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PICTURING PUBLIC HEALTH LAW RESEARCH: THE VALUE OF CAUSAL DIAGRAMS

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Summary

Given the multidisciplinary perspectives of public health law research and the wide range of topics included in legal epidemiology, the use of commonly understood pictures to illustrate the ways in which law and health interact can be invaluable (Burris, Wagenaar, Swanson, 2010). Ranging from laws that prohibit individual behaviors to laws that provide authority to act to laws that regulate organizational practices, legal epidemiology seeks to understand the mechanisms by which laws can improve health; visualizing these mechanisms in diagrams is an important tool for achieving such an understanding. The purpose of this chapter is to review some basic conventions used to create visual models, evaluate relevant examples of models in published legal epidemiology studies, and offer recommendations for constructing clear and informative models.

Causal diagrams can do important work in legal epidemiology, insofar as they answer several kinds of questions. They can help to describe ("how things are now"), classify ("why things go together"), explain ("how things really work"), predict ("what will happen if"), and decide ("what you should do now") As conceptual models, CDs not only map the steps by which law may impact health but also allow a researcher to more carefully consider the set of measures to be used in developing a methodologically rigorous study. Models that exhibit valid correspondence and are appropriately complex yet clear will help legal epidemiology researchers plan and carry out their work. Images that accurately represent the topic at hand may also be useful for policy makers in understanding new evidence for the many ways that laws may improve population health.

Learning Objectives

- Describe ways that conceptual models can be used to understand a phenomenon in public health law and translate that understanding into research designs.
- Construct a causal diagram, including inputs, mediators, moderators, outputs, and outcomes.
- Compare and contrast different applications of a basic causal diagram across a range of disciplines.

In 1927, New York publicist Frederick Barnard published a misattributed "Chinese proverb" that captured an obvious, yet profound idea: "One picture is worth ten thousand words." Barnard was trying to sell advertising space on streetcars, but the phrase aptly expressed a core truth about human cognition and learning: that we naturally use symbolic pictures to apprehend, organize, summarize, remember, and convey complex information.

Whether it is worth ten thousand or one thousand words (as today's shortened version of Barnard's adage has it), the reason we can trade all that language for "a picture" is that we understand the world around us largely through a process of simplifying representation (Dansereau & Simpson, 2009). We organize complex information into small chunks that can be visualized and recalled. We build mental models of the world – of what the chunks stand for and how they fit together and causally affect each other – and we unconsciously test and adapt such models to accommodate new, corresponding observations and experiences over a lifetime.

These images of our surroundings and of "how things work" are useful for what they include, but also for what they leave out; they enable us to ignore a vast amount of distracting information and to focus our attention on what is most relevant for a particular purpose. Models also allow us to understand a larger context, as they provide an overall orientation and a "place to stand," from which we can focus on smaller sections of the picture.

Varieties of Visual Representation

Academic disciplines – from the sciences to medicine, law, engineering, business management, and education – have long used formal schematic pictures to efficiently represent complex processes and to articulate theories about phenomena of interest (Coryn & Scriven, 2008; Ellermann, Kataoka-Yahiro, & Wong, 2006; Hamilton, Bronte-Tinkew, & Child Trends Inc., 2007; Jordan, 2010; Misue, Eades, Lai, & Sugiyama, 1995; Recker, Rosemann, Indulska, & Green, 2009; Wright, 1934). Various knowledge enterprises have given many names to their pet graphic images, as schematic pictures have become a key currency of technical information. Molecular diagrams depict basic structures of matter in chemistry (Daudel & Daudel, 1948). System flow charts illustrate how

computer programs, court proceedings, and organizations work (US Bureau of Justice, 2011). A business process model can show how a particular firm produces goods and services, sells a product, and makes a profit (Recker et al., 2009). Logic models illustrate plans for public health or policy interventions and lay out criteria for evaluating whether these interventions function as designed and produce desired outcomes (W. K. Kellogg Foundation, 2004). Concept mapping or concept webbing can elicit and clarify culturally divergent views of health and disease (Novak & Cañas, 2008). Statistical path analysis schematizes and guides empirical testing of theories of the component causes of social-behavioral phenomena in populations, drawing out ways in which causal factors sometimes interact or may take meandering detours in route to their effect (Duncan, 1966; Land, 1969; Wright, 1934). Regardless of the specific type of model and the associated discipline, all of these approaches are working to do the same thing: tell a story in a single image.

For their part, public health law researchers can use representational diagrams to derive specific research questions and hypotheses from a relevant theoretical framework and then design an appropriate study to test such hypotheses. An overarching model may encompass a broad agenda for research on a legal epidemiology topic, thus allowing the investigator to locate and sequence particular research questions and projects while understanding how they fit into a "big picture." Diagrams can also be used to help policy makers understand or refine a complex legal epidemiology topic. By viewing a diagram that clearly depicts a law's effect in, for example, modifying individual health behaviors or risks in the environment, stakeholders can understand how law is supposed to work or where there may be unintentional consequences. Moreover, this becomes a key communication tool for the media or advocates to explain the policy to public audiences.

Our purpose in this chapter is not to comprehensively review all the various graphical devices that have been used to corral knowledge across fields of human inquiry. Neither is it our purpose to endorse one discipline's particular modeling conventions or to propose some new iconography unique to legal epidemiology. Rather, in what follows, we set forth a few general principles – suggest modest guidelines – for drafting graphic models that are likely to prove useful in conceptualizing, implementing, and critically evaluating innovative legal epidemiology projects. We describe and illustrate several specific purposes that causal diagrams may serve, as they guide research on the effects of law and legal practices on population health.

What do we call these pictures for legal epidemiology? Without taking it too seriously, we use the term causal diagram (CD). We suppose that causal is a key element, insofar as the depiction of determining relationships between variables is a main point of these devices; if nothing else, they show how one thing leads (or could lead) predictably to another. Second, the word diagram seems to work because its Greek meaning is, roughly, "to mark out by lines."

Elements and Conventions of Causal Diagrams

What are the basic components and rules of causal diagrams? Novak and Cañas (2008) provide a useful description of "concept maps" that applies generally to CDs at the simplest level: "graphical tools for organizing and representing knowledge. They include concepts, usually enclosed in circles or boxes of some type, and relationships between concepts indicated by a connecting line linking two concepts . . . . We define concept as a perceived regularity in events or objects, or records of events or objects, designated by a label" (p. 1).

For the most part, the concepts represented in CDs are variables – characteristics or quantities with changeable values, which may be either observed, observable in principle, or theoretically postulated. CDs have a dynamic quality, using arrows to depict temporal processes, relationships, and sequences of events. Figure 10.1 adapts the main ideas of traditional statistical path analysis (Duncan, 1966; Land, 1969; Wright, 1934) to illustrate some of the key components and representational conventions that are common to many CDs.

CDs of this kind can be read "chronologically" from left to right in the manner that one might read a complex grammatical sentence. The diagrams "tell a story" with a beginning, middle, and end; there are things that happen first (causes, inputs), things that happen last (effects, outcomes), and a variety of things that happen in the middle (mediators, pathways, interactions, arguments). The "middle" involves a sequence of smaller steps or stages. Thus, depending on the focus of a particular study or analysis, the "dependent variable" may also function as an intervening output in the overarching legal epidemiology model.

