***Causal inference with spatio-temporal treatment and outcomes: Evaluating the effects of airstrikes on insurgent violence in Iraq by Dr Georgia Papadogeorgou***

Although many causal processes have spatial and temporal dimensions, the classical causal inference framework is not directly applicable when the treatment and outcome variables are generated by spatio-temporal point processes. The methodological difficulty primarily arises from the fact that there exists an infinite number of possible treatment and outcome event locations at each point in time. We consider the setting in which the spatial coordinates of the treatment and outcome events are observed but their timing is recorded only at aggregate time intervals. Our motivating application is the evaluation of the effects of US led airstrikes on insurgent violence in Iraq from 2004 to 2011, where the coordinates of airstrikes and insurgent attacks are recorded on a daily basis. We extend the potential outcomes framework by considering the treatment point process as a stochastic intervention strategy. Our causal estimands include the expected number of outcome events that would occur in an area of interest if a particular stochastic treatment assignment strategy were to be adopted. We develop a new estimation technique by applying the inverse probability of treatment weighting method to the spatially-smoothed outcome surfaces. We show that the proposed estimator is consistent and asymptotically normal under a set of reasonable assumptions.