Supplementary file for

Stimulant-Involved Overdose Deaths: Constructing Dynamic Hypotheses

In this supplementary document, we provide additional information on our methods. Specifically, we provide further information about the group model building workshops in South Dakota. These include activities, agendas, roles, and scripts. Additionally, we present a process chart of our methods. We also include quote samples to demonstrate how the data were categorized under the six dynamic hypotheses related to stimulant-involved overdose deaths.

Content

Table S 4: Agenda, activities, roles in groups model building workshops in South Dakota

Time	Activity	Roles
30 min	Team Check-in/Tech Check/Setting up room	Entire Team
30 min	Lunch with participants (we can do introductions during lunch)	Convener to lead introductions
15 min	Welcome, Agenda, & Introductions if still needed; consent to audio	Convener
20 min	Hopes & Fears	Facilitator, runner, wall-builder, timekeeper, notetaker
5 min	Presentation of reference mode	Facilitator/co-facilitator
10 min	System dynamics review (elephant parable & polarity/loops)	Presenter
20 min	Variable elicitation	Facilitator, wall-builder, timekeeper, notetaker, modeler
5 min	Break (tech check for audio and Vensim)	Runner, modeler
30 min	Connection circles and share-out (2-3 groups)	Facilitators/floaters, notetakers, timekeeper
45 min	Developing causal loop diagram from connection circles	Facilitator, co-facilitator, runner, notetakers, timekeeper
10 Min	Break and print the causal loop diagram	Runner
15 min	Leverage points/round-robin	Facilitator, co-facilitator, runner, wall-builder, modeler, notetaker, timekeeper
5 min	Reflection and wrap-up/next steps	Reflector/Convener

Table S 5: Script used in groups model building workshop activities in South Dakota

Activity	Scripts
Welcome, Agenda, & Introductions	• The convener welcomes the group to the session and goes over the consent and agenda. • Shares screen with slides. • Ask for consent to record –start recording if it is okay by all. • Discuss the purpose of the session and the purpose of the approach. • "We're here because, over the past 10 years, there has been a great increase in the number of people who are dying from stimulant overdoses in South Dakota and nationwide. The purpose of this gathering is to build towards some informed strategies that can be used to combat this increase, and stop more people from dying from stimulant overdoses, especially here, thinking about meth overdoses. In order to do this, we need to know more about what might be causing and driving this increase because this issue is complicated, and there are a lot of things that go into it. Everyone here has important information about what is really going on, and together, this information helps us all understand and think about what strategies may be best for our communities. One important thing I would also like to clarify is that the focus here is especially on thinking about how we can prevent overdoses and fatal overdoses. Recovery, sobriety, and use prevention are all very important parts, but here we are trying to think about how we can provide that opportunity for recovery by making sure that people aren't dying. Ask participants to introduce themselves. • Names
Hopes & Fears	• The facilitator says, "I'd like each of you to think of your hopes and fears about this workshop or about meth overdoses and write as many down as possible in the next 5 minutes. Let me show you an example. One fear I have, which I'll write on this blue piece of paper, is that I'll bore you [write this in all caps, large letters]. One hope I have is that you'll have fun. I'll ask you to share yours, and we'll have the wall-builder arrange them by themes on the board/wall." Facilitator hands both to the wall-builder. • The facilitator asks the co-facilitator/convenor to share their one hopes & fear, then goes to participants. • The timekeeper gives a 1-minute warning before 5 minutes are up and then announces when 5 minutes are up. (This will be adjusted to be a quiet announcement, such as a sign to the facilitator in the workshop that has the Indigenous community) • The facilitator calls on each individual to share one hope and one fear with the group, and then the runner takes the papers from the participants and gives them to the wall-builder. • Wall-builder clusters hopes & fears into themes. • The facilitator moves on to the next participant in round robin until 2 minutes left. • The timekeeper announces when 2 minutes left, and the facilitator allows the current participant to finish. • In the last 2 minutes, the wall-builder shares cluster themes and asks participants if they sound accurate – change if necessary. • The wall builder takes pictures of clusters to save them as artifacts.
Presentation of reference mode	• The facilitator/co-facilitator says that we want to focus the group by looking at what is called a 'reference mode' of the problem, which is a way of showing how the problem has changed over time, the most likely future evolution in the status quo scenario, and the desired scenario. (Emphasize that we want to use the session to understand how to get to the desired scenario.) • First, the facilitator/co-facilitator presents a reference mode of South Dakota's rates of overdose death over time (the focus is on the current behavior mode vs the desired one, not on the numbers) • Then, the facilitator/co-facilitator notes that there are a couple of data points to consider as they move into the activities for the afternoon: 1. Shows a graph with the fraction of all overdose deaths that are meth deaths and highlights how that has been rising over time 2. Shows the fraction of meth that involves any other substance over time and highlights how it might be different from what they'd expect 3. Shows the crude rates for both Indigenous and non-Indigenous populations (emphasize that raw numbers are more similar).