In Figure 10.1, the boxes labeled X1 through X4 could be considered antecedents or hypothesized component causes of Y. In turn, Y is the consequence, the thing to be explained, or the problem to be solved by an intervention. Boxes depicted on the left edge of the diagram are often referred to as "exogenous" or independent variables, meaning "of outside origin" and not affected by anything internal to the system. Variables configured to the right, within the system, are termed "endogenous." In some CDs, a double-headed arrow is drawn between two independent variables, as with the arrow connecting X1 and X2 in Figure 10.1. Here the arrow represents a preexisting correlation – a reciprocal association between two exogenous causes.

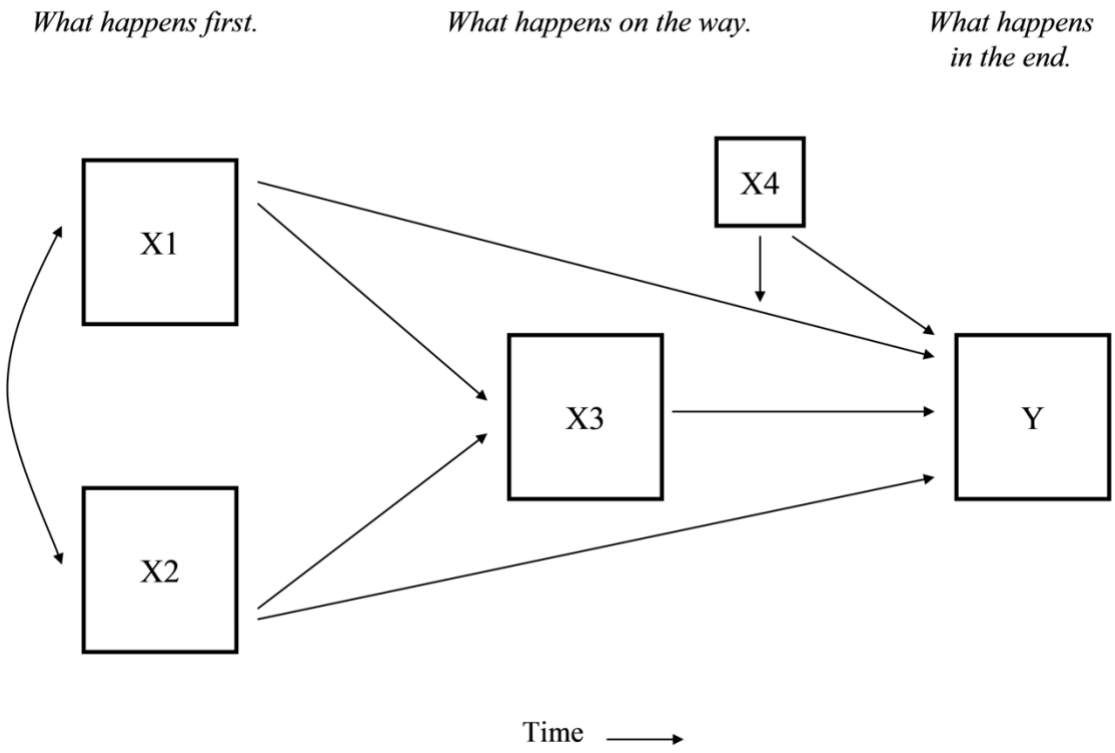

Figure 10.1. Some Conventions of Causal Diagrams.

To put some flesh on the skeleton, let us consider a hypothetical CD depicting the effects of state firearms laws on the rate of gun-related fatalities. If we were to assign relevant labels to the boxes in Figure 10.1, variable X1 might represent the household gun ownership rate while variable X2 might stand for the restrictiveness of a state's gun laws. In a test of a legal epidemiology theory of gun control effectiveness, these two variables predictably would be correlated with each other, as indicated by the arrow connecting X1 and X2, and both would be expected ultimately to affect the risk of gun violence in the community (Y).

The box labeled X3 in the diagram is a *mediator* – a variable that comes between the main cause(s) and the effect in question (Edwards & Lambert, 2007). To qualify as a true mediator, a variable must be related significantly both to the preceding cause and to the effect that follows, and must thereby explain some of the bivariate association between the first cause and its ultimate result; the mediator explains how it happens. In our gun laws example, X3 might capture a key mediating variable such as the frequency of crimes involving handguns. Logically, if there are more guns in the population (X1), then whenever a crime occurs it may be more likely to involve a gun (X3); in turn, when guns are used in crimes, it is more likely that a fatal injury will occur (Y). Exogenous predictor variables are also sometimes referred to as "distal" causes while mediating variables that immediately precede the outcome of interest are termed "proximal" causes

(Greenland & Brumback, 2002). In the current example, an intervention aimed at a distal cause of firearm fatalities might focus on reducing the number of guns in the population, while an intervention targeting a more proximal cause might focus on reducing violent crime.

Finally, the box labeled X4 represents both a moderating variable and one that interacts with another causal factor in the system. As depicted, this variable exerts a direct effect on Y, but also modifies the pathway between X1 and Y (that is, is also a *moderator*); hence, the arrow leads to another arrow, rather than to a box. In our gun control example, X4 might stand for a variable measuring implementation of firearms laws, such as the extent to which states report disqualifying records to the National Instant Criminal Background Check System (NICS). The diagram would help us show that we expect NICS reporting to exert a direct effect in lowering the risk of firearm fatalities (Y), but also to potentiate the effect of the law itself (X1) – interact with the law to produce a larger impact than the sum of each of these component causes' single effect. Another important way in which a moderating variable can operate is when a causal effect is stronger in one group than another, or when it works only in one group and not another. For example, Ludwig and Cook (2000) found that the Brady Handgun Control Act significantly reduced suicides, but only in people over age 55. Thus age was found to be a "moderator" of the law's effect.

It is important to recognize that building a CD is an iterative process; as an evolving model confronts new theoretical ideas or evidence, new mediators or moderators may be added, blocks may change position or be removed, and the direction of arrows may even reverse. The descriptive example here is just one way in which to create a CD. Ultimately, the CD should provide a one-to-one correspondence between the theoretical constructs and a testable empirical model. CDs are helpful to evaluate how well constructs in the model are operationalized with available data. Next, we move on to review a range of different options for constructing CDs and note the strengths and weaknesses of each approach in relation to legal epidemiology. However, all of these models proceed from the same basic idea of working through time with the inputs on the left and the outcomes on the right.

Variations on the Theme

Several different types of causal diagrams may be useful in legal epidemiology. These serve distinct but complementary purposes, and some of them follow the conventions we have just described more closely than others. There is no one-size-fits-all approach, and it is important for the researcher to modify the CD according to the features and complexity of the specific study, as well as the intended audience(s).

A COMMON UNDERSTANDING

The first purpose of CDs is descriptive classification, addressing the need for a specific, common understanding of the thing to be studied. For example, suppose we wish to examine whether involuntary outpatient commitment laws improve population health and safety. As a general

definition, outpatient commitment is a civil court order requiring that a person with mental illness meeting certain criteria participate in outpatient psychiatric treatment.

