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Final assessment of the COVID-19 pandemic impact between the different social and economic strata population of the city of Buenos Aires

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ABSTRACT

Background: During the pandemic, epidemiological communications reported an estimation of excess deaths. However, the final calculation requires a detailed analysis. The study aim was to ascertain the number and distribution of COVID-19 fatalities among various socio-economic strata in a large, moderate to low-income city.
Study design: Observational time series analysis in a large city, treated as a natural experiment.
Methods: Analysis of death certificates, demographic data, and health system records of positive RT-PCR COVID-19 tests from 2015 to 2021, categorizing by age, sex, and place of residence. The study measured the pandemic's impact on mortality, including COVID and non-COVID deaths, using corrected Poisson regression models for different demographics and assessing socio-economic status impact via ecological community-level analysis.
Results: Compared to the pre-pandemic period (2015–2019, IRR = 1.00), the sex- and age-adjusted rate of all-cause death increased significantly during the pandemic (2020–2021) IRR = 1.109 [1.054–1.167], $p < 0.0001$. This was observed in both males (IRR = 1.158 [1.1–1.219], $p < 0.0001$) and females (IRR = 1.068 [1.016–1.124], $p = 0.01$). There was no observed effect of the pandemic on the historical trend in the progressive reduction of mortality in people under 35 years of age. The increase in deaths was at the expense of COVID (+11,175 deaths) and cardiovascular causes (IRR = 1.114 [1.020–1.217] $p = 0.017$). During the pandemic, there was a significant increase in deaths at home (IRR = 1.219 [1197–1.242], $p < 0.0001$), especially in people dying of cardiovascular causes (IRR = 1.391 [1.360–1.422], $p < 0.0001$). The increase in the adjusted mortality rate during the pandemic was socially conditioned.
Conclusions: The pandemic not only led to increased COVID-19 mortality but also heightened fatalities from non-COVID causes, reflecting a potential bias in healthcare resource allocation towards SARS-CoV-2 at the expense of chronic pathologies care.

1. Introduction

The COVID pandemic increased mortality in all societies with the means to measure it [1]. However, the disease dynamics varied significantly among countries and even within them, depending on demographic, economic, healthcare system capacity, and the intensity and commitment to government measures aimed at controlling the epidemic [1,2]. Although the pandemic is a globally conditioned phenomenon, the response is locally conditioned. The COVID epidemic was primarily an urban phenomenon, with over 90 % of reported cases occurring in cities [3], and even within cities, heterogeneity is well-documented [4]. Thus, it is essential to reflect on the impact of the pandemic in large cities to contribute to the discussion on establishing healthcare systems resilient to new challenges, including epidemics and climate change. The Autonomous City of Buenos Aires (CABA) is the capital of Argentina and its most populous city, home to approximately 3.1 million inhabitants.

During the pandemic in CABA, increased vulnerability and a higher COVID fatality rate were documented among residents of informal settlements ("villas") [5], while the effectiveness of a containment network for these residents using a system of isolation hotels was demonstrated [6]. Although these contributions were made during the crisis, comprehending the final impact of the epidemic in a large city requires consolidated information and a certain temporal perspective. This

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manuscript aims to establish the ultimate burden of the COVID epidemic among the inhabitants of a major city like Buenos Aires.

2. Methods

Based on data published annually by the Ministry of Health of Argentina, the number of deaths per year, age, gender, and location of residence were collected at the most disaggregated level possible (communes, or second-level administrative divisions) from 2015 to 2022 (the last available). Data on the number of people resident in each commune by age and sex in each year were taken from national censuses; for the intercensal periods, the calculation of the number of people was carried out using estimates and corrections from the National Institute of Statistics and Censuses.

Adjusted age and sex death rates were calculated using standard demographic techniques. The standardized coefficients were computed based on the proportions of different age and sex strata in CABA population as collected in the 2021 national census. Death data include the number of deaths by cause, gender, and age groups.

Socio-economic condition was characterized based on the degree of unsatisfied basic needs (UBNs) at the level of the 15 communes of CABA using census data; each department was classified according to UBN quintile membership. The distribution and relative position of the communes among the different UBN quintiles was largely stable over the 7 years.

The definition of death from COVID was performed following the primary classification on official death certificates. Causes of death in Argentina are coded using ICD-10 and this is the one used to determine the final cause of death.

