CHALLENGES OF USING A MICROSIMULATION-BASED MODEL FOR MODELLING THE HEALTH IMPLICATIONS OF THE UK COST OF LIVING CRISIS

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BACKGROUND

Open-science and improved data synthesis techniques have stimulated the use of large-scale, *spatially representative data* to inform Agent-Based Models (ABMs) (Macal 2016). As a result, a transition to "descriptive" ABMs (Edmonds and Moss 2005) has been enabled. "Descriptive" refers to a setting in which an ABM can operate in a heterogeneous, full-scale population of agents - at a particular geographic scale, and while having a rich set of attributes impacting the behaviour of agents. Our paper describes a descriptive ABM for studying the health impacts of the current Cost-of-Living (CoL) crisis in Great Britain (GB). We define the CoL crisis as the fall in real disposable household income. The pathways by which the CoL crisis impacts short- and long-term population health outcomes – spanning behavioral (diet, physical activity, substance-abuse), material (food, housing, travel), and psychological (stress, reduced social activities) factors – are well understood in isolation. However, their interdependence and interaction are not well understood (Broadbent, Thomson, Kopasker, McCartney, Meier, Richiardi, McKee, and Katikireddi 2023). We discuss the methodology for an ABM which examines the complexity of these interacting factors at the level of households and individuals in a full-scale population of agents representative of the population in GB. We demonstrate that descriptive ABMs are well-suited for examining the impact of decreasing financial and material resources on population health.

METHODOLOGY

For GB, information for different spatial resolutions is available from census data. However, census data is typically not available at the individual-level and does not even provide cross-sectional snapshots. Spatial Microsimulation can resolve these limitations by creating a synthetic, attribute-rich, full-scale, individual-level population which supports a longitudinal perspective (Harland, Heppenstall, Smith, and Birkin 2012). Spatial microsimulation utilises spatial constraints from the census, which are typically reflective of small-area patterns (Lovelace and Dumont 2017). Using an annealing-based mechanism, we create a synthetic population for GB by combining data from the 2021 census with data from Understanding Society (US) - a large-scale panel survey (N = 40,000+) capturing individuals and households (Wu, Heppenstall, Meier, Purshouse, and Lomax 2022)

We are developing an ABM using the Python-based Mesa platform (Masad and Kazil 2015). Mesa is an open-source ABM platform that allows for multi-threading and the ability to handle GIS information. In our model, we examine individuals' choices of buying combinations of 2 different food categories: "cheap and unhealthy" or "expensive and healthy". Each food category has fluctuating prices, used as a proxy of policy intervention and market behavior. In addition, we are able to define changes in disposable household

income, used as a CoL crisis proxy indicator. The food acquired is dependent on individual-level factors and of the most *welfare* with respect to the local neighborhood defined by a Cobb-Douglas function of food's *desirability* - as long as it is affordable. Our model will utilise individual- and household-level synthetic populations to inform the attribute-rich population of agents. Our ABM will use GIS data to get real locations of merchandise and invoke interventions in deprived or affluent neighbourhoods.

CHALLENGES AND PROPOSED SOLUTIONS

Scale: A synthetic population of GB consists of more than 60 million agents. Simulating populations of this size is computationally feasible, but analytically likely not required. We propose an approach in which we focus on a specific metropolitan region to comprehend the behavioral evolution and outcomes. A behavioral validation of sufficient regions will precede a full-scale model.

Behavioral Validation: Behavioral rules for agents can be obtained by regressing the correlation from one state to the other based on the availability of aggregates. But, this does not truly describe the agents' behavior as "behavior" is more indigenous than states deemed important while collecting data. A common practice of ABMs is to start with behavioral and psychological theories, preferably with empirical evidence, and integrate the individualistic rules with accepted structural elements such as grid-based or continuous space, distances and neighborhoods, interaction ranges, mobility models, and networks. For example, a neighborhood-driven grid-based structure can be used to get the availability of products at various types of shops.

Nesting of Individuals within Households: This problem arises from the observation that the impact of the CoL crisis is typically captured at the household-level - for example, in changes to disposable household income or spending on fuel and food. However, the health implications of the CoL crisis require a specific individual-level perspective due to the strong association of health with individual-level factors such as age, sex, or risk factors. This discrepancy appears difficult to bridge with conventional methods as it requires a two-dimensional simulation process when creating synthetic populations. A possible solution would be to start from the households (along with the CoL indicators), generate a *representative* individual population for each household, and analyze individual-level health outcomes (Prédhumeau and Manley 2023).

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