However, there are several types of legal outpatient commitment (Swartz, Swanson, Kim, & Petrila, 2006); without understanding these types and distinguishing them from each other, it would be difficult to proceed with an informative study of outpatient commitment. Figure 10.2 illustrates how a CD can be used to define and graphically describe the different types of outpatient commitment laws (OPCs), showing the pathways by which someone in a mental health crisis may qualify for each type.

A PROCESS BLUEPRINT

A variation on the descriptive purpose of CDs is process modeling for a specific legal intervention, policy, or program. The goal of process modeling in legal epidemiology is to provide a detailed blueprint of a given legal intervention and how it is designed to function. By analogy, if a generic descriptive CD defines an automobile and distinguishes generally between cars and trucks and buses, a process model CD would "lift the hood" of a particular vehicle and show how the engine works.

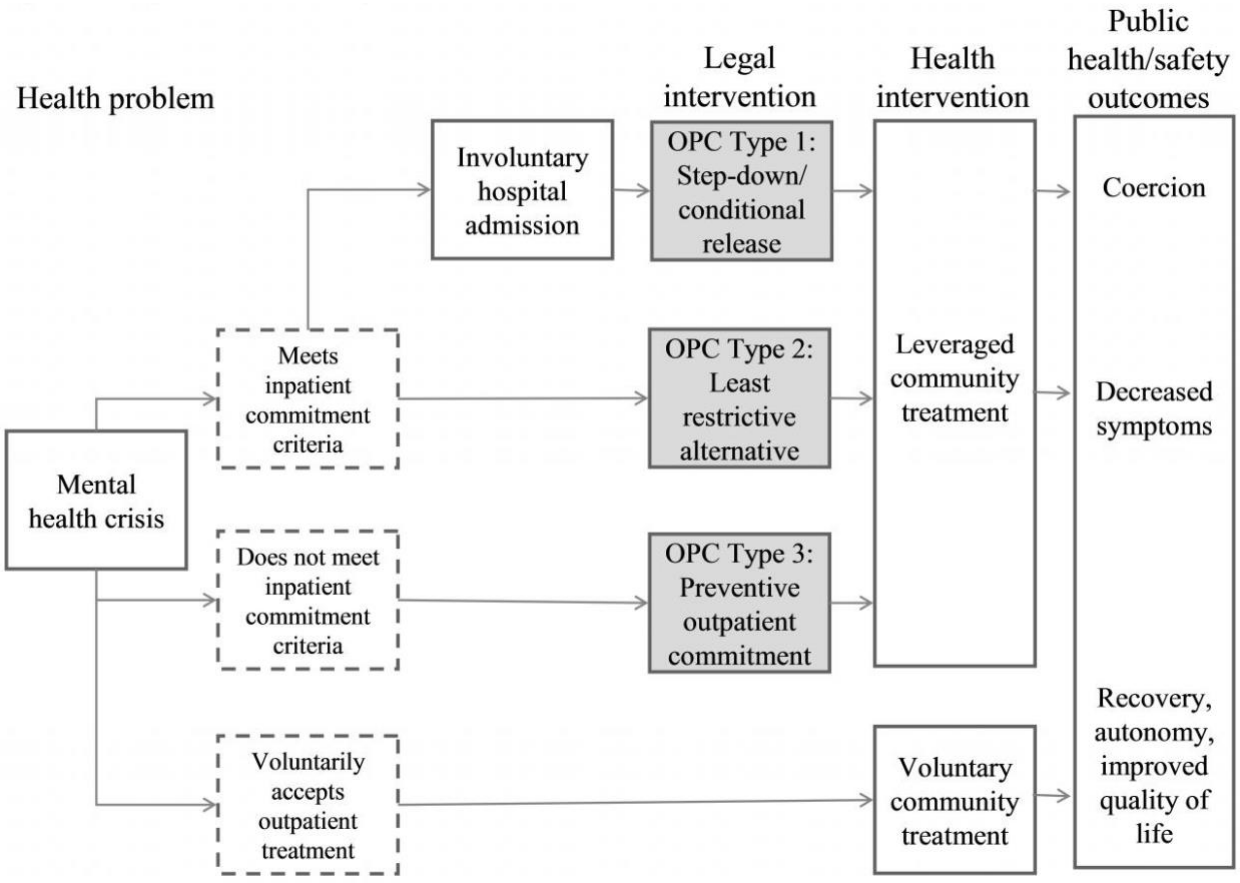

Figure 10.2. Types of Involuntary Outpatient Commitment.

Figure 10.3 illustrates such a diagram for a program of legal outpatient commitment, New York's Assisted Outpatient Treatment Program (AOT) (New York State Office of Mental Health, 2011). This type of model can also be used as an action map or decision guide for system actors who are involved with the AOT program. The CD moves from referral to investigation to assessment and service delivery, highlighting the range of potential mechanisms involving clinical and legal actors. The CD also provides context for how the individual moves through different institutions which is important to consider when formulating or revising policy interventions.

Sometimes the same information can be conveyed using different types of CDs to reach different audiences. While graphical boxes labeled with different types of actors and organizations may be useful for program administrators, these images may be meaningless to the general public or policy makers. As an alternative, Figure 10.4 presents a CD on the same New York AOT program, but directed toward a general lay audience (Pataki & Carpinello, 2005); this CD is centered on the perspective of an individual trying to navigate the system.

