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Causal inference for vaccine effects on infectiousness

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If a vaccine does not protect individuals completely against infection, it could still reduce infectiousness of infected vaccinated individuals for others. Typically, vaccine efficacy for infectiousness is estimated based on contrasts between the transmission risk to susceptible individuals from infected vaccinated individuals compared with that from infected unvaccinated individuals. Such estimates are problematic, however, because they are subject to selection bias and do not have a causal interpretation. Here we develop causal estimands for vaccine efficacy for infectiousness for four different scenarios of populations of transmission units of size two. These causal estimands incorporate both principal stratification based on the joint potential infection outcomes under vaccine and control and interference between individuals within transmission units. In the most general scenario, both individuals can be exposed to infection outside the transmission unit and both can be assigned either vaccine or control. The three other scenarios are special cases of the general scenario. For each scenario, the principal stratification based on the joint potential infection outcomes under vaccine and control of the individuals exposed outside the transmission unit is developed. The causal estimands for vaccine efficacy for infectiousness are well defined only within certain principal strata and, in general, are identifiable only with strong unverifiable assumptions. Nonetheless, the observed data do provide some information, and we derive large sample bounds on the causal vaccine efficacy for infectiousness estimands. For each scenario, several other causal vaccine efficacy estimands and estimators are defined. An example of the type of data typically observed in a study to estimate vaccine efficacy for infectiousness is analyzed in the causal inference framework we develop.

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