Activity	Scripts
System dynamics review	• Share slides • Elephant parable • Describing polarity and loops
Variable elicitation	• The runner gives each participant sheets of blank paper and markers. • The facilitator writes a task-focusing question such as, “What are the key factors causing and resulting from fatal meth overdoses?” on the whiteboard or flipchart. • “Please write as many factors as you can, one per piece of paper. Just a few words for each. We don’t need sentences or paragraphs.” [give an example with large, bold letters – not related to meth ODs] “You will have 5 minutes to work on this, and then we'll share our ideas with each other.” • The timekeeper gives a 1-minute warning and announces when 5 minutes are up. (This will be adjusted to be a quiet announcement, such as a sign to the facilitator in the workshop that has the Indigenous community) • At 5 minutes, the facilitator says, “Thank you. The time is up. Please finish what you’re writing now and then stack your factors from most important to least important, whether they are causes or results. Then, we’re going to take turns sharing. [give them 1 minute to stack] • When a variable name is open to several interpretations, the facilitator asks for a brief description or definition of the variable, including the units in which the variable can be measured. • The facilitator goes around the room and asks each person one by one to describe the variable at the top of their stack. The runner then takes them to the wall-builder, who tapes them on the wall in thematic clusters. • The timekeeper gives a 3-minute warning (3 minutes before the end of this script). The facilitator lets the person currently sharing the finish and then asks the wall-builder to reflect back on the themes that emerged from wall-building and asks participants for feedback. The wall builder may ask questions such as "Does this resonate with you? Are there other themes you notice or any factors you think should be moved?" • Wall-builder takes pictures of artifacts.
Break	• Tech check for audio and Vensim
Connection circles and share-out	• At the start of the exercise, separate participants into small groups and have them gather around a blank connection circle and a set of thick-tipped markers. • Introduce the exercise by stating, "The goal of this exercise is to discuss the connections between the factors related to meth overdoses that we talked about in the last exercise. We are going to draw a connection circle. A connection circle is a visual tool that can help us identify and understand problems and see the connections in a system. First, let me show you an example." • Tell participants, "We are going to start with a large circle. From the list, we came up with earlier, pick two factors that are connected and draw a line with an arrow pointing in the direction of influence. [pick two obvious ones?] This arrow shows causality, and it can indicate both a positive or a negative relationship. For instance, as ___ goes up, so does ___, but as ___ goes down, so does _____.” • Say, "Next, you will pick another set of variables that are connected and draw an arrow to show causality. After about 15 minutes or so, you might have something that looks like this." Show an example of a completed circle in the slides. • “There are several points to keep in mind before starting: • First, for a connection that goes in both directions, draw two separate lines, one going in one direction and the other going in the other direction. Remember that the arrow shows the direction of influence or of causation. The arrow can represent something positive or negative. • Second, it may be easier to bend some of the lines to make them easier to follow, and that’s okay. • Third, the variables and connections can be based on personal experiences, data, or research. • Fourth, this connection circle is the overall or combined group picture of what may be happening for meth overdoses. Some variables and connections may be common to all communities. Other variables and connections may be specific to only one community or group. • Finally, each person can participate by generating ideas and making connections in the circle.