To determine the effect of the pandemic on total as well as cause-specific mortality, a Poisson regression analysis was performed using the sex- and age-adjusted rate as the dependent variable. Three different analyses were performed as the independent variable: those that used each year of the series independently and took the first year (2015) as the reference category; those that condensed a pre-pandemic period (2015–2019) and then the years 2020 and 2021 separately; and finally, those that condensed a pre-pandemic period (2015–2019) with a pandemic period (2020 and 2021). Each of these analyses was conducted in each of 17 age groups (0–4; 5–9; 10–14; 15–19; 20–24; 25–29; 30–34; 35–39; 40–44; 45–49; 50–54; 55–59; 60–64; 65–69; 70–74; 75–79 and 80+ years), as well as using a single age- and sex-adjusted rate per year. In addition, for the sake of practicality, an analysis was carried out taking into account three clearly differentiated population groups: up to 40 years; from 40 to 79 years; and people aged 80 and over. To explore the relationship further, a linear regression model was fitted. The coefficient of determination (R^2) was calculated to assess the proportion of the variability in the delta of the adjusted all-cause mortality rate between the pre-pandemic and the pandemic period, explained by the degree of UBN of each commune. A 95 % confidence interval around the regression line was plotted to visualize the precision of the estimated relationship. A scatter plot was generated with the UBN on the x-axis and increased rate in all-cause mortality on the y-axis. The line represents the linear regression fit, indicating the trend between the two variables. The shaded area around the line represents the 95 % confidence interval.

All analyses were conducted using R version 3.6.1 for Windows (R Foundation for Statistical Computing, Vienna).

2.1. Ethics

Since all analyses were conducted using publicly available anonymous data no ethical approval was necessary for present study.

3. Results

This study analyzed a total of 210,040 deaths from 2015 to 2022. Of these, 144,344 (63,848 in men and 80,496 in women) occurred during the 5 years of the pre-pandemic period and 65,696 (30,559 in men and 35,137 in women, respectively) during the pandemic (2020–2021). Of the total deaths, 69,436 were considered to be from cardiovascular causes (47,665 during the pre-pandemic period and 21,771 during the pandemic). Specifically, in the group aged 40 and older, a total of 204,709 deaths were recorded throughout the period. In particular, there were 27,840; 29,482; 28,628; 26,776; 27,738; 32,146; and 32,099 deaths from the years 2015–2022, respectively.

Compared to the pre-pandemic period (2015–2019, reference category IRR = 1.00), during the pandemic (years 2020 and 2021) the age and sex adjusted death rate increased significantly (IRR = 1.109 [1.054–1.167], $p < 0.0001$) (Table 1). This was true for both the year 2020 (IR = 1117 [1045–1193], $p < 0.0001$) and 2021 (IR = 1102 [1031–1178], $p < 0.0001$). In males this increase was 1.158 [1.100–1.219], $p < 0.0001$ and in females was 1068 [1016–1124], $p = 0.01$. The increase came at the expense of the number of deaths classified as COVID (n = 11,175–6111 males and 5064 females) and cardiovascular causes.

Considering all social and economic strata in the City of Buenos Aires, during the pandemic, no increase in the sex- and age-adjusted rate was observed after the age of 40 years (Fig. 1); in fact, there was a significant reduction in the adjusted death rate among 15–24-year-old (Fig. 1). In the age group up to 39 years, the adjusted mortality rate did not change significantly (IRR = 0.955 [0.683–1.337], $p = 0.79$) during the pandemic. On the other hand, in each of the five-year age groups from the age of 40 onwards, there was a significant increase in the adjusted death rate (Fig. 1) (see Fig. 2).

Socio-economic variables were related to the increase in the adjusted mortality rate during the pandemic. The correlation between the percentage of unmet basic needs in the commune and the delta of the adjusted death rate during the pandemic was 0.459, $p < 0.0001$.

Considering the whole population, a significant increase in the adjusted death rate was observed after the age of 40. However, this increase was heterogeneous across socio-economic categories. The most notable difference was at the expense of the better off quintiles where no significant increase in mortality was observed, but only from the age of 55 onwards (Figs. 3–5).

3.1. Cardiovascular deaths and deaths at home

During the pandemic, the sex- and age-adjusted cardiovascular death rate increased significantly (IRR = 1.114 [1.020–1.217], $p = 0.017$). This increase was statistically significant among women (IRR = 1.134 [1.042–1.235], $p = 0.004$), but not among men (IRR = 1.081 [0.986–1.186], $p = 0.098$). This is complemented by the observation that the number of total deaths in public hospitals from all causes

Table 1
Main outcomes measured.

