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# Discussion of "Small area estimation: its evolution in five decades", by Malay Ghosh

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This review article will help to promote further the "exponentially" expanding literature on small area estimation (SAE), which became one of the most researched and practiced topics in statistics in the last three decades. The areas are small, but the research and applications are huge. Malay Ghosh is undoubtedly one of the world leading experts in the theory and application of SAE, and his pioneering articles with his students and colleagues paved the way for new research and applications all over the world. No wonder that he is frequently invited to make keynote presentations in conferences and workshops, and from time to time to write review articles as this one.

I have sent Malay already a few remarks, leaving him the choice to include them in the text or just ignore them, which I shall not repeat here. (I was asked to send a short review anyway.) In the last section of the paper, Malay acknowledges that "the present article leaves out a large number of useful current day topics in small area estimation", referring the readers to look for them in the very comprehensive book of Rao and Molina (2015) and the extensive list of references therein. I shall therefore list a few topics which have been researched more recently (but need to be researched further), and topics that to the best of my knowledge have not been researched so far, but in my view should be investigated. (Unfortunately, due to my extensive administrative roles in the last 7 years, I no longer follow the SAE literature as I used in the past.)

1. SAE with unit observations in the presence of NMAR nonresponse. As well known, the response rate in surveys is steadily declining all over the world, and the nonresponse is often informative, implying inevitably the same problem in at least some of the areas. NMAR nonresponse need to be handled properly, irrespectively of the method of inference, whether design- or model-based; following the frequentist or the Bayesian approach.

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2. Accounting for mode effects. Modern surveys leave the sampled units the choice whether to respond via the internet, by telephone or via a "face to face" interview. As well known, the responses obtained from the different modes are often different, either before different profiles of people respond with different modes, or because the answers depend on the mode chosen. Mode effects can bias the estimates, if not accounted for properly. This is a well-known problem in national surveys, which cannot be ignored in SAE either.
3. Accounting for measurement errors in the covariates in generalised linear mixed models (GLMM). Malay mentions the problem of measurement errors as one of the topics that he has not covered but from my knowledge, this topic has only been investigated (quite extensively) for linear models. Has someone investigated the problem in the context of GLMM?
4. Benchmarking with GLMM. Malay discusses in some detail the issue of benchmarking, citing several studies published in the literature under the frequentist and Bayesian approaches. However, almost all these studies consider linear models. A PhD student of mine just completed his dissertation in which he considers among other topics benchmarking when fitting GLMM, but his study is under the frequentist approach. Extensions under the Bayesian approach will be welcome.
5. Estimation of design-based MSE of model-dependent estimators. The use of models for SAE is often inevitable. Users, (not statisticians), don't care much how the area parameters are estimated, but they are familiar with the concept of design-based (randomization) MSE. The concept that the true target mean or other area characteristics are random makes little sense to them; they like to know how well the predictors estimate the true (finite) area value. Hence, the often need to estimate the design-based MSE. Some work in this direction has been published in recent years, but much more need to be done, depending on the form of the model-dependent predictors.

I follow Malay by acknowledging that the 5 topics listed above are only few drops in a big pool of problems that call for new or further investigation. However, I can see that my review is no longer "short", so let me finish by congratulating Malay for this thoughtful, inspiring review.