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Utilizing P-Scores to Quantify Excess Mortality During the COVID-19 Pandemic

Alexander V. Sergeev*

Department of Social and Public Health, Ohio University, USA

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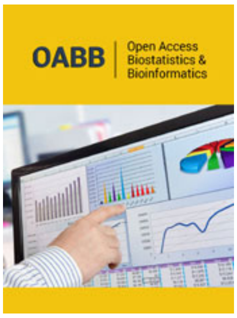

***Corresponding author:** Alexander V. Sergeev, Department of Social and Public Health, Ohio University, W343 Grover Center, Athens, OH, 45701 USA

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Abstract

Death numbers have been reported since the beginning of the COVID-19 pandemic, but they may not represent the true impact of the pandemic. Excess mortality is a robust metric and a critical indicator of the impact of the COVID-19 pandemic. P-scores provide estimates of excess mortality and have been widely utilized in many COVID-19 studies around the world. P-score analyses have revealed more pandemic-associated deaths than official COVID-19 statistics alone. While a substantial proportion of excess mortality during the COVID-19 pandemic can be directly attributed to the virus infection itself, mortality from major non-infectious chronic diseases substantially contributed to an increase in excess mortality P-scores. Thoughtful considerations of approaches to defining counterfactual mortality are important for ensuring the validity of calculated P-scores.

Keywords: Excess mortality; P-scores; COVID-19

Introduction: Assessing COVID-19's Full Mortality Impact

Public health agencies and authorities around the world have been reporting the number of deaths due to the SARS-CoV-2 virus infection (COVID-19) since the beginning of the pandemic. However, these numbers may not completely represent the entire true impact of the pandemic for various reasons [1,2]. One such reason was underdiagnosis and underreporting of COVID-19 deaths that occurred before the deceased got tested, especially at the beginning of pandemic when there was a shortage of COVID-19 testing kits. Also, some deaths from non-infectious diseases, such as cardiovascular diseases, diabetes, kidney diseases, have been attributed to delayed medical assistance and reductions in acute and chronic care due to heath care resource limitation, or capacity strain, during the pandemic [3,4]. Excess mortality, defined as "the increase of the all-cause mortality over the mortality expected based on historic trends" [5], is a robust metric which allows accounting for these effects [6-8]. This positioned excess mortality as a critical indicator of the direct severity of the COVID-19 pandemic crisis and its indirect impact on health care and public health systems around the world.

P-Scores: Evaluating Excess Mortality in Public Health

Quantifying excess mortality is essential for assessing the full mortality impact of the COVID-19 pandemic. It also allows better assessing effectiveness of public health interventions. P-scores offer a straightforward quantitative approach to estimating excess mortality based on the number of observed deaths compared to expected baseline deaths. Specifically, P-scores are calculated as follows [9]:

P-score = (Observed reported deaths - Expected deaths) / (Expected deaths) x 100

Here, "expected deaths" refers to the number of deaths expected under the baseline mortality distribution, often derived from historical pre-pandemic data [3]. A P-score of 0 indicates the number of observed reported deaths matches the number of expected based on historical trends, and P-scores higher than 0 indicate that excess mortality beyond the number of expected deaths has occurred. A key advantage of P-scores is avoiding sole reliance on death counts. P-scores express the difference between observed and expected deaths as a percentage of expected deaths and provide a robust metric for tracking pandemic excess mortality attributable both directly and indirectly to COVID-19. The P-score approach quantifies the divergence from normal fluctuations as a percentage increase above the baseline. The percentage anchors excess mortality to baseline expectations.

