Small Area Estimation: New Developments and Directions for Health and Human Services Data

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Introduction

Household surveys provide timely estimates of a wide range of population characteristics and play a critical role in policy analysis and development in the federal government, but the sample designs of most household surveys do not support estimates below the national level. Program administrative data avoid the limits of sample size when they include the entire population of participants in a program, but their contents are often narrowly focused, and the universes that they cover may be narrow as well.

Small area estimation (SAE) methods were developed to address the need for estimates of characteristics for geographic areas or other domains (population subgroups, for example) that cannot be obtained directly from survey or administrative data. Many of the techniques used in small area estimation combine data from multiple sources and often include both a survey component and an administrative component. With advances in data processing capacity and computational algorithms, it has become feasible to apply estimation methods that were impractical not that long ago. Applications of SAE by federal agencies have multiplied in the past two decades.

Greater sharing of information about methods, data sources, and how to present small area estimates would be useful to all who are involved in preparing such estimates—but especially to those who are new to this endeavor, have more limited resources than the major statistical agencies, or continue to use less effective methods.

Seeing the opportunity for a significant step forward, the Office of the Assistant Secretary for Planning and Evaluation (ASPE) in the Department of Health and Human Services (HHS) undertook the planning of an expert panel meeting to bring together practitioners of SAE to share their insights and jointly explore possibilities for improving their methods and outcomes. ASPE contracted with Mathematica Policy Research to identify prospective panelists and other attendees and develop an agenda; prepare background materials for the meeting participants; facilitate the meeting and prepare a summary of the panel discussion; and synthesize the background materials and the panel discussion into a final report. The broadly written objective of the project was to assist agencies within HHS and the broader federal statistical community in making more effective use of SAE to address data gaps for small geographic areas and populations.

The panel meeting was held on June 4, 2013, at the Hubert H. Humphrey Building and had 37 attendees, including the ASPE and Mathematica project staff. Eight operating divisions of HHS were represented along with seven other federal agencies and the Committee on National Statistics. Panelists included faculty from three universities and

members of four research organizations. This paper summarizes the principal findings and conclusions from the panel meeting and the broader project.

Overview of Findings and Observations

Based on our review of federal government programs producing small area estimates coupled with the discussion at the expert panel meeting, we report the following observations:

- Within HHS use of SAE methods to produce small area estimates on a regular basis is limited, but these applications show a high level of sophistication and cutting edge methods
- The development of a program of small area estimates requires significant time and resources, but these costs are small in comparison to new or expanded data collection
- Software limitations are an especially challenging part of the development and implementation of small area methods
- The identification and use of suitable auxiliary variables present a number of challenges
- Comparative evaluations of alternative approaches are not as common as prospective users might expect
- Understanding how estimates will be used and how they will perform under those circumstances are important to both development and evaluation
- Validation of small area estimates remains a significant challenge, and varied approaches have been used
- Interpretation and communication of small area estimates require careful attention
- The American Community Survey (ACS) changes the landscape for small area estimates in a number of ways
- Collaboration presents both opportunities and challenges, yet the sharing of technical resources across agency divisions and even across agencies may be necessary to more fully exploit the potential of small area methods

Below we develop each of these points.

Applications within HHS

We identified several production applications of SAE within HHS. These include:

- State estimates of age-group-specific prevalence estimates of 25 substance use behaviors measured in the National Survey of Drug Use and Health; Substance Abuse and Mental Health Services Administration (SAMHSA)
- County estimates of diabetes prevalence, incidence and risk factors; Centers for Disease Control and Prevention (CDC)
- State and county estimates of cancer risk factors and screening; National Cancer Institute (NCI)
- State estimates of household substitution of wireless for landline telephones; National Center for Health Statistics (NCHS)
- Model-based estimates of vital statistics for geographic and demographic small domains; NCHS

Most of these applications are relatively new. The CDC and NCI estimates and the NCHS estimates of wireless substitution were produced within the last decade. By contrast, the SAMHSA estimates began in the early 1990s.

Reflecting the skills of those involved, the newer approaches and the SAMHSA estimates all employ empirical or hierarchical Bayes methods.

In addition to these production applications, small area estimates have been developed as part of methodological research at NCHS, and both CDC and NCI are working to extend their methods to other measures while the Agency

for Healthcare Research and Quality (AHRQ) is developing experimental county-level estimates for its quality indicators program and exploring the production of additional state estimates from the Medical Expenditure Panel Survey (MEPS).

