
Simulating the Nutritional Traits of Populations at the Small Area Levels Using Spatial Microsimulation Modelling Approach

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Abstract: Nutritional traits simulating at an awesome local geographic level is vital for effective nutritional promotion programs, provision of better nutritional services and population-specific nutritional planning and management. Deficient in micro-dataset readily available for attributes of individuals at small areas affects the local and national agencies on the route ahead of their smooth managing of the serious nutritional issues and related risks in the community. A solution of this ongoing challenge would be to form a method to simulate reliable small area statistics. This paper provides a dashing appraisal of the methodologies for simulating nutritional traits of populations at geographical limited areas. Findings reveal that microsimulation-based spatial models have the significant robustness over the other methods stated in this study representing a more precise means of simulating nutrition-related traits of population at the small area levels.

Keywords: Nutritional Traits, Microsimulation Modelling, SWOT Analysis, Multilevel Models, Small Area Estimates

1. Introduction

Nutrition-related traits of a population in a society are significant to nutrition promotion programs and to the provision of better nutritional services [1-3]. The efforts of feasible nutritional planning generally target limited areas such as the local nutritional region or small area nutritional units, while the population-specific nutritional planning often requires precise estimates of nutritional behavior at these levels, for which nutrition-related data are not always available [4-6]. Even if regional knowledge of nutrition-related behavior can be attained by conducting a costly sample survey, such surveys seldom generate reliable data for small geographic surroundings, i.e., Statistical Local Areas (SLAs) in Australia, countries in United States (US) or wards (electoral divisions) in United Kingdom (UK) and therefore alternative biostatistical techniques are in galore need to obtain small area nutritional indicators.

The policy makers and nutritional researchers often rely on national or state-level data set to understand the nutritional needs of their communities. The lack of national dataset for

traits of individuals at small area levels hampers the local and national agencies to manage the horrors of nutritional soundness and associated risk factors in the communities and so forming a model [7-9] can be a problem solving bid to simulate spatial micro-population dataset [10-12] at an awesome geographic level. These can be achieved applying Small Area Estimation (SAE) techniques, commonly known as the statistical modelling approaches, i.e., indirect standardization and individual level modelling [13-15], multilevel statistical modelling [16-20] and microsimulation modelling [21-29].

The SAE can provide robust estimates of the population nutritional behavior in small geographic areas to support comparisons within and between local areas such as SLA levels and state or national level estimates. Though the indirect standardization and individual level modelling approaches are simpler than the multilevel modelling approaches, they are not robust in terms of computational processes [30-33]. The latest microsimulation modelling approaches are more advanced than the other statistical modelling methods, and they are also methodologically and

computationally more sophisticated. However, it is yet to be assessed which small area technique produces the most valid, statistically reliable and precise estimates of nutrition-related characteristics [34-37]. The basic problem with surveys at the state or national level is that they are not designed for efficient simulation of the situation in small areas [38, 39].

Due to the lack of enough sample information in small geographic area levels, there is much possibility in using simulated or synthetic estimators for small areas [40, 41]. The estimates of small area nutrition-related traits such as the smoking behavior of youth and adults, characteristics by overweight and obesity etc. at small area levels are not readily available for policy making purposes [42-44]. This article provides a significant appraisal of the methodologies for the estimation of nutrition-related traits of populations in

geographic limited areas. A wide range of methodologies have been used in simulating small area nutritional traits (Figure1). Traditionally there are two types of SAE namely direct and indirect model-based estimations. Synthetic reconstruction and reweighting are commonly used in microsimulation approaches and each is stimulated by different techniques, i.e., Combinatorial Optimization(CO), Generalized Regression Weighting (GREGWT) and Bayesian reweighting algorithms to yield simulated estimators (Figure 1). All of these SAE have not been rampantly applied for nutritional modelling, especially not for simulating nutritional traits. There are different reasons for this, i.e., the lacuna of initial data requirements for some methods and the distribution of predictors at the small area levels are not known.