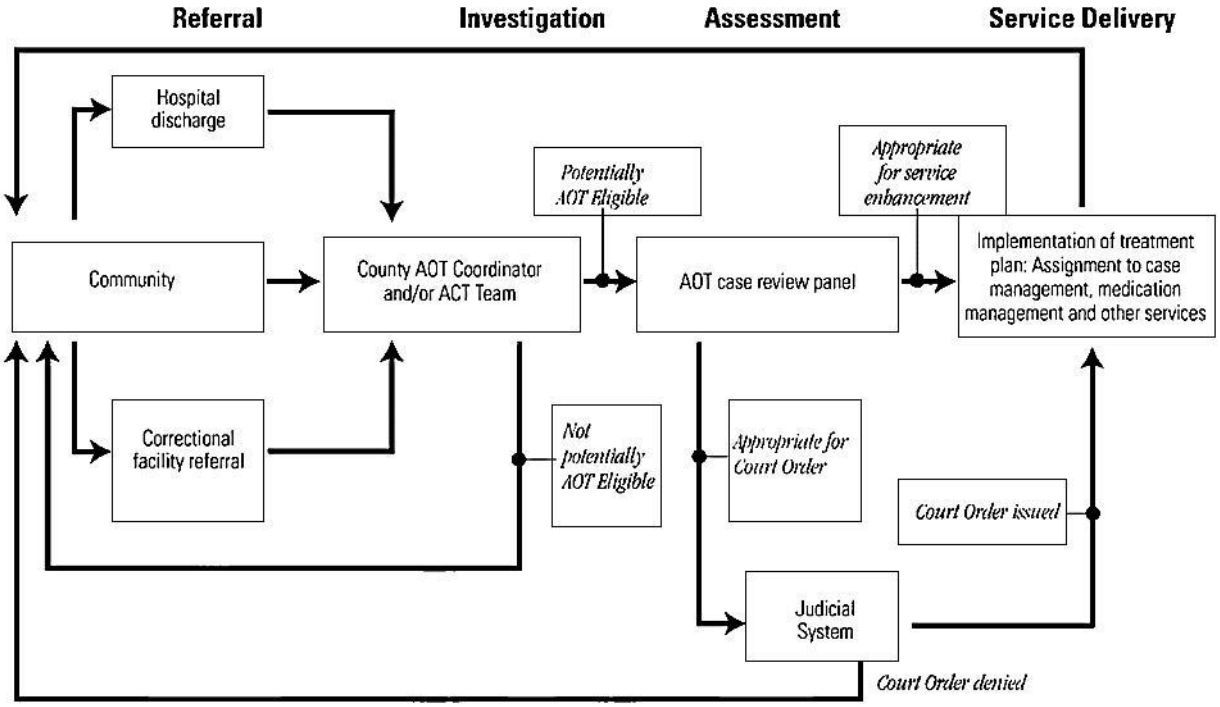

Figure 10.3. Schematic Representation of AOT Processes in Nine Areas of New York State.

Source: New York State Office of Mental Health, 2011.

MAPPING MULTIPLE INTERVENTIONS

The CD can also be used to map the cumulative and interacting effects of a range of interventions that address a specific health topic. Figure 10.5 provides an example of a model depicting ways to curtail youth consumption of alcohol, such as reducing economic and physical access to alcohol,

enforcing societal norms, and exercising other social control mechanisms. The model combines theoretical elements from several disciplines, including social and behavioral sciences and economics, and engages the issue of underage drinking from the perspectives of several key actors, including the minor who would consume alcohol, the retailer who would sell alcohol to minors, and the law enforcement officer who would detain the minor (Wagenaar & Perry, 1994). While this is a complex model, it represents an inherently complicated set of interconnecting phenomena and does so in a comprehensible way that provides an opportunity to consider multiple points of potential modification to existing laws and legal practices. However, the beauty of a complex model such as this one is that it allows the viewer to trace different pathways depending upon need, while still acknowledging the larger context. The CD may facilitate collaboration between a behavioral scientist and an econometrician to better understand policy levers to restrict access to alcohol.

THEORETICAL FOUNDATIONS

A fourth important purpose of CDs is the theoretical explanation or the articulation of a causal theory. Here the diagram identifies a particular phenomenon to be explained, sets forth a proposed cause or multiple component causes of the phenomenon, and specifies the pathways of association – patterns of common, sequential occurrence – that theoretically connect the causal factors to the effect of interest. Figure 10.6 draws from behavioral theory and applies the theory of planned behavior (TPB) to explain how a law restricting or prohibiting cell phone use while driving can result in a behavior change and improvements in health outcomes.

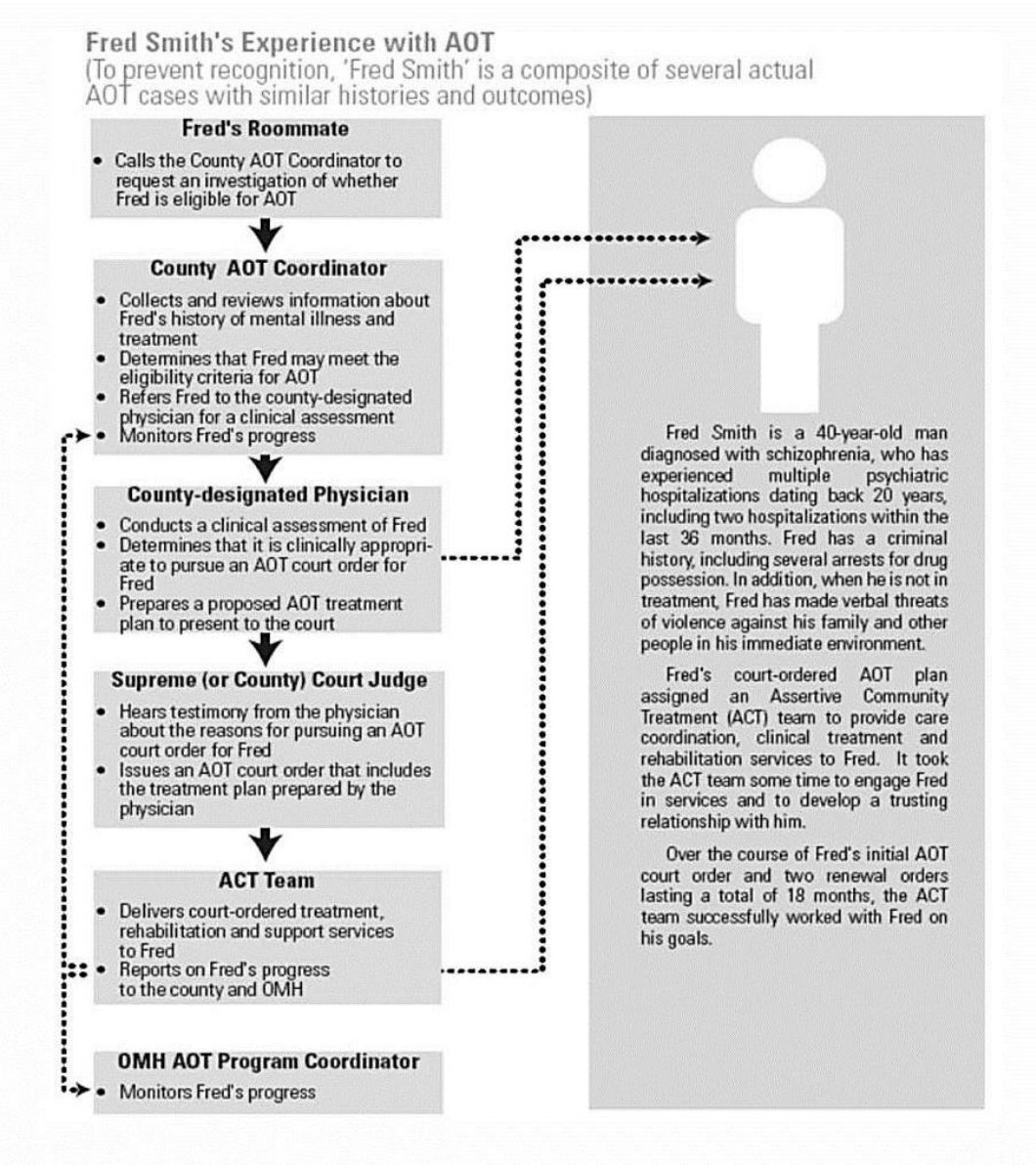

Figure 10.4. New York State Office of Mental Health Diagram Explaining OAT to the Public.

Source: Pataki & Carpinello, 2005, p.6.