Requirements for Establishing an SAE Program

The development of a program of small area estimates requires significant expertise, time and resources. Requisite skills include statistics and/or econometrics with an emphasis on modeling; high-level programming; and strong communication ability. Meeting these needs may require hiring new staff or obtaining contractor support. Development and implementation can take two or more years. Nevertheless, these costs are dwarfed by the expense of new or expanded data collection.

Software

Most of the formal SAE methods used by federal agencies and their contractors are computationally intensive. As such, they require specialized software or specialized routines within larger software packages. Computational speed is a particular issue for users, as is the extent of diagnostic information that the software can provide. Some of the most sophisticated users of SAE methods have written their own software to address these limitations.

Auxiliary Variables

Auxiliary variables play a critical role in the production of small area estimates. Administrative records are a valuable source of auxiliary variables because they can provide very precise estimates for small domains. In addition, the quality of measurement in administrative records can exceed that of comparable survey estimates, but quality may vary widely across items, across areas, and over time. Moreover, anomalies can occur as the result of administrative actions, natural disasters, or other factors. This underscores the importance of consulting with agency staff when using an agency's administrative data.

Comparative Evaluations

Our literature search and our review of federal programs identified very few examples of comparative evaluations of alternative small area methods. The primary reason, we infer, is that the effort required to implement a method fully enough to conduct an empirical evaluation is substantial. Because of this, agency staff may research the alternatives through the literature or by talking to other users, but the choice of a method, typically, is made before significant development occurs. In refining the application of the chosen method, agency researchers may conduct comparative evaluations of selected options within the overall methodology, but even this type of methodological research sees limited use. Consequently, the federal statistical community has learned little about how different SAE approaches compare when applied to the same estimation problem. Thus, agencies that are developing new applications and seeking to choose the most suitable method cannot draw on external research to determine what methods are likely to work best for their particular applications. What they can learn is what methods have been applied successfully to similar problems and, if they choose one of these methods, what issues they can expect to encounter and how they can address these issues.

Anticipating Uses

How a set of small area estimates is likely to be used may have implications for how they are created and how they are evaluated. A number of the estimates produced by federal agencies are used for funding allocation, and in those circumstances the quality of the estimates has direct implications for how well federal funds are targeted and how efficiently they are distributed. Stability, on the one hand, and sensitivity to change in underlying needs are important properties for an estimator that will produce estimates for funding allocation—although they may appear to be at odds. The desired properties of an estimator should affect design choices at the outset and determine what criteria are given the most weight in evaluating the estimates. If the estimates prove to be inadequate in some respects, the response of administrators or legislators may be to establish hold-harmless provisions or other administrative remedies that undermine the use of the estimates. Statistical solutions would be preferable but may be difficult to implement once the estimates have begun to be used.

Validation

Evaluating small area estimates is perhaps the most challenging aspect of their production. That small area methods had to be used in the first place implies that direct estimates of sufficient precision are not available to use in an evaluation. When the census long form was still in place, small area estimates of census-like variables could be evaluated by applying the methodology to a census year and comparing the results to the census estimates. But this is no longer an option except for the basic demographic characteristics measured on the decennial census short form.

Users have developed creative solutions to evaluate their estimates. Simulations using an artificial population are popular. Subsamples are drawn from the simulated population, estimates are created from the subsamples, and the estimates are compared to "truth" as defined by the simulated population. Comparisons using the most precise direct estimates (for example, the largest states) are sometimes used, but the largest areas may model differently than smaller areas, and the findings may be more limited than the users would prefer. Another approach used by a federal agency is to assess how well the small area estimates preserve known correlations. Cross-validation has also been applied to evaluate small area estimates; a subset of areas is removed, the model re-estimated, and the results applied to the areas that were removed. Finally, given the critical role of modeling in the development of small area estimates, careful examination of model diagnostics—that is, internal validation—may be the most common form of validation.

Interpreting and Communicating Results

No less than with direct estimates, producers of small area estimates need to consider how best to communicate the uncertainty associated with their estimates. They may also have to explain why the estimates are better than direct estimates. Meeting with stakeholders can be exceedingly useful in explaining the notion of borrowing strength and how it is reflected in the small area estimates and in learning and addressing the concerns and questions that the stakeholders may have regarding the estimates.