Outcome	p-value	IRR	Lower 95% CI	Upper 95 % CI
All cause mortality (pandemic)	0	1,109	1,054	1,167
All cause mortality males (pandemic)	0	1,158	1,1	1,219
All cause mortality females (pandemic)	0,01	1,068	1,016	1,124
All CV mortality (pandemic)	0,017	1,114	1,02	1,217
All CV mortality males (pandemic)	0,101	1,081	0,985	1,185
All CV mortality females (pandemic)	0,004	1,134	1,042	1,235
All cause mortality Q1	0,001	1,096	1,039	1,157
All cause mortality Q2	0,001	1,095	1,039	1,154
All cause mortality Q3	0,005	1,073	1,022	1,128
All cause mortality Q4	0	1,152	1,097	1,21
All cause mortality Q5	0	1,129	1,075	1,186

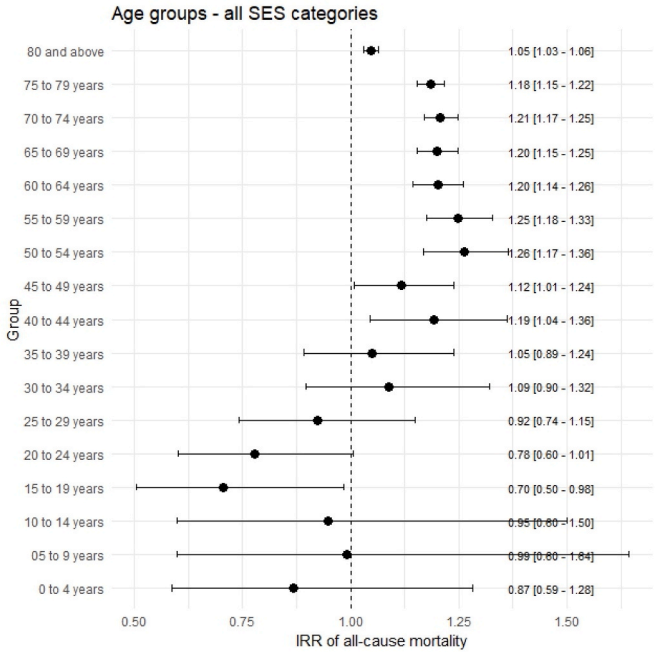

Fig. 1. IRR (95% CI) of the increase in the adjusted all-cause death rate by age group.

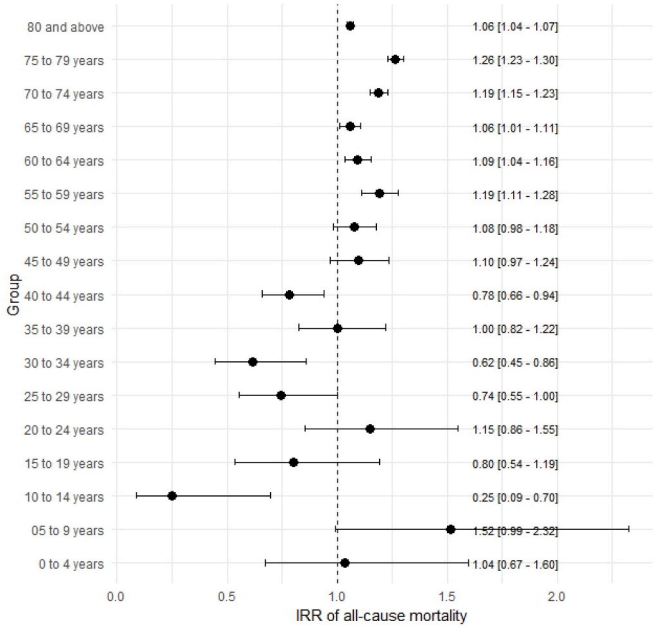

Fig. 2. IRR (95% CI) of the increase in the adjusted all-cause death rate by age group in persons living with low UBN (quintile 1 – Better off).

increased during the pandemic (IRR = 1.154 [1.132–1.176], p < 0.0001), but the number of deaths from cardiovascular causes decreased significantly (IRR = 0.865 [0.829–0.903]), p < 0.0001). In private hospitals, the same phenomenon was observed, characterized by an increase in deaths from any cause (IRR = 1.144 [1.128–1.159], p < 0.0001) and a decrease in deaths from cardiovascular causes (IRR = 0.95 [0.918–0.983], p = 0.003).