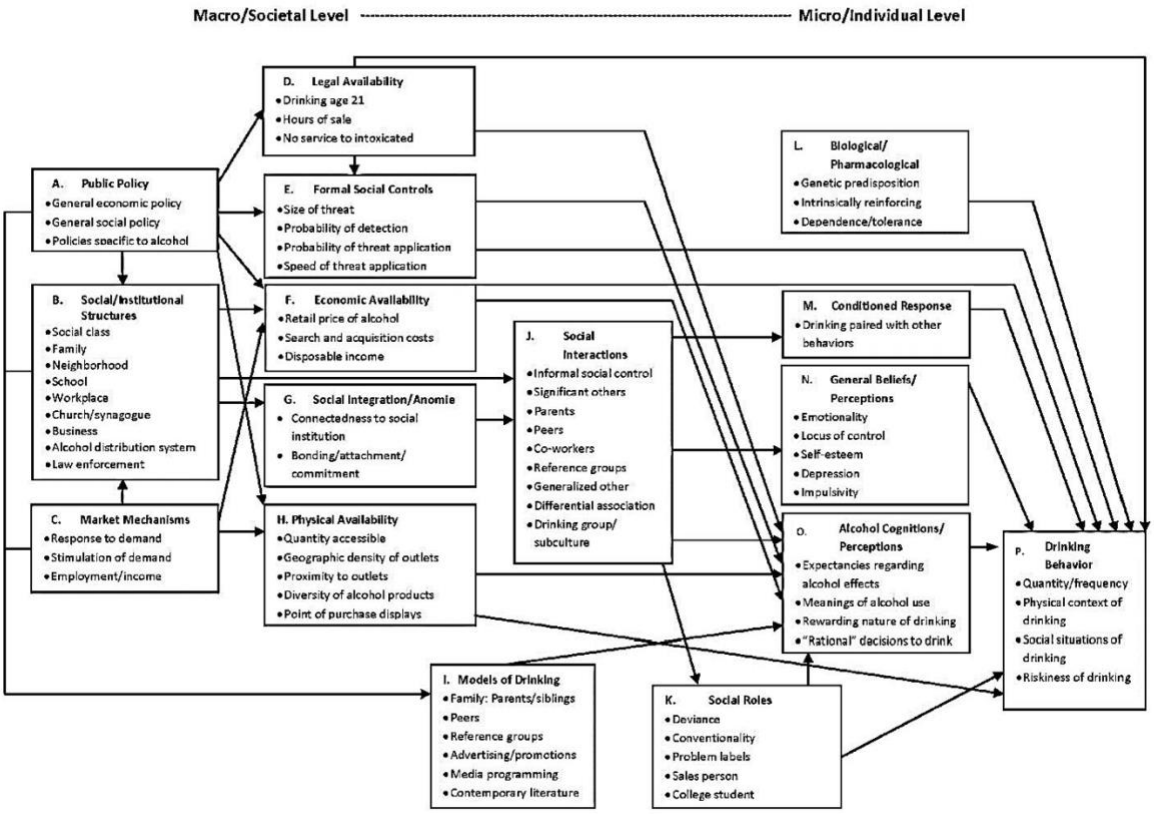

Figure 10.5. An Integrated Theory of Drinking Behavior.

Source: Wagenaar & Perry, 1994, p. 322.

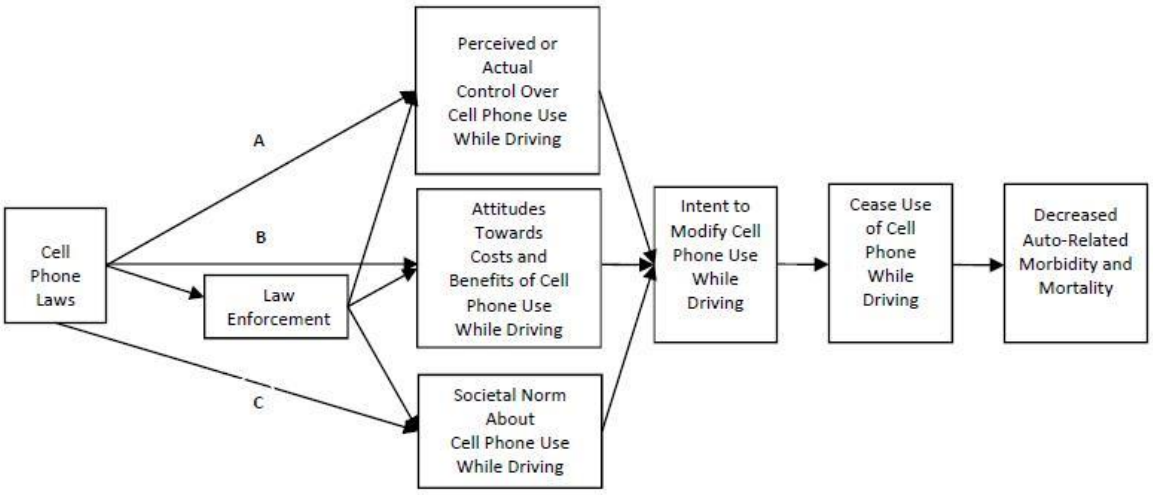

Figure 10.6. Use of Theory of Planned Behavior to Frame Distracted Driving Behaviors.

In this model, we offer three potential hypotheses for how TPB can be used to explain mechanisms for expected legal effects on population health and safety. The diagram clarifies theoretical mechanisms by which legally restricting cell phone use while driving can be expected to change driving practices, and potentially reduce mortality associated with distracted driving. This specific example demonstrates the integration of a classic behavioral sciences theory with classic legal theory on deterrence.

First, a "fear hypothesis" (path A in Figure 10.6) would posit that fear of being caught and punished – deterrence, in legal terms – inhibits the individual's independent action of using a cell phone while driving. A second option is the "guilt hypothesis" (path B), which posits that negative social sanctions attached to the behavior of using cell phones while driving affect the actor's attitude toward these behaviors and persons who engage in them. Finally, the "shame hypothesis" (path C) posits that laws and law enforcement activities can induce in the actor a sense that others look down on the sanctioned behavior, in this case, that fellow drivers will be annoyed and irritated by someone using a cell phone while driving. These attitudes determine the intention to use a cell phone while driving.

If the law is working, one or more of these mediating mechanisms will modify the subjects' intention and behavior, and eventually, the risky practice of driving while using a cell phone will decrease across the population. Given valid measures and sufficient observations of data from a representative sample, such an effect would be detected as predicted by the model. We could also expand the model to include mediators and moderators of the relationship between the intent to modify the behavior of using a cell phone while driving and actually stopping the behavior. However, it is best to keep the CD focused on a few elements that are both theoretically relevant and empirically testable, rather than to include any number of extraneous variables that might co-vary with the law and correlate with its outcome.

MOVING FROM PICTURES TO MEASURES

A fifth purpose of CDs in public health law research is to guide tests of direct and indirect causal effects of laws on public health outcomes (Rothman & Greenland, 2005). To illustrate, Figure 10.7 articulates testable mechanisms by which various tobacco control policies could modify smoking behavior (Fong, Cummings, Borland, et al., 2006). Any policy's effect is likely to be moderated by individual characteristics – from sociodemographic descriptors to personality features and previous smoking behaviors – and mediated by psychosocial factors such as shared beliefs and attitudes, group norms, and perceptions of risk. The model allows us to think about the specific measures and sources of data that would be necessary to test alternative and complementary hypotheses. While the model was created mainly as a general framework for tobacco control policy efforts, it also provides a useful catalogue of mediating variables that specific policies might target, and which could be measured to test these policies' effects. The CD could also help identify

variables that have not yet been operationalized and may therefore be included in future data collection.