Activity	Scripts
	• Tell participants that they will have 15 minutes to complete the exercise, and a warning when only five minutes remain will be provided. Tell participants that their task is to identify connections that impact [meth overdoses]. • As groups work on their connection circles, facilitators walk around the room, observe how the groups are doing, and coach them. The focus of coaching moves through three phases: • For the first phase (approximately the first five minutes), the focus is on clarifying the instructions and providing positive reinforcement that the participants are on the right track. For example, tell participants, "That looks great. You have several variables representing [topic] and connections with arrows pointing in one direction." • During the second phase, focus on helping groups improve their skills in developing the diagrams and representing their discussion. For example, tell participants, "Remember, if you want to show a relationship that goes in both directions, draw two separate lines," and, " Seems like you're having a lot of disagreement about whether the variable is the same for all communities. Why don't you try adding a second variable and representing both ideas on the page, even if they feel a bit contradictory or are only relevant for some communities." • During the final phase (approximately the last five minutes), look for a group that has a good example to start the next exercise, and role model how one explains the connections as follows: • The timekeeper says: "You have 5 minutes left before we return to a large group. " • To encourage participants, the facilitator notes: That looks great. I see how [variable 1] is influencing [variable 2], and this is influencing [variable 3], which then affects [variable 4]. Nice job. • Tell the groups to stop after 15 minutes. • Ask participants to share their connection circles with the larger group as time allows. Have all participants move around the room to each connection circle as it is presented. Presentations should focus on sharing the connections that the group found most important or relevant.
Developing causal loop diagram from connection circles	• "We are now going to construct a causal loop diagram based on the connection circles." • The modeler picks two variables that are linked in one of the connection circles and then asks the group to help identify the variables linked to that variable. Then, add a plus or minus sign to indicate the direction of influence. If the group can't decide if a link should be plus or minus, use a question mark. If it could be both, then draw two separate causal links, one positive and one negative. • As the number of links increases, look for positive and reinforcing feedback loops. • If loops aren't being formed, say: "Our goal in this exercise is to develop a causal loop diagram, meaning we're looking to identify the individual linkages between variables as well as the loops. So, a good strategy here is to look for ways to "close the loop." We do this by looking for variables that don't have any arrows going into them and seeing if there is another variable in our model that might influence this variable. If there is, we can then draw a link." • The timekeeper warns when 5 minutes left, and then the facilitator asks, "What are some themes we see here? Where do you see the most interesting feedback loops?"
Break	• The runner prints a copy of the causal loop diagram for each participant.
Choose 3 leverage points/round-robin	• Runner hands out two copies of the causal loop diagram and a pen or pencil to each participant. • The facilitator says, "Please circle or put a star by the top 3 areas on the causal loop diagram that you think would have the most impact on reducing meth overdoses AND would be most feasible. An 'area' can be a single factor or a loop that involves multiple factors.'
Reflection and wrap-up/next steps	• Share slides, and the convener summarizes the session.