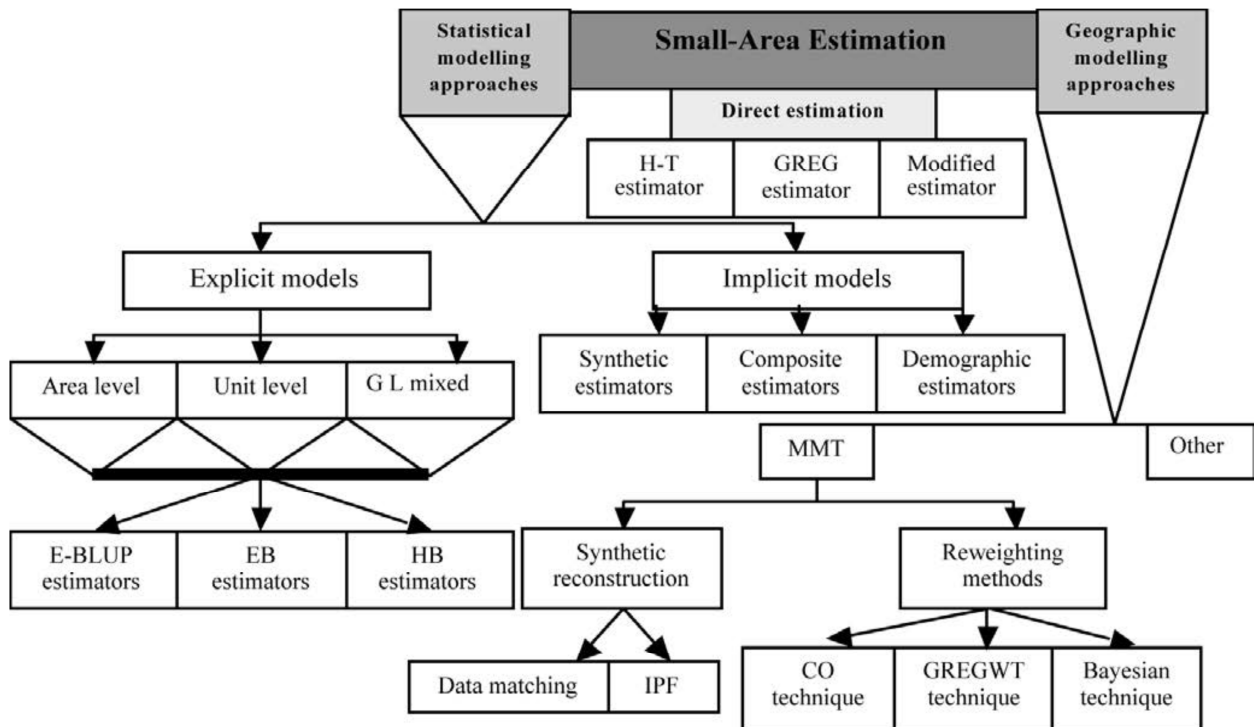


Figure 1. A summary of different techniques and estimators for small area estimation [45].

2. Methodology and Data Sources

This is a methodological review study to design a trendy microsimulation modelling technique for estimating nutritional characteristics of population at small area levels. A wide range of instruments have been collected from the different kinds of microsimulation methods in biostatistics, spatial approaches in nutritional physics, algorithmic gesture in computational biology, the SWOT analysis in applied sociology, Chi-square test and the GREGWT modelling in Newton-Raphson method of iteration in computational physics. These instruments have then used for examining all the statistical modelling in quest of an effective microsimulation modelling technique to simulate nutritional traits of populations at small area levels in different countries in the world.

3. Results

Microsimulation modelling approach is getting vast attention to the nutritional researchers for its robustness to the use in geographical information at small-area levels [46]. A growing literature indicates that microsimulation models are being popular tool in nutritional research to simulate nutrition-related behavior, future prevalence rates, cost of treatment, provision of care needs, and the potential outcomes of policy intervention at small areal levels [47-49]. This is a promising technique for creating synthetic or simulated microdata describing household characteristics at the small area level. The creation of reliable synthetic microdata at the small area level is often challenging for some regions.

