European Doctoral School of Demography (EDSD) 2024/2025

Agent-based Modelling and Simulation Course

Assignment

Write a Research proposal in which you plan to implement an agent-based model.

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Date: **Sunday 02 February 2025**

Topic: Implementing an Agent-Based Model and Simulation to understand the causes of Low death Registration in Uganda: A Micro-Macro Level Perspective.

1. Introduction

1.1 Background to the Study

Most countries in Europe, the United States of America, Asia and Oceania report 100 per cent death registration rates. On the contrary, most Sub-Saharan African countries report less than 10 per cent of death registration (Nkengasong, Gudo, Macicame, Maunze, Amouzou, Banke, ... & Jani, 2020). Only 4 countries (South Africa (92%), Mauritius (98%), Cabo Verde (92%) and Seychelles (91%) have high death registration rates that meet international standards (Agyekum, Kyei-Arthur, & Bosompem, 2024).

Uganda is one of the Sub-Saharan African countries with a low death registration rate. Out of an estimated 370,000 deaths annually in Uganda, the National Identification and Registration Authority (NIRA) in Uganda registered only 2% in 2021 (Habaasa,2022). Recent studies associate low death registration with limited awareness, inaccessibility of services, cost of death certificate, low enforcement of death registration law and poor infrastructure among others (Atuhaire, Nansubuga, Nankinga, Nviiri, & Odur, 2022; Kasasa, & Akuze, 2024). Habaasa (2022) argues that social norms and behavioural practices are instrumental in preventing individuals from registering death events. The studies above however have not examined the role of different actors especially individuals within a household and health facilities in explaining the current death registration rates at the national level.

Agent-based modelling (AGM) has been proposed by demographers and other research scientists as an important tool for understanding the micro-macro relationships within a population (Billari & Prskawetz, 2003). The AGM is key in applying theoretical rules of behaviour and decision-making at the micro level through simulation to get an idea of their implications at the macro level (Van Bavel & Grow, 2016). The agent-based modelling approach allows us to study individual and institutional decisions' contribution to death registration rates in Uganda. Using microsimulation approaches, the study will show changes in the death registration rates due to individual and institutional interactions. The study will

visually show the effect of policy interventions such as registration enforcement, incentives, and increased public sensitization to individuals and institutions will consequently have on the death registration rate in Uganda.

1.2 Problem Statement

The Ugandan Government has a National Civil Registration and Vital Statistics System Strategy 2020/21–2024/25 with a focus on improving death registration rates. Annually, UGX 76 billion is allocated to NIRA and the government has deployed a civil registration officer to almost all districts to register deaths (NIRA, 2021).

Despite the efforts, the death registration rate in Uganda is very low at 6.0% for the year 2024 (NIRA, 2025). The factors influencing the low death registration rates are complex and multifaceted. Due to the above, normal statistical analysis and models fail to capture fully the dynamic interactions among actors and environmental factors that exert pressure on individuals leading to low death registration rates. An agent-based modelling approach is therefore proposed.

1.3 Research Objectives

1.3.1 Main Objective

To propose an agent-based model approach and simulation to understand the causes of low death registration in Uganda through a micro-macro level perspective.

1.3.2 Specific Objectives

i. To identify key factors influencing low death registration rates in Uganda.
ii. To develop an agent-based model that simulates individual and institutional interactions affecting death registration in Uganda.
iii. To analyse potential policy interventions on death registration in Uganda using the Agent-based model framework.
iv. To propose recommendations for improving death registration in Uganda based on the agent-based model results.

1.4 Research Hypotheses

i. There is no significant difference in the observed and simulated death registration rates in Uganda for the past 5 years.
ii. The perceived cost of death registration influences individuals from registering deaths that have occurred in their households with the civil registration Office.
iii. Cultural beliefs and traditions influence household decisions on whether to register a death that has occurred in their households.
iv. A simulated increase in public awareness campaigns will lead to a higher probability of death registration at the household level.

1.3 Theoretical background

The research will be anchored on the Theory of Planned Behaviour propounded by Icek Ajzen in 1985. The theory assumes that an individual ability to perform a particular behaviour depends on attitude, subjective norms and perceived behavioural control (Ajzen, 1985). Attitude refers to a person's subjective evaluation of the behaviour and its outcomes. The subjective norms refer to one's assessment of whether significant others would approve of the behaviour. On the other hand, behavioural control refers to one's assessment of whether he or she is ready and able to enact the desired behaviour.