The decrease in deaths of cardiovascular origin in hospitals translated into an increase in deaths of cardiovascular origin at home. CV death increased significantly at home during the pandemic (IRR = 1.391 [1.360–1.422], p < 0.0001). This increase in deaths at home was also

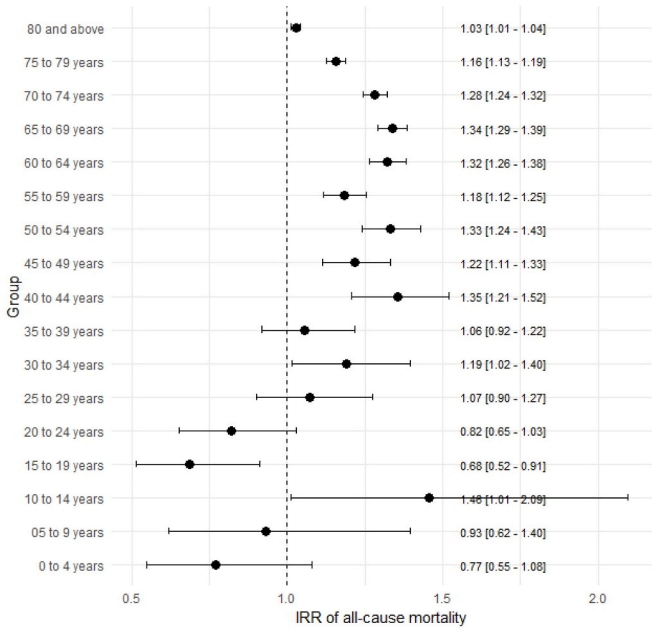

Fig. 3. IRR (95% CI) of the increase in the adjusted all-cause death rate by age group in persons living with high UBN (quintile 5 – Worst off).

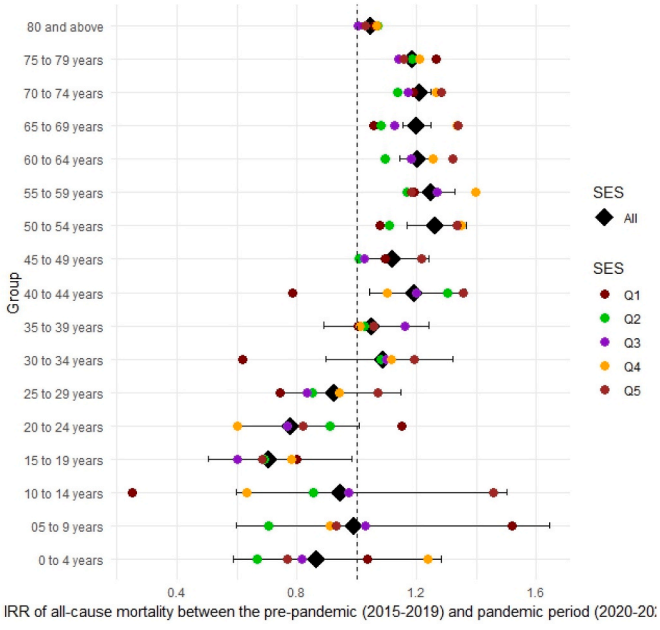

Fig. 4. IRR (95% CI) of the increase in the adjusted all-cause death rate by age group in persons all people and different quintiles of UBN.

observed for all-cause deaths (IRR = 1.219 [1.197–1.241], p < 0.0001).

4. Discussion

The main findings of this study can be summarized in two concepts for discussion. Firstly, all-cause mortality increased significantly during the pandemic in a large city like Buenos Aires, but this increase was significantly heterogeneous. No increase in mortality was observed until the age of 40, and, in fact, a significant reduction in deaths in individuals aged 15 to 24 was verified, considering all social groups. However, death was socially and economically conditioned. An ecological approach allowed us to identify a statistically significant difference

