



The Impact of COVID-19 on National Mortality: Population-based Interrupted Time Series Study in South Korea

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INTRODUCTION

- The COVID-19 pandemic, with its direct impact on human lives, has caused significant mortality.
- However, the pandemic might influence mortality not only through the virus itself but also, indirect factors, including policy measures like social distancing, lockdown, and securing hospital vacancy rates.
- Understanding the multifaceted causes of mortality during the pandemic is crucial for better preparedness for future public health crises.
- This study aims to comprehensively investigate the impact of COVID-19 on national mortality in South Korea.

METHODS

- Study design:** Interrupted time series analyses
- Data source**
 - National mortality data from January 1995 to December 2021.
- Covariates (individual slope coding)**
 - Time (month, integer): 1, 2, 3, ... 299 (from January 1995 to December 2019), 300, 300, 300 (from January 2020 to December 2021)
 - COVID-19 (dummy variable): 0 (before January 2020), 1 (after January 2020)
 - Interaction term – COVID-19 * time: 0, 0, 0, ... 0 (from January 1995 to December 2019), 1, 2, 3, ... 24 (time after COVID-19, from January 2020 to December 2021)
- Outcome**
 - The number of monthly deaths in South Korea.
 - The number of monthly deaths classified 19 of diseases according to the ICD-10 chapter.

Disease Code	Name
A00-B99, U07.1, U07.2, U10	Certain infectious and parasitic diseases
C00-D48	Neoplasms
D50-D89	Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism
E00-E88	Endocrine, nutritional and metabolic diseases
F01-F99	Mental and behavioral disorders
G00-G98	Diseases of the nervous system
H00-H57	Diseases of the eye and adnexa
H60-H93	Diseases of the ear and mastoid process
I00-I99	Diseases of the circulatory system
J00-J98, U04	Diseases of the respiratory system
K00-K92	Diseases of the digestive system
L00-L98	Diseases of the skin and subcutaneous tissue
M00-M99	Diseases of the musculoskeletal system and connective tissue
N00-N98	Diseases of the genitourinary system
O00-O99	Pregnancy, childbirth and the puerperium
P00-P96	Certain conditions originating in the perinatal period
Q00-Q99	Congenital malformations, deformations and chromosomal abnormalities
R00-R99	Symptoms, signs, and abnormal clinical and laboratory findings
V01-Y98, U12	External causes of morbidity and mortality

- Statistical analysis**
 - Models for 20 classifications of diseases
 - A p-value of <0.05 was considered statistically significant.
 - Generalized linear square regression (GLS) with AR1 model accounting for autoregression

$$Y = \alpha + \beta_1 \text{Time} + \beta_2 \text{COVID} + \beta_3 \text{COVID} \times \text{Time} + \epsilon_j$$

- β_2 : immediate impact on monthly patients for COVID-19 by diseases
- β_3 : sustained impact on monthly patients for COVID-19 by diseases

- Statistical tool**

- All analyses were performed using R (version 4.0.1, R Foundation for Statistical Computing, Vienna, Austria).

