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Policy Implications of Demographic Impacts on COVID-19, Pneumonia, and Influenza Mortality: A Multivariable Regression Approach to Death Toll Reduction

Saiakhil Chilaka

ABSTRACT
Understanding the demographic factors that influence mortality from respiratory diseases like COVID-19, pneumonia, and influenza is crucial for informing public health policy. This study utilizes multivariable regression models to assess the relationship between state, sex, and age group on deaths from these diseases using U.S. data from 2020 to 2023. The analysis reveals that age and sex play significant roles in mortality, while state-level variations are minimal. Although the model's low R-squared values indicate that additional factors are at play, this paper discusses how these findings, in light of recent research, can inform future public health policy, resource allocation, and intervention strategies.

I. INTRODUCTION

The COVID-19 pandemic has highlighted the importance of timely and targeted public health interventions in reducing mortality. However, res-piratory diseases like pneumonia and influenza have long been significant contributors to global mortality. Investigating mortality trends across these diseases is essential for improving public health policy, resource allocation, and interventions during future outbreaks.

Informed by recent studies such as the use of support vector regression models to predict COVID-19 cases in India and Iran based on environmen-tal factors, and the exploration of sex-based differences in COVID-19 out-comes, this study investigates how demographic variables can guide policy decisions. By identifying which populations are most vulnerable, govern-ments and health organizations can optimize resource allocation, healthcare delivery, and preventive measures to mitigate mortality in future disease outbreaks.

This paper uses multivariable regression modeling to analyze U.S. death data from 2020 to 2023. It assesses how demographic factors impact mor-tality from COVID-19, pneumonia, and influenza, and discusses the impli-cations of these findings for future public health policy. We explore how policies can evolve to better address the unique vulnerabilities of different populations, ultimately aiming to reduce deaths in future pandemics.

II. DATASET

The dataset used in this study includes U.S. death records from 2020 to 2023, categorized by state, sex, age group, and cause of death (COVID-19, pneumonia, and influenza). The key variables in the dataset are:

- State: Geographic representation of death locations.
- Sex: Biological sex of individuals.
- Age Group: Various age brackets, as mortality risk typically in-creases with age

III. METHODOLOGY

3.1 Multi-variable Regression

We applied multi-variable linear regression to evaluate how state, sex, and age group influence mortality from COVID-19, pneumonia, and influenza. The regression models allow us to determine the magnitude and direction of the impact of each demographic factor.

The models were evaluated using R-squared values, which measure how much of the variance in death rates can be explained by the selected demo-graphic variables. The regression coefficients provide insight into the relative impact of each variable on mortality.

The results of this study can be placed in the context of the broader research landscape. For example, in the study by Almalki et al. [1], support vector regression models were used to predict the trajectory of COVID-19 in different regions . The insights derived from that model emphasize the importance of location-specific variables in disease prediction, supporting the inclusion of ”state” in our analysis. Meanwhile, Yadaw et al [2]. found significant sex-based differences in COVID-19 mortality, aligning with our model’s findings that sex plays a critical role in predicting death rates.

IV. RESULTS

COVID-19 Deaths:

- R-squared: 0.0176
- Coefficients:
  - State: -0.649
  - Sex: 23.14
  - Age Group: 21.08

Pneumonia Deaths:

- R-squared: 0.0185
- Coefficients:
  - State: -0.929
  - Sex: 24.08
  - Age Group: 21.24

Influenza Deaths:

- R-squared: 0.0186
- Coefficients:
  - State: -0.00018
  - Sex: -0.25
  - Age Group: 0.38

While the R-squared values across all models are low, indicating that only a small portion of the variance in deaths can be explained by state, sex, and age group, the coefficients provide valuable insights:

- Sex and age group consistently show significant positive correlations with deaths. Males and older individuals are at significantly higher risk of dying from these diseases.
- State shows a weak or negligible effect, suggesting that while geo-graphic differences exist, they are overshadowed by other factors, such as individual health, socioeconomic status, and access to medical care.

V. DISCUSSION

5.1 Implications for Public Health Policy

Targeting Vulnerable Populations: The findings from this study un-derscore the need for targeted interventions focused on the most vulnerable groups: older individuals and males. Public health policies during future pandemics should prioritize these populations for:

- Vaccination: Ensuring that the elderly and male populations are prioritized for vaccines, given their increased mortality risk.
- Protective Measures: Emphasizing tailored protective measures, such as social distancing and mask mandates, for high-risk age groups during disease outbreaks.
- Early Medical Intervention: Allocating resources to ensure that older individuals and males have access to early medical interventions, such as antiviral treatments and ventilators, if needed.

Policy Recommendation: Governments should implement age- and sex-specific public health guidelines. For instance, during the initial vaccine rollout for COVID-19, elderly populations were rightly prioritized. How-ever, these models suggest that males should also be given priority in future vaccination campaigns, particularly in the early stages when vaccine supply is limited.

Improving Healthcare Capacity: The limited impact of state on mortality, as indicated by the coefficients, suggests that state-level health interventions and healthcare systems were relatively uniform in their ability to address COVID-19 and related respiratory diseases. However, policy-makers should not interpret this as a call for complacency. Instead, the findings suggest that while the capacity and responsiveness of health-care systems did not vary drastically between states, regional and local public health resources (like ICU capacity) must be scalable in future crises.

Policy Recommendation: Governments should invest in building scal-able healthcare infrastructure that can handle surges in demand during pan-demics. This includes:

- Stockpiling ventilators, personal protective equipment (PPE), and an-tiviral drugs.
- Expanding ICU capacity in hospitals located in areas with aging pop-ulations.
- Establishing mobile health units to serve regions that may lack imme-diate access to critical care facilities.

VI. CONCLUSION

This study reveals that demographic factors, particularly age and sex, play a significant role in determining mortality outcomes for COVID-19, pneu-monia, and influenza. However, the limited variance explained by state, sex, and age group indicates that policymakers must consider a broader set of variables when designing interventions for future pandemics. By focusing on targeted interventions for vulnerable populations, scalable health-care systems, and equitable resource distribution, governments can better mitigate mortality during pandemics.

Research, like the studies by Almalki et al. [1] and Yadaw et al. [2], demonstrates that data-driven approaches, whether through machine learn-ing models or demographic analyses, are essential for developing effective

public health policies . The insights gained here, particularly regarding the vulnerability of older populations and males, should inform future strategies for vaccination, healthcare provisioning, and targeted interventions.

In conclusion, while demographic modeling provides valuable insights, the success of public health policies in reducing mortality will depend on their ability to evolve and address the complex, multifaceted nature of dis-ease outbreaks.

REFERENCES

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