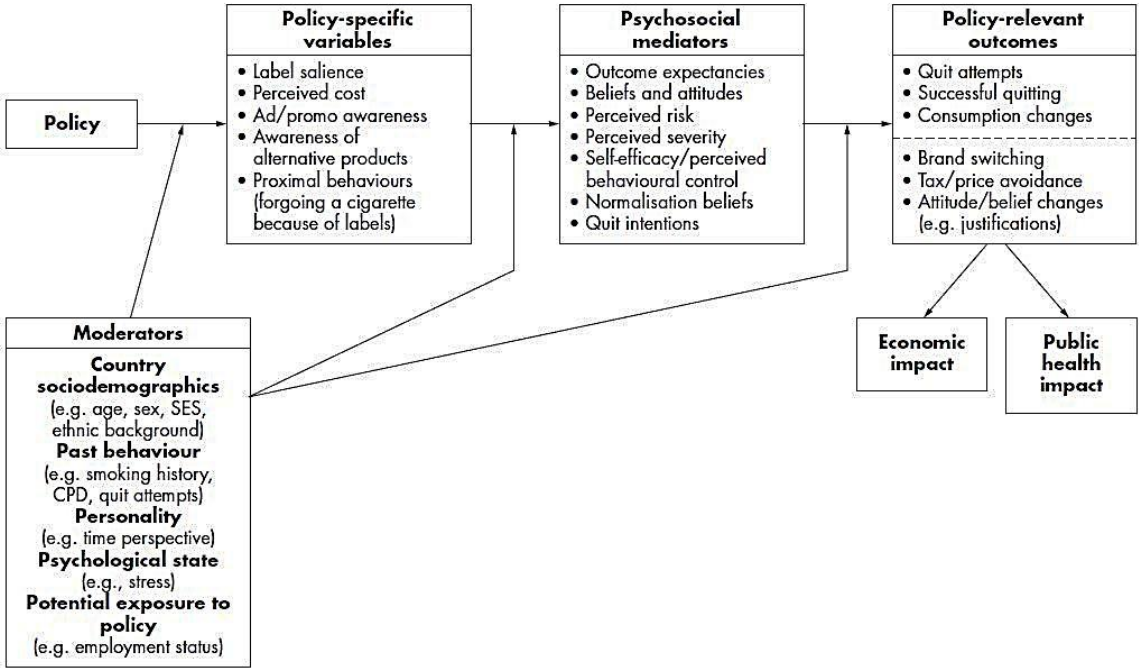

Figure 10.7. Conceptual Model of the Impact of Tobacco Control Policies Over Time.

Source: Fong, Cummings, Borland, et al., 2006, p. iii5.

A final purpose of CDs in public health law research is to depict and guide the process of research or evaluation itself. An extensive literature exists that explains the use of "logic models" in public health program evaluation (W. K. Kellogg Foundation, 2004). The main distinguishing feature of these types of CDs is a depiction of programs' "theory of change," including inputs, activities or strategies, outputs, and impact or outcomes in order to demonstrate and evaluate effectiveness. Beyond use for research or evaluation, CDs may also be deployed as a tool for program development, policy making, and analysis, particularly in cases when policy makers must make decisions without the benefit of strong evidence for the likely effectiveness or adverse consequences of a course of action. By graphically unpacking a policy's potential requirements, goals, and expected pathways of effect, the CD provides an opportunity to consider hidden assumptions, barriers, or unintended "side effects" that might not otherwise be debated. Figure 10.8 is an example of CD that was used to develop and monitor strategies to minimize the spread of COVID-19 when there was rapidly changing science around the disease and a lack of evidence on the effectiveness of different interventions (Centers for Disease Control and Prevention, 2020).

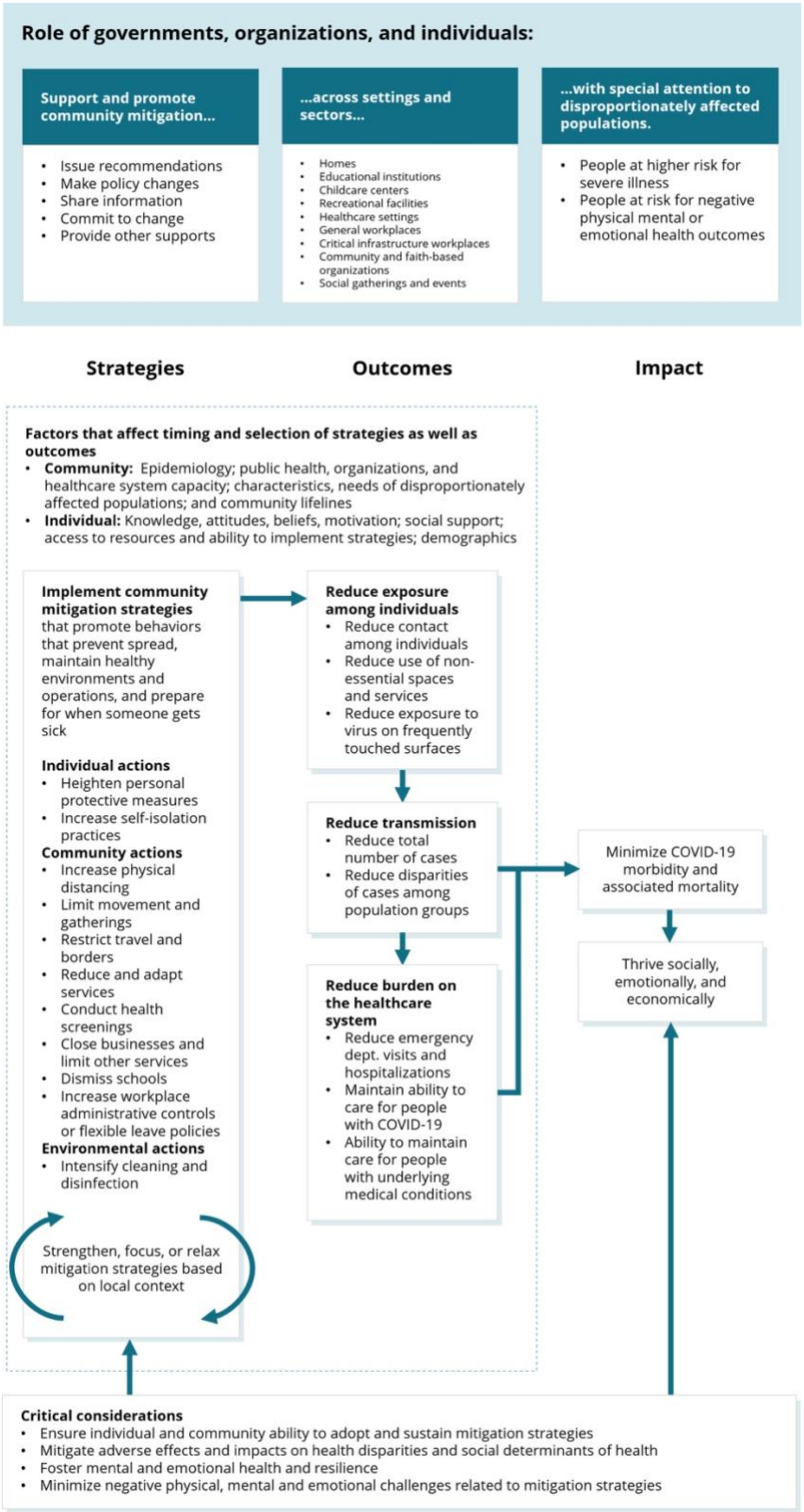

Figure 10.8. Logic Model for Monitoring and Evaluating Community Mitigation Strategies for COVID-19.