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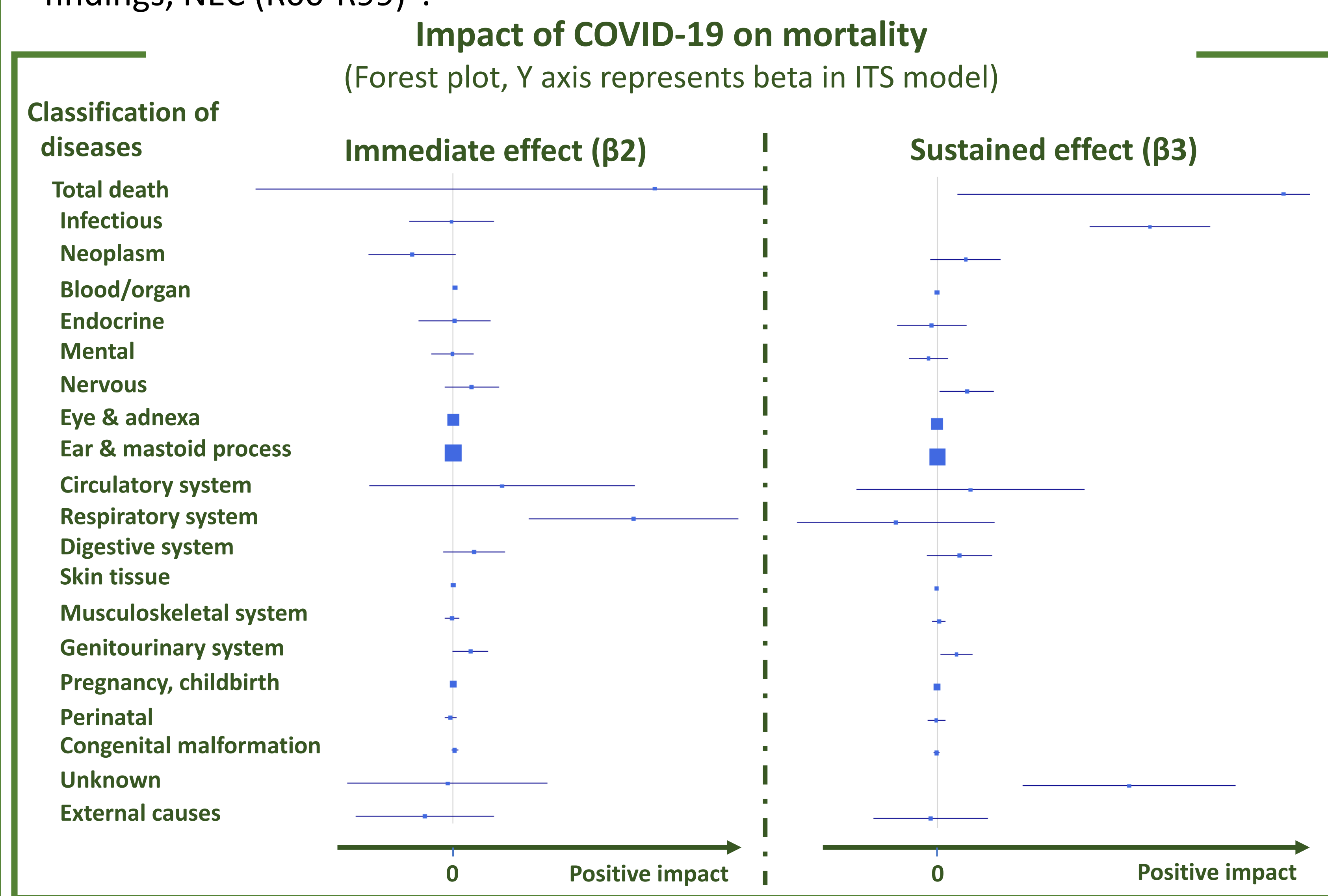
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RESULTS

- A comprehensive analysis was conducted on a total of 20 ITS models with various causes of death including all deaths.
- Positive and negative impacts on deaths

COVID-19 effect	Significant Positive Impact	Neutral (non-significant)	Significant Negative Impact
Immediate effect (β_2)	Diseases of the respiratory system	- All deaths - Certain infectious and parasitic diseases - Neoplasms - Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism - Endocrine, nutritional and metabolic diseases (E00-E88) - Mental and behavioral disorders - Diseases of the nervous system - Diseases of the eye and adnexa - Diseases of the ear and mastoid process - Diseases of the circulatory system	- Diseases of the digestive system - Diseases of the skin and subcutaneous tissue - Diseases of the musculoskeletal system and connective tissue - Diseases of the genitourinary system - Pregnancy, childbirth and the puerperium - Certain conditions originating in the perinatal period - Congenital malformations, deformations and chromosomal abnormalities - Symptoms, signs, and abnormal clinical and laboratory findings - External causes of morbidity and mortality
Sustained effect (β_3)	- All deaths - Certain infectious and parasitic diseases - Diseases of the nervous system - Diseases of the genitourinary system	- Neoplasms - Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism - Endocrine, nutritional and metabolic diseases - Mental and behavioral disorders - Diseases of the eye and adnexa - Diseases of the ear and mastoid process - Diseases of the circulatory system - Diseases of the respiratory system	- Diseases of the digestive system - Diseases of the skin and subcutaneous tissue - Diseases of the musculoskeletal system and connective tissue - Pregnancy, childbirth and the puerperium - Certain conditions originating in the perinatal period - Congenital malformations, deformations and chromosomal abnormalities - Symptoms, signs, and abnormal clinical and laboratory findings - External causes of morbidity and mortality

- The COVID-19 dummy variable exhibited a significant positive association ($p < 0.001$) for patients who died from "Diseases of the respiratory system (J00-J99)".
- The time after COVID-19 variable demonstrated a significant positive association ($p < 0.01$) for total deaths, "Certain infectious and parasitic diseases (A00-B99)", "Diseases of the nervous system (G00-G99)", "Diseases of the genitourinary system (N00-N99)", and "Symptoms, signs and abnormal clinical and laboratory findings, NEC (R00-R99)".



CONCLUSIONS

- Our findings highlight the substantial impact of COVID-19 not only on respiratory-related diseases but also on the nervous and genitourinary systems.
- In the case of "Diseases of the genitourinary system," reduced access to healthcare and potential COVID-19 infections may have led to decreased dialysis treatments and increased the number of deaths.
- Our study emphasizes the imperative to address fatalities caused by both pandemics and containment measures, highlighting the effective disease management strategies for future pandemics.***