Microsimulation modelling can be conducted by

reweighting a national level sample so as to estimate the detailed socioeconomic and demographic characteristics of populations and households at the small area level. The presence of geographical information and detailed household characteristics which both have impact on nutrition-related behavior in the synthetic spatial micro-population indicates the applicability of a microsimulation modelling. The features of microsimulation modelling technology and the associated theories, tools and techniques behind this approach are provided in a number of studies and hence an appraisal of the misprovided. Two types of methodologies for creating simulated micro-population datasets are in use: i) synthetic reconstruction and ii) reweighting. The former approach includes data matching or fusion [50] and iterative proportional fitting [51, 52] while the latter utilizes GREGWT [53] and Combinatorial Optimisation (CO) [54].

GREGWT is an iterative generalised regression algorithm written in SAS macros to calibrate survey estimates to benchmark marks. The use of auxiliary information improves the resulting survey estimates that are reproduced using them modified grossing factors. The algorithm used in GREGWT is based on a constrained distance function known as the truncated Chi-squared distance function that is minimised subject to the calibration equations for each small area. The method is also known as linear truncated or restricted modified Chi-square [27, 55] or the truncated linear regression method. The truncated Chi square distance function is used in the GREGWT algorithm as follows:

$$D_{X^2} = \sum_{K \in S} \frac{(w_K - D_k)^2}{D_k}; \text{ for } L_k \leq \frac{w_K}{D_k} \leq U_k$$

Where D_k is the given sampling design weights, w_k the new weights, and L_k and U_k the pre specified lower and upper bounds, respectively, for each unit k in sample S . The basic advantage of this method over linear regression is that the new weights must lie within an a priori specified boundary condition for each small area unit. The upper and lower limits of the boundary interval could be constant across sample units or proportional to the original sampling weights. The GREGWT algorithm uses the Newton-Raphson method of iteration to minimize this distance function [56].

4. Discussion

Most of the developed nations are using small area estimation methodologies as an essential means to support the process of effective decision making and policy analyzing purposes for various issues at local area levels [57, 58]. The microsimulation modelling technology-based spatial models are more precise means in which two or more sources of data can be combined [59, 60]. The premier objective of creating simulated micro-population datasets at the small area level is to create data that does not currently exist for small areas and

so the validation of simulated micro-data is difficult and may be considered one of the drawbacks of MMT. However, then the Bayesian prediction-based model can eclipse this drawback through simulating the complete scenario of micro-population units at the small area level and then producing the statistical reliability measures of the SAEs from MMT-based model [61]. There are also ways to deal with the validation problem for other MMTs which are more reliable and scientifically standard means for validating the estimates from microsimulation modelling method. Yet scholars are working to improve the validation methods and/or trying to develop a further one for then on-Bayesian reweighting based microsimulation models [60]. The multilevel statistical modelling approach is frequently used in explaining the variability in human characteristics. The method has an extended ability to incorporate unexplained variability between small areas into the nutrition-related attributes estimation procedures and can be applicable to survey data that simultaneously accounts for either individual and small area level effects or small area random effects on nutrition-related behaviors [62, 63]. As the multilevel modelling includes the individual level covariates this method also imposes quite stringent data requirements, like individual level modelling and hence important individual level predictors of nutrition-related traits may be dropped from the model due to unknown distributions of these variables at the local level. The SAEs procedure is also rather complex in multilevel statistical modelling.

The microsimulation modelling has emerged recently as a splendid alternative for small area estimation of nutrition-related characteristics. The main challenge is the requirement for reliable synthetic spatial micro-data. Findings have revealed that two reweighting methods, the GREGWT and CO are commonly used tools to generate small area micro-data. The former utilizes a truncated Chi-squared distance function and generates a set of new weights by minimizing the total distance with respect to some constraint functions. A comparison between the GREGWT and CO reveal that they are using quite different iterative algorithms having considerable properties. The CO has a tendency to include fewer households giving them higher weight and conversely the GREGWT has a tendency to select more households giving them less weight. However, the overall performances are fairly similar for both micro-data simulation techniques from the standpoint of use in microsimulation modelling. The study findings create a pinch of salt on using the microsimulation modelling technology because of its containing more robustness than that of the other methods in the study on the basis of the choice of spatial scales (Figure 2). This nutritional microsimulation modelling can be an effective tool in simulating nutritional characteristics of populations at small area levels at the field of health pedagogy in nutritional biostatistics [64-68].