Source: Centers for Disease Control and Prevention, 2020.

What Makes a Good Causal Diagram?

Scholars have described several criteria to evaluate the adequacy of representational diagrams used in process modeling, particularly in the context of business and information sciences (Recker et al., 2009). The ideas underlying several of these criteria can be adapted to evaluate CDs for public health law research and to identify specific problems that may arise with these models. We propose related criteria that can be summarized as the "Three C's": correspondence, comprehensiveness, and clarity.

CORRESPONDENCE

The first criterion for evaluating CDs is *correspondence*, meaning that a given concept or construct in the model must correspond in a valid, specific way to the particular phenomena or set of observations that it purports to describe in the real world. Since the basic premise of the model is to explain real-world phenomena to facilitate research, it is important that each box has a clearly defined connection to some element directly or indirectly observed in reality.

To illustrate this criterion, consider a CD that is designed to illustrate a test of whether states' laws against driving while using a mobile communications device prevent motor vehicle crashes and injuries. Imagine that the CD depicted in Figure 10.6 had included separate boxes labeled "distracted driving laws" and "laws against texting and driving." The first problem with such a model would be a *poor correspondence* between at least one of the constructs and the real-world phenomena of interest.

Specifically, the box labeled "distracted driving laws" would suffer from what Recker and colleagues (2009) call "construct overload." As they explain (in the context of business process modeling), construct overload occurs when a term "provides language constructs that appear to have multiple real-world meanings and, thus, can be used to describe various real-world phenomena. These cases are undesirable, as they require users to bring to bear knowledge external to the model in order to understand the capacity in which such a construct is used in a particular scenario" (p. 349). In short, "distracted driving laws" could refer to distractions such as eating, doing make-up, reading, and a whole host of other activities that individuals may do while driving, rather than the intended focus on the use of mobile communications devices while driving.

Second, the inclusion of two boxes labeled with slightly different definitions of the law, and with varying degrees of specificity, would also show poor correspondence. The logical deficit here could be called *concept redundancy*. A legal epidemiology model containing constructs with overlapping meanings and real-world referents is difficult to understand, impossible to test, and hopeless to apply to policy making. As mentioned earlier, it is possible to create a CD that includes multiple legal interventions to address a particular public health issue, but it is imperative that each box has

a mutually exclusive definition within that model, and that hypothesized interactions are depicted with appropriate precision.

COMPREHENSIVENESS

A useful CD should incorporate all necessary elements to achieve its specific purpose – whether description, classification, explanation, testing, or evaluation. Thus the model must include sufficient detail to adequately represent the hypothesized legal causes, hypothesized mediators, and health effects to be examined in a legal epidemiology project; it should not omit relevant variables and pathways. At the same time, the model should not be made more complex than necessary in an attempt to "represent the whole world." Just as a figure that is too basic invites misinterpretation, a diagram that is too complicated may create confusion. The goal is to construct a model that strikes an appropriate balance between the bare bones and the byzantine.

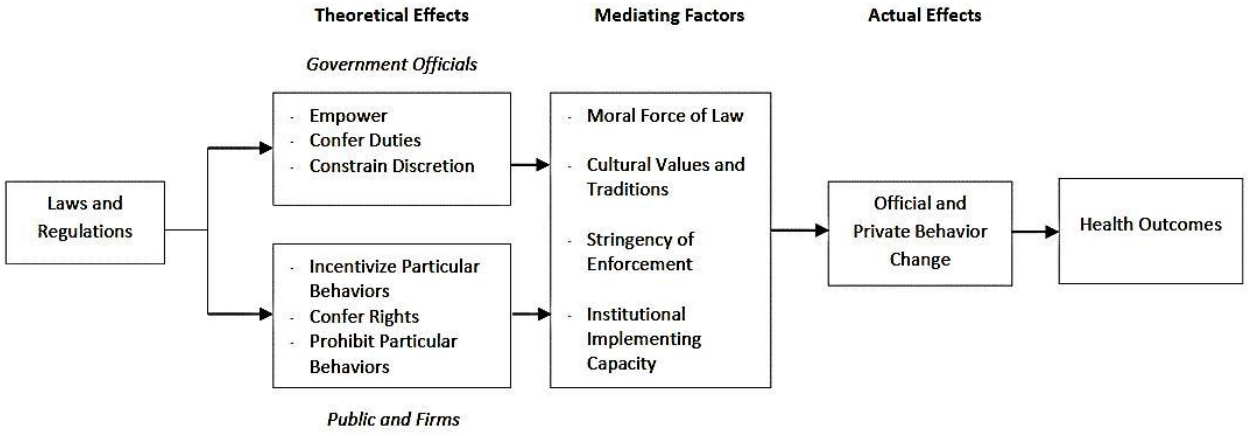

Figure 10.9. Conceptual Model of the Effect of Law on Public Health Outcomes.

Figure 10.9 is a CD designed to explain how laws and regulations influence the behaviors of the public and government and private entities, resulting in a change in health outcomes (Mello, Powlowski, Nañagas, & Bossert, 2006). The model provides an example of a CD that avoids the clutter of irrelevant details, yet does not oversimplify its relevant constructs and connections. The model is thus able to achieve its goal of visually representing, and therefore illuminating, the link between theoretical and actual effects of law on public health outcomes. Moreover, while the model provides an overall picture, it is possible to segment out one section of the model – for example, government actors only – and create a more granular version that elaborates on the mediating and moderating factors. The comprehensiveness criterion is also related to the term *parsimony* as used to evaluate theories in philosophy of science: all things considered, the simplest explanation is the best.

CLARITY

The final CD criterion that we will mention here is clarity, which refers both to visual intelligibility and conceptual lucidity. Clarity means, in essence, that a CD's images and accompanying labels should be easy to read, and they should make the concepts they stand for easy to understand. While this is related to considerations of correspondence and comprehensiveness, the clarity criterion expresses the model's intuitive logical appeal, and the extent to which it conveys an intended message with sufficient detail in definition – the elements in sharp focus with a minimum of surrounding "fog." The diagram must also be visually appealing and easy to follow; the reader should spend time thinking about the ideas, not figuring out how to interpret the boxes and arrows. It is possible for a model to be relatively simple, even to have good correspondence between constructs and their real-world referents, and still not be clear. For example, consider a model designed to depict the population health effects of regulatory action on pharmaceutical companies' innovation in developing new antimicrobial medications. Imagine a series of boxes labeled "regulation," "innovation," "incentives," "overutilization," "resistance," "effectiveness," and "population health," with multiple arrows connecting the boxes. The main problem with such a model would be a lack of clarity: What does it mean? How do these elements fit together according to some logical scheme?