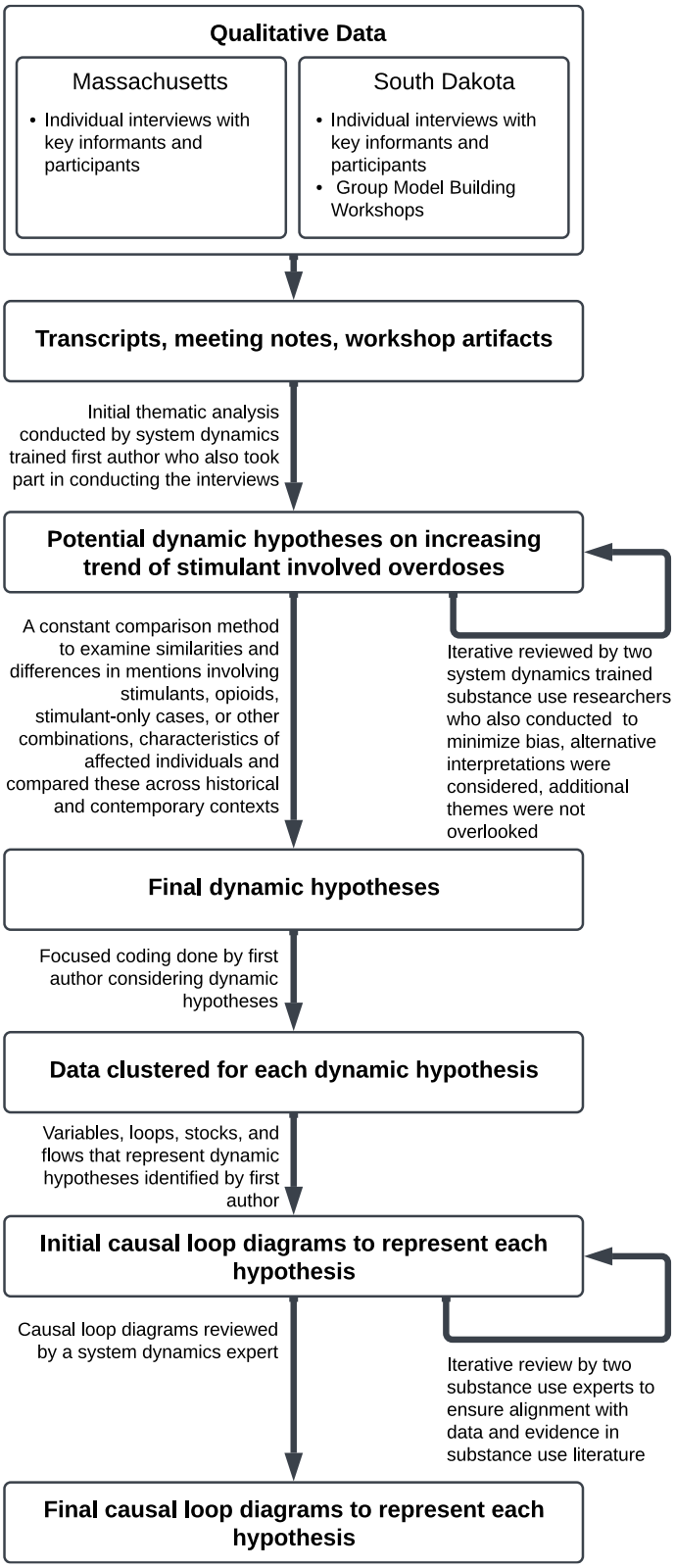

Figure S 2: Methodology process chart

Table S 6: Example quotations supporting each of the six dynamic hypotheses regarding stimulant-involved overdose deaths