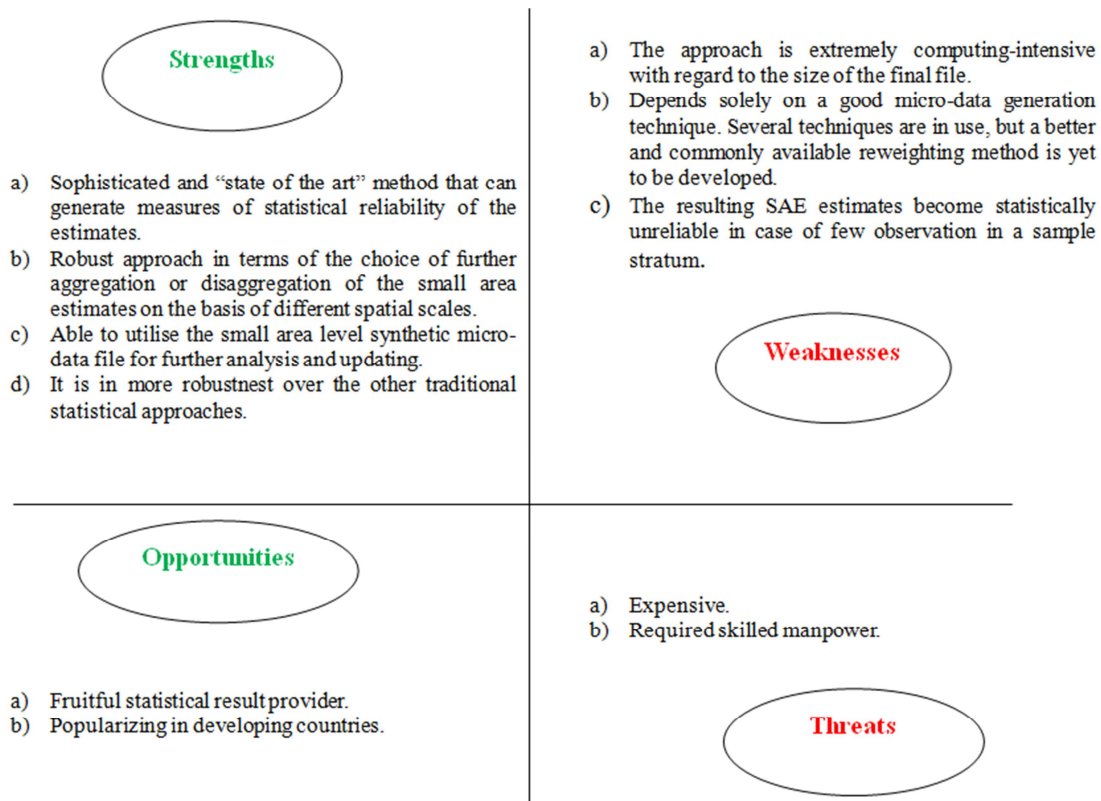


Figure 2. SWOT analysis [69-73] of spatial microsimulation modelling technique.

5. Conclusions

This paper has reviewed the methodologies in simulating nutrition-related characteristics of populations at the small area levels. This simulation in nutritional disparities offer more informative way than that of the other approaches and it can help to direct for developing advance policies to reduce inequities across different populations. The spatial model with the static microsimulation model is used to assess small area effects of policy changes. The MMT approaches allow what-if scenarios in terms of policy changes. The MMT is a comparatively precise way to estimate small area nutrition-related characteristics and evaluating policy changes. Future research should adopt this cozy simulating approach to get the estimates of these traits, especially the estimates of smoking behavior of adults and/or in estimating the prevalence of overweight and obesity of adults at the small area levels in Australia, the UK and the US.

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