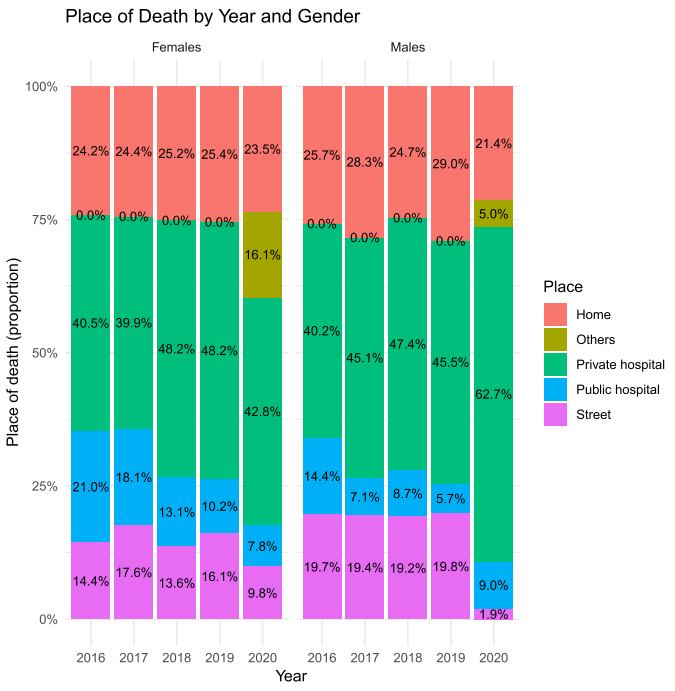

Fig. 5. Change in the place of occurrence of deaths of cardiovascular origin.

between economic affluence measured in terms of Basic Needs Index (NBI) per commune and the increase in death. The difference exhibited a linear gradient, but to express it in even more graphic terms, the difference in the increase in the mortality rate was "postponed" by a decade when comparing the best-positioned quintile against the worst-positioned. The association between the increase in death among the poorest fraction of society during the pandemic is not new [5,7–9]. Studies in high and low-income countries have shown similar gradients. In fact, in the City of Buenos Aires, increased susceptibility to infection among slum residents was documented at the beginning of the pandemic [5,6], associated with higher mortality even when corrected for age and sex. However, these findings not only demonstrate that mortality is socially conditioned but also that vulnerability to new contingencies disproportionately impacts different inhabitants of a large city. The fact that Buenos Aires is a relatively small city makes these findings even more remarkable, where profound differences are evident within a radius of a few kilometers.

The second finding is that deaths attributable to the pandemic were not only related to SARS-CoV-2 infection. The significant increase in the adjusted death rate from cardiovascular causes is probably an indirect consequence of the focus of a healthcare system - both public and private - that prioritized pandemic care. This finding is robust not only because of the significant increase in adjusted cardiovascular death rates but also because this increase is accompanied by a significant reduction in cardiovascular deaths in public and private hospital settings. Other works has documented a similar phenomenon [10,11]. Death at home -as other works have pointed out [12]- is another aspect of these findings. Although home deaths increased significantly, the unusual increase in the number of cardiovascular deaths at home was noteworthy. This pattern aligns with broader disruptions in healthcare services, as outlined earlier, where Argentina's health emergency, declared to manage the COVID-19 crisis, led to a substantial decline in routine medical care and diagnostic practices. This systemic shift likely contributed to an increase in unmanaged chronic conditions and a decrease in hospital-based interventions for cardiovascular diseases, exacerbating the overall cardiovascular mortality".

The analysis presented in this manuscript has strengths and limitations. Although mortality data for an entire population over an extended period contribute to the robustness of the analysis, it must always be considered that the classification of the cause of death can be imperfect, especially in circumstances of health emergencies. The debate on death caused by COVID or with COVID has permeated the medical literature for a considerable time, and the uncertainty surrounding this issue cannot be resolved in our study. However, an extensive time series in a demographically "stable" city like Buenos Aires indicates that the increase in deaths is likely attributable in large part to the excess of COVID. On the other hand, the same applies to the classification of deaths of cardiovascular origin. While the study lacks any other evidence than that which arises from the notifications of causes of death, the excess death data is internally consistent with what happens with the location of death: the reduction in deaths in public and private hospitals aligns with the excess deaths at home. Finally, although ecological indicators are widely used in epidemiological studies like this, they cannot replace individually collected data.

Ethical approval

This survey falls outside of the national requirement for ethical review. The current legal norm (resolution1480e11) in Argentina in relation to the obligations regarding clinical research allows exceptions to the registration of informed consent. Specifically, the rule states "In the following situations, applicable only to observational investigations could be exempt from obtaining consent: (a) when the research uses only non-binding data or samples, or information frompublic knowledge. That is, it is not possible to establish the identity of the people".

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Declaration of competing interest

None declared.

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