Uncovering More Accurate COVID-19 Mortality Data with P-Scores

P-scores have been widely utilized in many COVID-19 studies [9-17]. Ceccarelli et al. investigated excess mortality during the COVID-19 pandemic in Italy and its association with socioeconomic status characteristics across 610 Italian labor market areas using P-scores to quantify excess mortality [10]. Labor market areas were clustered into four groups based on excess mortality patterns over time. Notably, lower income levels were negatively associated with P-score values, but neither population density nor percent of individuals over 70 years of age in the population demonstrated a significant effect on excess mortality. Study authors indicated diverse geographic and temporal excess mortality patterns as well as heterogeneity in the impact of socioeconomic characteristics and local government and health system responses. Their analysis indicated diverse geographic and temporal excess mortality patterns as well as heterogeneity in the impact of socioeconomic characteristics and local government and health system responses.

In their study of mortality in the Philippines during the COVID-19 pandemic in 2020-2021, Migrino et al. used all-cause mortality data from the Philippine Statistics Authority to generate expected mortality, excess mortality, and P-scores at the national and regional levels [11]. At the national level analysis, the researchers found that observed mortality exceeded expected mortality from August 2020 through November 2021. Excess mortality peaked in September 2021, with P-scores reaching 114%. In 2021, reported COVID-19 deaths attributed to only 20% of excess mortality. On the regional level, consistently high P-scores were obtained in the National Capital Region and Bangsamoro Autonomous Region in 2020. Further, most regions had high P-scores from June to October 2021. Analysis of excess mortality identified the regions disproportionately affected by the pandemic and found substantially more deaths than official COVID-19 statistics. The authors leveraged P-scores to uncover undercounts of pandemic deaths and concluded that excess mortality was likely due to underreported COVID-19 mortality and indirect pandemic impact.

Kapitsinis analyzed factors associated with excess mortality across 79 countries in 2020, the first year of the COVID-19 pandemic [9]. P-scores were calculated using 2015-2019 averages as baseline expected deaths, to estimate 2020 excess mortality. The study revealed that the vast majority of countries experienced excess mortality, with substantial geographic variation. In 2020, the highest P-scores were calculated for Mexico, Nicaragua, Ecuador, and Bolivia (ranging from 48.8% to 50.4%). Several important factors were examined in relation to excess mortality using median quantile regression: COVID-19 mortality, pre-pandemic healthcare conditions, COVID-19 testing policies, timing of pandemic response measures, and socioeconomic factors. Results showed that lack of healthcare funding and inadequate resources were associated with higher excess mortality levels. Notably, delayed government response and weak testing and contact tracing capacity were also key drivers. Importantly, earlier implementation of response measures and longer duration of workplace safety policies decreased excess mortality. Lower socio-economic status and higher population density predicted higher excess mortality. The author demonstrated that P-score analysis captures the broader mortality impacts - both direct and indirect - compared to reported COVID-19 deaths alone.

Oduor et al. used P-scores to investigate estimated excess mortality during the COVID-19 pandemic in Kenya [12]. Using data from the Population-Based Infectious Disease Surveillance system database and utilizing historical mortality data as expected baseline mortality, the investigators identified rural-urban disparities and heterogeneous COVID-19 mortality trends, marked by a significant mortality impact on the population of the rural Asembo region.

Impact of COVID-19 Pandemic on Non-COVID-19 Excess Mortality

While a substantial proportion of excess mortality during the COVID-19 pandemic can be directly attributed to the virus infection itself, mortality from major non-infectious chronic diseases, such as cardiovascular disease, cancer, and diabetes, considerably increased as well, substantially contributing to an increase in excess mortality P-scores. Only 67% of excess mortality in 2020 in the United States was caused by COVID-19 viral infection [18]. Several interconnected factors were driving this phenomenon. With healthcare facilities being overwhelmed with COVID-19 patients, disruptions and lapses in care and rationing of services emerged, resulting in suboptimal chronic disease management and treatment adherence for a number of patients. In about 59% of countries, there were various degrees of restriction of access to non-communicable disease outpatient services [19].

