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Zhang, J.L. and Bryant, J. (2020). *Fully Bayesian Benchmarking of Small Area Estimation Models*. Journal of Official Statistics 36:197-223.

­ As the need for estimates of small areas defined by social, demographic, and geographic variables increases, so too does the need for methods overcoming the difficulties of small area estimations. Due to unreliability from small sample sizes in these areas, model-based estimates are preferred over direct methods (i.e., calculating a rate by taking number of events over exposure). These small area estimates are frequently compared to aggregate estimates for larger areas that are more likely obtained using direct methods (referred to as *benchmarks*). Inconsistencies between the low level and aggregate estimates are cause for varying degrees of concern, so small area estimates are often adjusted to be consistent with aggregate estimates (referred to as *benchmarking*). Many previously existing benchmarking methods use benchmarks as constraints in the small area estimation models but are only able to provide point estimates of small area parameters.

In their article, Zhang and Bryant propose, implement, and demonstrate a fully Bayesian general approach to benchmarking. Their approach produces a full benchmarked posterior distribution by taking benchmarks as estimates for underlying aggregate parameters and modifying the likelihood function by multiplying it by the probability distribution of the benchmarks. Benefits of this approach include the ability to use multiple benchmarks, benchmarks nonlinearly related to small area estimates, and to specify acceptable discrepancy between benchmarks and model-based estimates.

For this report, I propose evaluating their methods by implementing and applying them to real demographic data from a location with data available a subnational level. I will test multiple benchmarking methods, including one allowing for larger discrepancy from the estimates, and another requiring an exact match. These tests will include benchmarks both linearly and nonlinearly related to the small area quantities.