Based on the theory, an individual with a positive attitude towards death registration, for instance, due to strong awareness of the benefits of a death certificate, will most likely notify the sub-county and district authorities and civil registration office of the deaths that have occurred in his or her household. In the same vein, an individual who perceives social support from significant others, such as cultural leaders and district leaders (agents), will likely conform to their expectations.

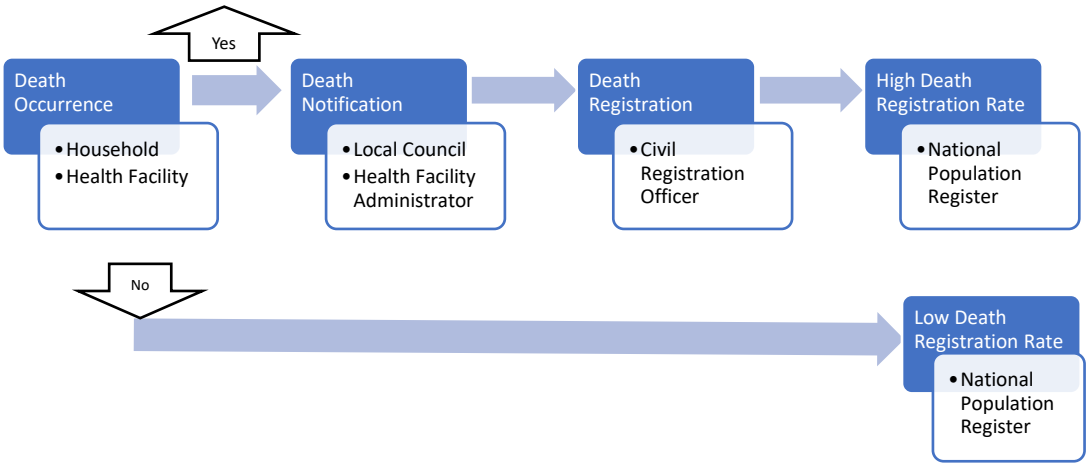
The theory of Planned behaviour is relevant to the study, especially in explaining the interactions of individuals and other actors towards death registration in Uganda. Despite this, the theory has been criticised for its failure to have a clear and explicit definition of behaviour control (Rhodes & Courneya, 2003).

2.0 Methodological Innovations

2.1 Model development

Inspired by the Wedding Ring agent-based marriage model (Billari, Prskawetz, Aparicio Diaz, & Fent, 2007), the current study will use an agent-based modelling approach to simulate the behaviours of individuals and institutions to understand death registration rates in Uganda (**Figure 1**). The model will integrate all actors and the environmental variables. The individual agents include household members, community leaders and registration officers. The institutional agents include health facilities and district local governments. The environmental variables include geographical accessibility, cost of registration, cultural beliefs, and awareness of death registration information. All the actors have agency in addition to attributes, attitudes and even preferences. The actors interact with each other and the environment influences their behaviour regarding death registration.

Figure 1: Flow Diagram for actors and death registration in Uganda



2.2 Model Implementation

The research will implement the death registration model using the R package (R Core Team, 2021). This package is suitable because it allows parallel computing and visualization of agent interaction trajectories. The calibration and validation will be conducted using data from Iganga-Mayuge Health and Demographic Surveillance System site data as well as well as field data.

2.3 Data

The agent-based model will use data from the Uganda National Population and Housing Census 2024 which reports a population size of 45,905,417 persons, an annual growth rate of 2.9 per cent and 212,393 deaths (UBOS, 2024). The model will be simulated for 50 years to establish the changes in the death registration rates due to the interactions between the individuals and institutions at the micro level. Sensitive analysis will be done using Analysis of Variance (ANOVA) of the regression meta-modal to assess how much of the modal variance is accounted for by each of the parameters used in ABM and simulation.