In general, when addressing cardiovascular and metabolic (such as diabetes) mortality, the impact of mortality disparities should be considered [20,21]. Further, research has demonstrated that environmental pollutants, such as persistent organic pollutants, constitute a risk factor for cancer, cardiovascular disease, and diabetes [22-24], and a number of studies have investigated the relationship between environmental contaminants and COVID-19 risks [25]. Also, the role of anti-aging genes in the relationship between COVID-19 and cardiovascular disease has attracted the interest of researchers [26].

Healthcare system overload also diverted resources from routine management of chronic diseases, such as coronary artery disease, hypertension, diabetes, increasing risks of developing acute complications in predisposed vulnerable patients, ultimately capable of precipitating normally preventable deaths from heart attacks, strokes, and diabetes complications. Limited capacity for managing urgent cases on non-communicable diseases ultimately increased mortality risk. Disruptions to non-communicable disease services occurred in 75% of countries [19]. Coupled with patients' fear of COVID-19 exposure in healthcare facilities, this resulted in deterring some patients from seeking care, including cancer screening, to the extent that newly diagnosed cancer cases declined noticeably and weekly incidence estimates of several types of cancer decreased by 16-42% [27]. Supply chain disruptions had a negative effect on medication shortages that impacted the leading causes of death, such as cardiovascular disease and cancer [28].

Considerations in Defining Counterfactual Mortality for P-Scores Calculation

Thoughtful considerations are essential for estimating expected mortality in the absence of the event of interest, such as COVID-19 pandemic, because it is a crucial component for calculating excess mortality P-scores [29]. It is common to use historical mortality data to account for seasonal fluctuations. The average number of deaths per week or month in the five years before COVID-19 pandemic can provide a baseline rate accounting for usual seasonal peaks. This historical baseline rate can then be projected into the epidemic period as the expected mortality without the epidemic, thus establishing a counterfactual for comparisons.

When using historical baselines, key considerations include data quality, accounting for trends, and averaging across multiple years to smooth fluctuations. While high-quality vital statistics registries capturing all deaths are ideal, they are not always available. In these cases, survey data or sample registration systems may provide alternative mortality measurements, coming with the cost of incomplete counts or representativeness issues. Researchers should assess data limitations and adjust analyses accordingly. Once baseline historical data is compiled, statistical methods can estimate and account for long-term trends and seasonal patterns. Overall mortality has generally declined in most countries recently, so projecting historical death rates into an epidemic period requires adjusting for this downward trend. Such trends and cycles should be incorporated into baseline estimates.

Arguably, vital statistics registries and civil registration systems provide the gold standard for establishing baseline expected mortality before and during an epidemic [30]. Countries with universal birth and death reporting have complete, high-quality, timely mortality data for in-depth analysis of trends and baseline rate calculations. Where timely vital statistics are unavailable, alternatives like hospital deaths may be used, recognizing limitations in completeness and possibly validity. Each data source and method for estimating baseline mortality has strengths and weaknesses - a trade-off that must be considered. But even imperfect systems can prove valuable. No approach is perfect; all baseline estimates entail uncertainty. Defining an accurate counterfactual baseline mortality rate is essential yet coming with intrinsic uncertainties. Key considerations include accounting for all influencing factors, acknowledging limitations, and avoiding over-interpretation and over-generalization.

Conclusion

P-scores are a robust metric of excess mortality, overcoming limitations of raw mortality data and allowing to account for direct and indirect impact of COVID-19 pandemic on the population, including COVID-19 virus deaths and non-COVID-19 deaths during the pandemic. Studies have effectively leveraged P-scores to uncover geographic and temporal heterogeneity in excess mortality patterns and related disparities. P-score analyses have revealed more pandemic-associated deaths than official COVID-19 statistics alone. Factors driving excess non-COVID-19 mortality are multifaceted but involve healthcare access limitations, disruptions in chronic disease management, and patients' perceptions of COVID-19 exposure risks in health facilities. Thoughtful considerations of approaches to defining counterfactual mortality are important for ensuring the validity of calculated P-scores.

Conflict of Interest

No conflict of interest to declare.

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