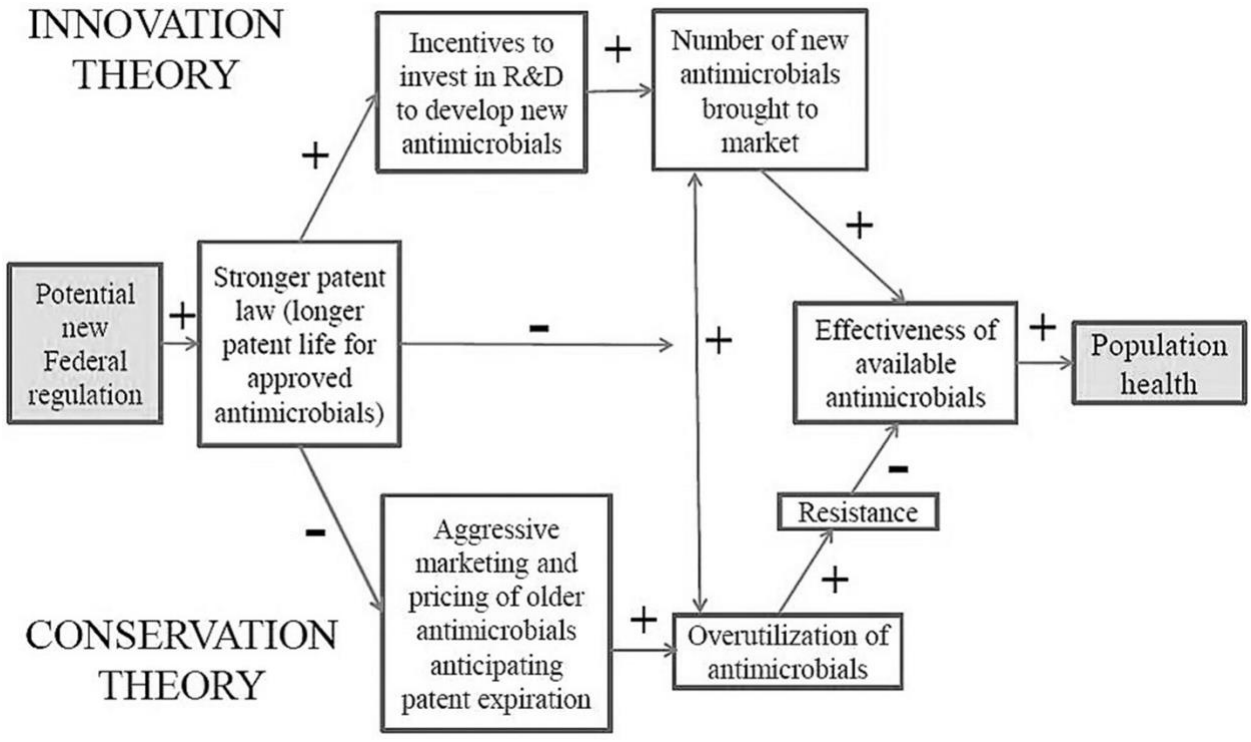

Figure 10.10. How Stronger Patent Laws Could Improve Antimicrobial Effectiveness.

Figure 10.10 presents a model of clarity using the same basic concepts, but lays out the logic for two different approaches to solving the public health problem of antibiotic resistance – innovation and conservation – and shows how strengthening patent law could plausibly work through both

mechanisms simultaneously (adapted from Outterson, 2005). The picture is clear and it is easy to see potential research questions, hypotheses to be tested, and measures to represent each box. This is the ultimate goal of CDs.

How to Create an Effective Causal Diagram

An informative and effective CD begins with careful preparation. The creative activity of sketching boxes and arrows should follow from, not precede, a solid understanding of the substantive topic at hand. Thus, the first step should be to selectively review the current academic literature on several facets of the subject: the basic dimensions of the public health problem at hand; its established or putative causes; contours of the law, policy, or regulatory scheme whose possible effects on health are the subject of inquiry; and what may already be known about the mechanisms of these laws' effect on health. It may also be valuable to review the literature on parallel topics to glean lessons from other applications of the law. A selective literature review should be carried out to extract key constructs, ideas, and causal relationships that recur in the literature across relevant fields of study, or that seem to bridge parallel understandings in diverse disciplines – from the health sciences to social sciences and the law.

The selective literature review should be driven by several basic theoretical questions that could also become research questions: What are the major causes of this public health problem? How could law, policy, or regulation conceivably affect the problem? What factors could modify or strengthen the law's effect on the health problem? Are there reasons to posit a fairly direct link between law and health in this instance? Or is it more likely that complex processes – environmental change, structural change, behavioral change, or all three – would intervene as foreseeable mechanisms of effect?

Armed with a basic understanding of key concepts and how they might fit together, there are many ways to actually draw a CD. Here is one: start by sketching a box that represents the health problem – the main outcome to be affected – on the right-hand side of a sheet of paper (or its computer-screen equivalent.) Next, sketch a box representing the legal intervention on the left of the drawing space. Connect the two boxes with a long arrow from left to right; keep in mind, the diagram "moves" chronologically from left to right. Next, stop and ponder: What other important variables could influence the health problem, and how might they be affected by the law as well? Add these variables to the diagram in the form of labeled boxes positioned above or below the central horizontal arrow, and suspended between the legal intervention on the left and the health outcome on the right. Connect these middle boxes with diagonal arrows coming from the law and proceeding to the health outcome.

The final step involves revising the diagram with an eye to the whole picture – repositioning boxes, adding or subtracting arrows – until the CD begins to form a clear, legible, and intelligible portrait of a health problem and its potential legal solution, along with any necessary "scaffolding"

to make it work. While described here in a few steps, in practice this is an iterative process. The final result should be a CD that is sufficiently detailed to convey all the information that is necessary to represent the theoretical mechanism or research problem at hand without extraneous conceptual or visual clutter.

Conclusion

Causal models have become increasingly common in the presentation of theory-driven research schemes across a variety of disciplines. However, there are few clear conventions in the current practice of graphic representation of variables, associations, interactions, and time that allow such pictures to be understood across disciplines. In this chapter, we have described a set of simple conventions for using causal diagrams as heuristic models to visually represent key independent and dependent variables, hypothesized mediators, moderators, and direct and indirect pathways of effect. The use of these models in legal epidemiology can yield powerful insights into the intended and unintended effects of laws on population health, as well as the social and institutional contexts in which they occur.

Causal diagrams can do important work in legal epidemiology, insofar as they answer several kinds of questions. They can help to describe ("how things are now"), classify ("why things go together"), explain ("how things really work"), predict ("what will happen if") and decide ("what you should do now"). As conceptual models, CDs not only map the steps by which law may impact health but also allow a researcher to more carefully consider the set of measures to be used in developing a methodologically rigorous study. Models that exhibit valid correspondence and are appropriately complex yet clear will help legal epidemiology researchers plan and carry out their work. Images that accurately represent the topic at hand may also be useful for policy makers in understanding new evidence for the many ways that laws may improve population health.

Further Reading

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