The Impact of Healthcare Access on COVID-19 Burden in Poland: An Investigation of Causal Relationships to Uncover the 'Dark Figure' of Infections

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Abstract

Introduction:

Biases in the measurement of COVID-19 burden and the uncertainty in estimation of the corresponding epidemiologic indexes are known and common phenomena in infectious diseases. Seeking causal relations between the vaccination or infection-gained immunity level and the infection dynamics could be misleading without understanding the socio-epidemiologic context such as the moderating and mediating role of healthcare access HCA (sensu lato). We investigated to what extent (HCA)-related supply/demand interfered with the registered data on COVID-19 in Poland.

Material and Methods:

We ran casual models with Bayesian optimisation criteria (with use of 'mediation' and 'bnlearn' R libraries) to explain the geographic variation of incidence/mortality in beginning of the 4th wave of COVID-19 (so-called "Delta" wave in Autumn 2021) on county – old NUTS-4 level. We took vaccination coverage and cumulative incidence up to the so-called 3rd wave as predictor variables and supply/demand HCA as moderating/mediating variables.

Results:

HCA (mainly demand) directly or through paths was shown to have the highest causal effect on incidence. We proved that hypothesis of mediation triangle between cumulative and current incidence by demand HCA has > 99% probability of being actually mediation triangle, as well as it is very strong (at least by order of magnitude higher that any other causal path) and stable (94% of occurrence by hill-climbing criterium). There is also not as strong, but also significant (95% of occurrence by hill-climbing criterium) moderating phenomenon of supply HCA on vaccination having protective effects deaths due to COVID-19.

Conclusion:

The most important finding is that spatial distribution of case notifications is mainly driven by the way people decide to use the healthcare system rather than epidemic processes. Moreover, death rates and the vaccination rates by regions have been significantly confounded by supply HCA, which is linked to the healthcare system capacities. We suggest that future epidemiological models must adopt demand HCA as a factor of so-called 'dark figure' of infections. Otherwise, spatial models may be more likely to overfit into people's decisions on testing rather than to actual burden of disease. Moreover, the link between the reported case numbers and the true state of the epidemic can be spatio-temporally adjusted according to our proposition.