Some producers of small area estimates have developed informative graphics to assist users in making comparisons across areas. State estimates, for example, lend themselves to visual displays showing which state estimates are significantly different from others. In addition, maps can be useful not only in validation, but also as an aid to interpretation and communication of findings.

Users who are interested only in point estimates present a particularly difficult challenge because they profess not to care about the lower variance that differentiates small area estimates from direct estimates. Persuading them to accept the small bias in model-based estimates in return for lower variance is a hard sell. Sometimes the best way to explain uncertainty is to allow those who use the statistics to observe it first hand—by showing them estimates for multiple areas for consecutive years.

Impact of the ACS

The replacement of the census long form by the ACS affects small area estimation in a number of ways. First, it eliminates long-form variables previously used in models and validation. Second, it provides direct estimates for many characteristics, geographic areas, and subpopulations that would have required SAE previously. Third, it provides a wide range of auxiliary variables that are contemporaneous with the direct estimates used in model development. Fourth, it eliminates the need to deal with the variable time lag that characterizes the use of auxiliary variables from the last decennial census. Fifth, it expands opportunities for SAE through pairing the ACS with other surveys that capture the relevant content but lack the ACS's sample size. At the same time the ACS also shows the limits of even very large-scale surveys. For most substate areas, only three- or five-year averages are published, and they can be very imprecise. For such areas SAE can provide more timely and more precise estimates.

Cross-agency Collaboration

Two important benefits of collaboration are providing access to broader staff expertise and providing access to data. Nevertheless, the challenges to collaboration can be significant—particularly across departments. Common interest

in a successful collaboration is critical to establishing inter-agency agreements that will foster a successful partnership. Models of successful collaboration—such as that between NCI, NCHS, and two universities—can be studied for ideas on how to make such ventures effective.

In addition to formal collaboration, interagency working groups can be helpful for sharing ideas and keeping members up to date on activities that are ongoing or under consideration. Panelists responded enthusiastically to an OMB offer to create a group under the FCSM that would allow those working on small area projects or interested in the topic to communicate on a regular basis.

Considerations

One of the goals of this project was to help ASPE in communicating to others in the department what small area methods can and cannot do to address data gaps involving states, substate areas, and other small domains. The successful SAE programs at CDC, NCHS, NCI, and SAMHSA and the ongoing work at the Agency for Healthcare Research and Quality (AHRQ) to develop county estimates for its quality indicators program provide examples that illustrate the potential of these methods to fill such data gaps, the amount of effort that this may entail, and the types of data that must be assembled. It would be useful to draw on these examples to convey a realistic appreciation of what SAE can do and what its application entails.

Other agencies in HHS that routinely use small area statistics in their work recognize the value of such data but may not have the requisite staff or resources to develop their own small area estimates. We suspect that each of these agencies may be able to identify needs for expanded small area data in the future. If that should occur, agencies should explore potential collaboration with NCHS, which has the deepest staff with significant experience with SAE techniques.

Administrative data collected by CMS could provide a potential source of new auxiliary variables for applications of SAE within HHS. It will be important to monitor applications within the operating divisions to identify needs that could be addressed by CMS data and, where such needs exist, encourage collaboration. There might be interest in state estimates from the Medicare Current Beneficiary Survey (MCBS) and, if such interest is identified, CMS might work with NCHS staff that could be helpful in setting up a collaborative program to produce such estimates.

The Division of Program Statistics in the Office of Public Health Support in the Indian Health Service (HIS) produces a major report that relies heavily on decennial census data: Regional Differences in Indian Health. With the elimination of the census long form, many of the estimates in this report will have to be obtained from the ACS. This opens up the possibility of producing estimates more often than once a decade to better document trends, but sample size becomes an issue. It may be valuable for IHS to assess the merits of using SAE methods to produce more frequent statistics on the AIAN population.

While HRSA does not require SAE methods to identify shortage areas as they have been defined traditionally, using actual counts of medical professionals along with Census Bureau population estimates, the application of small area methods could enable HRSA to broaden the way it defines shortage areas. HRSA may want to explore whether there might be value in this approach.

Finally, some mechanism for sharing experiences with SAE would serve a broad array of current users and prospective users within the federal government. We encourage OMB to pursue the establishment of a working group on small area methods and applications, and we anticipate that ASPE would participate in this effort and inform the operating divisions of HHS of developments that are communicated through this group.