SD: South Dakota MA: Massachusetts ◊ People who use stimulants ✱ Provider

Stimulant and opioid-involved overdose deaths	**Accidental exposure to fentanyl from stimulants**
	MA✱ "Talking to folks about fentanyl test trips…a lot of people…were totally caught off guard hearing that there was fentanyl in cocaine."
	MA✱ "Particularly last year, [there was] a significant uptick in opioid-related overdoses among folks who thought they were only using cocaine… There were some fatal, some non-fatal, but just a common pattern of folks who did not have a history of using opioids, didn't think they were using opioids."
	SD◊ "That's how I lost a nephew and almost lost a niece. Their supplier went to a different individual to get the drug [meth] and it was laced with fentanyl."
	SD◊ "The guy who's cutting the [meth with] fentanyl, they don't ever know how much cutting it with. May cut it too much, maybe cutting it too little."
	SD◊ "This guy here, he [dealer] is doing that [lacing with fentanyl], and then this guy here [another dealer] can buy it off of him and lace it with fentanyl more, and all of a sudden, all you do is smoking fentanyl. So that is how people OD… Mix it up and they don't know that there's all this fentanyl."
	SD◊ "They unknowingly use the meth that's got fentanyl in it, because unless you've been around for a long time, you know who's cutting it with fentanyl or who's selling meth cut with fentanyl, but at an early age you don't know. It's a risk you take."
	MA◊ "I was smoking something [crack], but they had put something in it. You know, this – fentanyl, xylazine. Now they're lacing a lot of stuff with something and some of the dealers that you buy it from, some of them don't even know what's in it, you know?"
	Primary stimulant users increasingly using opioids, often with resignation
	SD◊ "I smoked it [meth] but now if I'm starting to shoot up, I need help. Because I don't know what's going in my veins…I had a friend that overdosed on fentanyl because that's what they put in it. But I don't know what I'm taking, I'm just starting to just get whatever."
	MA◊ "Back then I was fiending for crack. I couldn't find it, whatever, whatever. So, I told this guy to get whatever [he] had. I saw someone shoot it up. Then I tried it [fentanyl] two times. I overdosed both times… I didn't ever try shooting up again… I've been sniffing and that's how I started."
	MA◊ "I would have to get [meth] on the street because I couldn't get a hold of my dealer… But getting it from the street around here [homeless services area], it's very cut with fentanyl… I could get it tested [at the local drug checking program], and they would do it…the test strips, I've never used them."
	MA✱ "Younger people of color coming in with sort of complex substance use…They started with cocaine and then they started using dope as landing gear. And now they're sometimes doing benzos and moving into mixing and matching."
	MA✱ "For a lot of stimulant users, they view [harm reduction services] more as an opioid-related service…they didn't know that that's a resource they can tap into."
	SD◊ "I don't even know what Narcan is… [laughs] Sorry. I don't even know if it's a drug, or if it's an anti-drug or what?"
	SD◊ "No, Narcan doesn't [work]. There's nothing you can do, usually in almost all of them [overdoses]. It doesn't work because you don't know what you're firing."
	Primary opioid (especially fentanyl) users increasingly using stimulants to balance the sedating effect of fentanyl
	MA✱ "I have definitely heard of people using stimulants with fentanyl because fentanyl they have more numbing and more sedation with fentanyl than maybe they had with heroin. And they're using stimulant to counteract some of these sedative properties of the newer opiate supply."
	SD◊ "Like my little daughter when she's doing fentanyl pills. The only way that her boyfriend can get her to be human and get out of bed is to give her meth."
	MA✱ "We are just seeing more of those very visible negative consequences of meth use…like here on the street… I see people getting kicked out of their housing. And I don't think people see that necessarily happening as much with just fentanyl use."
	SD◊ "The reason that they're [fatal overdoses] testing both now for the opioid and the stimulant is because you're taking more of the opioid and thus of the stimulant… I think people don't really realize how potent meth is. So, they probably do their regular shot of heroin or fentanyl…and then they do a shot [of meth].
	SD◊ "It's usually the opiates or the painkillers, or whatever they're doing before that. And then they use the meth. And they don't realize that their breathing has slowed, and their heart slowed. So, when you get high with meth, your heartbeat is going so fast from an almost stop position."
	SD◊ "I watch my boyfriend do it. He did less than he's always done with heroin and he overdosed in the bathroom. And he never believed in that before. He never imagined it was too much for him… But he was using meth in that day, but he did shot heroin and we almost lost him."

