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AGENT-BASED MODEL FOR ANALYSIS OF CERVICAL CANCER DETECTION

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ABSTRACT

Using Agent-Based Models (ABM) for disease incidence may help decision-making processes. This work shows an ABM for cervical cancer detection. Our results show the relevance of social indicators.

1 INTRODUCTION

The analysis of disease incidence may help health organizations to improve patients' wellbeing. These analyses must consider Social Determinants of Health (SDoH), that is, the social and environmental conditions in the places people live (on Social Determinants of Health et al. 2008). In cancer care, spending is increasing, and some costs are related to SDoH (Yabroff et al. 2019). For cervical cancer, treatment costs are high, especially when detected at an advanced stage (Singh et al. 2020). The use of ABM eases modeling behaviors and their impact in the overall public or private system. For example, focus on modeling spread and countermeasures for COVID-19 may help decision-making (Starr and Kain 2022).

This work shows the creation of an ABM for studying the early detection of cervical cancer considering SDoH in the State of São Paulo, Brazil. We previously found a relationship between SDoH and early detection (Galindo et al. 2023). Specifically, the Index of Social Responsibility (ISR) of the State of São Paulo, based on the Human Development Index. ISR goes from 1 (low wealth, schooling, and longevity) to 5 (high wealth, schooling, and longevity).

2 MODEL DESCRIPTION

We considered two types of agents: women and health facilities both located within a city. There are 64 cities with one facility per city. For validation, we performed a Logit regression model, with the cervical cancer detection stage as the dependent variable and women's age and schooling level, as well as cities' ISR, mean income rate, access to water, garbage, elementary school percentage, fecundity level, and beds per 1000 inhabitants as independent variables. We used data from the São Paulo Oncological Foundation (FOSP) and from the State of São Paulo Statistics (SEADE). We used these results to create an ABM to check the detection of cervical cancer at an early stage. To keep the model simple, from the variables present in the Logit model, we focused in this work on the ISR for cities.

Each time step corresponds to one year, when women try to be tested at their city's facility. Each facility decides to attend a number of women based on its capacity, related to the city's ISR. Also, each year, women may develop cancer. As the number of years without attention increases, the chances to have cancer at an advanced stage increase. For initial conditions, women's location is random, and cancer and last screening year are 0. For facilities, the number of women attended is set to 0. We varied the number of women in the model, from 100 to 3000 in intervals of 100 women. We performed 100 runs for each case, (3000 in total), to see how the ISR may affect the proportion of cases detected at an early stage.

3 RESULTS

Figure 1 shows the proportion of cases at an early stage and total cases versus women's population, having minimal change after 1000 women. Table 1 shows that proportion for 1500 women in the ABM and in the Logit model. In both cases, as the ISR increases, the proportion increases. Yet, error rates are high.

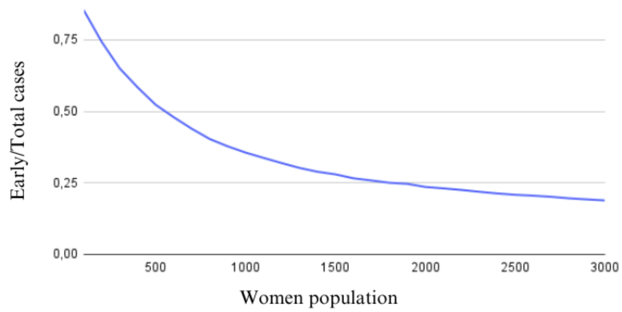

Figure 1: Variation of early detected/total cases for women population.

Table 1: Proportion of cases detected at an initial stage for each ISR for 1500 women

Early Detected Cases/Total Cases	ISR 1	ISR 2	ISR 3	ISR 4	ISR 5	General
Simulations	0.216	0.270	0.276	0.273	0.287	0.272
Logit model	0.172	0.218	0.261	0.306	0.340	0.280
Error rate	0.203	0.192	0.054	0.120	0.140	0.029

4 CONCLUSIONS

This work presents an ABM for cervical cancer incidence considering SDoH, specifically ISR, serving as a baseline for more complex models, showing, not only qualitative, but also quantitative relationship between social indicators and incidence of diseases. We recommend the consideration of SDoH for decision-making in cervical cancer prevention. Future work includes the use of reinforcement learning.

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