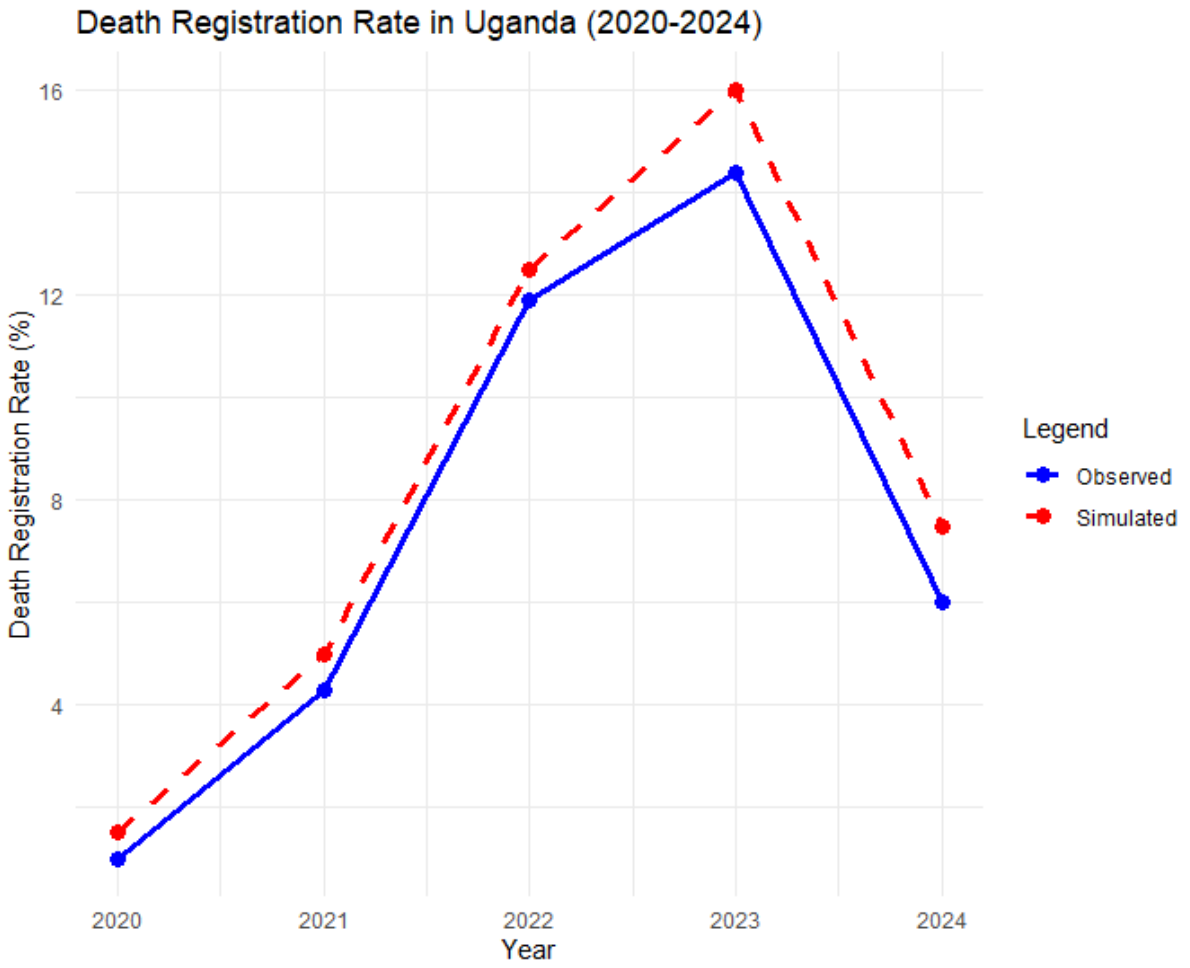
2.4 Simulation

To strengthen the robustness of our death registration agent-based model, a multi-scenario policy simulation technique will be used to test some proposed policy interventions. Scenario analysis will be conducted in which several policy interventions such as financial incentives, enforcement of death registration law and community sensitization) will be simulated to assess their impact on death registration rates at the macro level.

3.0 Expected Results and Outcomes

NIRA (2025) reports Uganda's death registration rate of 6.0 per cent based on estimates of 370,000 deaths annually. However, empirical data from the census report 212,393 deaths in 2024. This means that the death registration rate will be higher (10.4 per cent) in 2024 according to the census results (UBOS, 2014). The ABM and simulation results are expected to fit well with data from the census unlike estimates as shown in the preliminary results (Figure 2).