Stimulant-only overdose deaths	**Disbelief that death could occur from stimulants alone, and a subsequent doubt in testing capabilities to detect fentanyl** **SD**◊ "Her toxicology report only showed meth from all of the blood test and urine. Meth was the only thing in the system. And she smoked a blue pill that morning… But they can't test it. It will not come up in the UA [urinalysis]. Those blue pills...There's not a test for it because it's not for human." **SD**◊ "Still in denial of it [my nephew's death] that it was the meth – [it] was a fentanyl overdose. But his cousin told me, she said, 'Uncle, it was fentanyl that killed him, but they're denying it. They're lying to you. I was there. That was fentanyl.'" **SD**◊ "I don't know what the statistics of that [meth-only overdose death] is. But I do know for a fact that from my knowledge, I've never known anybody to OD from methamphetamine, but I know that, from my experience and knowledge, people [who use meth] have OD'd from fentanyl." **SD*** "I know for the past two years…I haven't seen only a UA [urinalysis] with just a meth… not doubting the data [on meth-only overdose deaths]. Everything is cut. There isn't 'I just popped hot for meth.'" **MA**◊ "I haven't seen any stimulants [sic] from an overdose of meth or cocaine. I have from fentanyl." **SD**◊ "I've seen a person inject two one-milligram syringes in both arms at one time… of pure methamphetamine… and didn't overdose. Pure methamphetamine. I don't believe that you can OD on pure meth. But mix it with fentanyl, is a deadly killer." **Stimulant supply has changed, leading to higher unpredictability and thus higher risk of overdose** **MA**◊ "The local stuff [meth], it's not so potent, but stuff that does come from down in Mexico is really, really good." **SD**◊ "A lot of good cocaine coming in here…but you got to be careful who you're buying it from… they put everything but the kitchen sink in it." **SD**◊ "You don't know if it's going to be just meth this time or it's going to be meth and something else. And it depends on how they make it, what they put in it because, I mean, literally just about anything you can find under the hood of your car." **SD**◊ "You don't know if you're going to get an ace or if you're getting an ounce of baby powder." **SD**◊ "It's better to know someone who you're getting it from than to get somebody new… It's plenty of people out there [selling drugs], lately. Used to be not that many [dealers], but now it seemed like it did grow." **SD**◊ "Like you don't want to smoke it [meth]….It literally feels like it's burning your face off. It's the chemical breakdown or whatever… I know even the people that are only smokers really smoke now [they inject]...It's hardly not smokable." **SD**◊ "Some people take big doses where [it would] wipe me out if I took... And then they can run into a batch that, it's not weak… and then that'll wipe them out too. Everything you get from everybody ain't the same. You might get some here that are stronger than other different places, from different people." **MA*** "The economic forces of the drug market are driving things in the meth direction. The cheaper synthetics can always outcompete the farm grown products." **Stimulant users are using long-term, thus contributing to and/or exacerbating underlying health conditions** **MA*** "What we see is lots of older people using cocaine. Older Black and Puerto Rican people, but especially Black…Gen X people who were young in the first wave of crack." **MA*** "I am struggling to think of a single person who I have seen in the past few years seen through to stop using… I think that probably that trend of people really just struggling with stimulants is something that carries over across providers." **SD**◊ "My ex-boyfriend, I always tell him if we keep doing it, you're going to end up having a heart attack or stroke because he's got diabetes and he's really getting skinny… he says, 'Well, I'm okay right now [how] I'm doing it.'" **SD**◊ "I don't really think it [supply] changed, it [meth] just eats up some things in your body that you used to feel…you're immune to it now. So, it's going to take you more [to get high]. And sometimes they can get a stone dose and then it'll exceed their heartbeat and take them out." **SD**◊ "I think it has been, using it [meth] a lot. Plus it don't make you eat… Just that their body is getting worse as they're doing it… Can't sleep in. Lack of sleep." **SD**◊ "My friend ended up in the hospital for two weeks. He's got COPD; he was smoking [meth], and he couldn't breathe, and we took him to the hospital, and he was in the hospital two weeks because of that." **MA**◊ "There is no moderation with cocaine and it just seems like you never get enough. Get out and sit up there and smoke it all by yourself, and then you might die… Because you can only do so much of that stuff."