Abstract: Scientific research is often concerned with questions of cause and effect. For example, does eating processed meat cause certain types of cancer? Ideally, such questions are answered by randomized controlled experiments. However, these experiments can be costly, time-consuming, unethical or impossible to conduct. Hence, often the only available data to answer causal questions is observational.

We consider the problem of identifying total causal effects from observational data. We develop a necessary and sufficient graphical criterion for identifying causal effects under the assumption of no hidden variables. Our result gives a closed-form solution to the causal identification problem. Furthermore, our criterion allows the inclusion of background knowledge in the form of certain partial causal orderings (see Meek, 1995). Our criterion can be seen as a generalization of the g-formula of Robins (1986). Consequently, we also obtain a generalization of the truncated factorization formula (Pearl, 2009) for graphs learned from observational data and background knowledge.