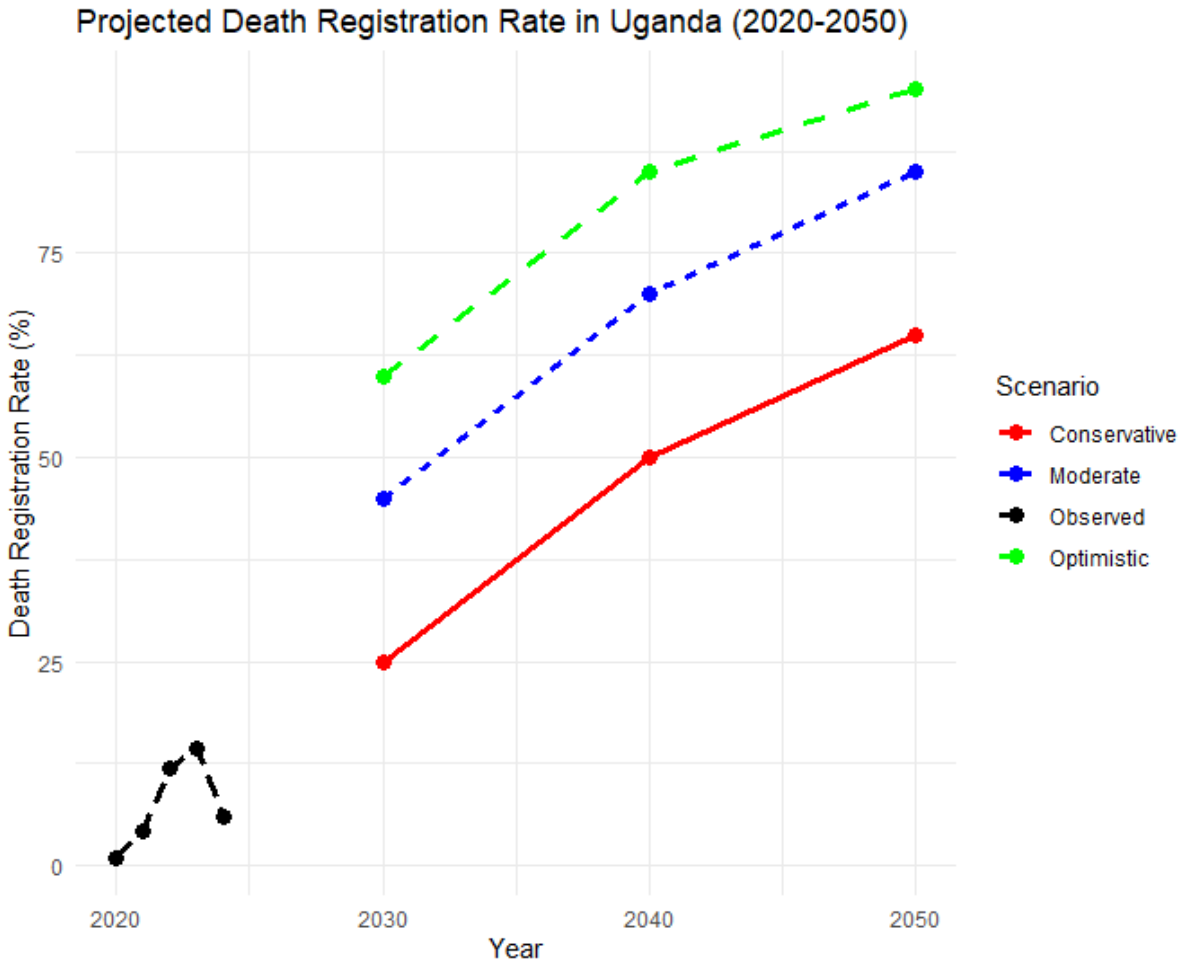
Figure 2: Agent-based modelling of death registration in Uganda



Source: NIRA (2025).

Based on the model results, the proposed death registration rates from 2020-2050 are also proposed based on the simulation of various policy changes such as increased awareness, enforcement of death registration laws, introduction of incentives such as free death certificates and extension of civil registration officers near households at sub-county level to ensure all deaths are registered. The projected simulated death registration rate for 2020-2050 is presented.

Figure 3: Simulated Death Registration Rates in Uganda (2020-2050)



Source: NIRA (2025).

Using observed data from the Uganda census of 2002, 2014 and 2024, it is expected that our proposed agent-based model and simulation will predict better the death registration rates in Uganda through a micro-macro level perspective. This approach helps guide demographers and planners on the future trajectory of death registration in Uganda for 2025-2100. Despite the usefulness of ABM and simulation, there is a likelihood of complications in modelling, especially with the inclusion of many parameters (Kashyap & Villavicencio, 2016). In this case, actors and environmental factors exert pressure and influence behavioural beliefs towards death registration in Uganda.

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