJ.** When the facts are just not enough: credibly communicating about risk is riskier when emotions run high and time is short. *Toxicol Appl Pharmacol.* 2011;254(2):206-214. doi: 10.1016/j.taap.2010.10.023
37. **Combs DL, Quenemoen LE, Parrish RG, *et al.*** Assessing disaster-attributed mortality: development and application of a definition and classification matrix. *Int J Epidemiol.* 1999;28(6):1124-1129. doi: 10.1093/ije/28.6.1124
38. **Lagassé LP, Rimal RN, Smith KC, *et al.*** How accessible was information about H1N1 flu? Literacy assessments of CDC guidance documents for different audiences. *PLoS One.* 2011;6(10):e23583. doi: 10.1371/journal.pone.0023583
39. **Seeger MW, Sellnow TL, Ulmer RR.** *Communication and Organizational Crisis.* Greenwood Publishing Group; 2003.
40. **World Health Organization**. The impact of the COVID-19 pandemic on noncommunicable disease resources and services: results of a rapid assessment. Published 2020. Accessed March 24, 2022. https://www.who.int/publications-detail-redirect/9789240010291
41. **Dey S, Davidson J.** The determinants of non-COVID-19 excess deaths during the COVID-19 Pandemic: a cross-country panel study. *Studies in Microeconomics.* 2021;9(2):196-226. doi: 10.1177/23210222211046412
42. **Adam D.** The efforts to count the pandemic's death toll. *Nature.* 2022;601:312-315. Accessed November 10, 2022. https://media.nature.com/original/magazine-assets/d41586-022-00104-8/d41586-022-00104-8.pdf