Formulation of a spatiotemporal model for the analysis of neonatal mortality amidst SDG interventions: The case of Uganda

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Abstract

This study aimed to formulate a dynamic linear model within a Bayesian framework to conduct a spatiotemporal analysis of neonatal mortality in Uganda during SDG interventions. This study formulated a model based on appropriate health-related covariates while considering the spatial and temporal dimensions of the data whose variable of interest (dependent variable) was a quantitative variable measuring the monthly rates of neonatal mortality (number of newborns dying within their first 28 days of life) at the district level. Through Markov chain Monte Carlo (MCMC) simulations, the applicability of the model could be assessed using simulated data covering 14 years, starting in January 2010, to evaluate the situation before and after the implementation of interventions to achieve the SDGs targets. Using a Bayesian approach through the Kalman filtering technique, the parameters of the formulated model were estimated. This study used the same technique through Gibbs sampling to extract meaningful information from the simulated data and provide reliable forecasts for the rates of neonatal mortality.

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Introduction

The burden of neonatal mortality has continued to increase in most countries [1]. A healthy economy with a minimal mortality rate is desirable for every country worldwide. Neonatal (newborn) mortality is defined for this study as death within the first 28 days of life per 1000 live births as established by the World Health Organization [2]. As noted by [1], reducing neonatal mortality is an essential part of SDG 3, Section 3.2.2: *countries should aim to reduce neonatal mortality to at least 12 per 1,000 live births and under five mortality to at least 25 per 1,000 live births by 2030* and achieving this requires an understanding of the levels of and trends in neonatal mortality. According to a study by [3], 5.2 million children died before reaching their fifth birthday in 2019, with almost half of those deaths, 2.4 million occurring in the first month of life, despite the countries' efforts to reduce death rates, for instance, UN member states' interventions in terms of the MDGs and SDGs.

In Uganda and globally, most studies on neonatal mortality, such as [4–6], have focused on risk factors while ignoring progress and forecasting the situation given that the targeted 2030 to achieve the SDGs is fast approaching. Moreover, these studies did not consider the influence of time or space. This study aimed to formulate a dynamic linear model to analyze neonatal mortality using a case study of Uganda to simultaneously investigate its persistent patterns over time and space and illuminate any unusual patterns. As mentioned by [7], the majority of time series models include well-known models such as autoregressive (AR) and moving average (MA) models. The autoregressive integrated moving average (ARIMA) and autoregressive moving average (ARMA) are helpful for handling stationary data; otherwise, they become limited. This is further supported by [8–12], as they suggest that state space models offer a very rich class of models that have several advantages. For example, they do not require stationarity, which eliminates the need to transform the data since data transformation leads to the loss of some important components in the data, which at times leads to less accurate results. To formulate a dynamic linear model, this study simulated data for health care-related factors and health care policies that were put in place as a way of achieving SDG 3.2. The health policies used are shown in Table 1.