Hierarchical models for international comparisons: A case study of smoking, disability and social inequality in 21 European countries

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Background International comparisons of social inequalities in health are challenging. The level of disaggregation often required can result in sparse data. We show the value of a hierarchical Bayesian approach that partially pools country-level estimates, reducing the influence of sampling variation and increasing the stability of estimates. A further challenge is how to simultaneously present the level of inequality and their precision on relative and absolute scales. We illustrate a new way of displaying estimates of prevalence, relative and absolute inequalities, and the uncertainty of these three estimates, on one plot.

Methods We used the 2014 Eurobarometer Social Survey to estimate smoking prevalence, absolute and relative inequalities for men and women with and without disabilities in 21 European countries. Smoking prevalence estimates are generated from a hierarchical Bayesian model, where we assume country-specific estimates are drawn from an overall ‘population distribution’. The model is set up with the likelihood (country-specific data) and priors (the assumed population distribution) pulling in opposite directions. The likelihood pulls the country-specific smoking prevalence estimate towards the observed value, whereas the priors pull the prevalence towards the European average, a phenomenon known as shrinkage. We simultaneously display smoking prevalence for people without disabilities (x-axis), absolute (y-axis) and relative inequalities (contour lines), capturing their uncertainty by plotting a 2-D normal approximation of the posterior distribution from the full probability (Bayesian) analysis.

Results Our model shifts more extreme prevalence estimates, based on fewer observations, toward the European average. For example, disabled males in Portugal have a high observed smoking prevalence (53%, 95% Uncertainty Interval (UI): 42%-63%) and a small number of observations (23). The model shifts this estimate, shrinking it to 43% (UI 38%-58%).

Conclusion We argue that our contributions allow for better decision making under uncertainty, through the combination of better statistical inference and an indication of the strength of evidence decision-makers have access to. Sensitivity to shrinkage could indicate whether a policy maker could benefit from more data to make an informed decision. If estimates are insensitive to partial pooling then a policy maker could be relatively confident in their evidence/data. Conversely, in a country where there is a large amount of shrinkage, decision-making could still benefit from the collection of more data. Being able to include all this information on a single graphic provides a useful tool for evaluating both the geographical patterns of variation in, and strength of evidence for, differences in social inequalities in health.