The differential geometry of homogeneity spaces across effect scales

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If an effect measure is more homogeneous than others, then its value will be more stable across different subgroups or subpopulations. A more homogeneous effect measure implies that trans- portability of research results is more plausible. Applied researchers often claim, for a binary out- come, that the risk difference is more heterogeneous than the risk ratio or odds ratio, because they find, based on evidence from surveys of meta-analyses, that the null hypotheses of homogeneity are rejected more often for the risk difference than for the risk ratio and odds ratio. However, the evidence for these claims is far from satisfactory, because of different statistical powers of the homogeneity tests under different effect scales. For binary treatment, covariate and outcome, we theoretically quantify the homogeneity of different effect scales. When homogeneity holds, the four outcome probabilities lie in a three-dimensional sub-space of the four-dimensional outcome probability space. We use results from differential geometry to compute the volumes of these three-dimensional spaces to compare the relative homogeneity of the risk difference, risk ratio, and odds ratio. We demonstrate that the homogeneity space for the risk difference has the smallest volume, and the homogeneity space for the odds ratio has the largest volume, providing results relevant to the claim that the risk difference is more heterogeneous than the risk ratio and odds ratio.