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RESEARCH ARTICLE



Dynamics of prescribing and accessing medications for opioid use disorder: a community-based systems analysis

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ABSTRACT

Background: Although medications for opioid use disorder (MOUD) are effective for treating opioid use disorder (OUD), persistent barriers still prevent patients from accessing this life-saving care. Policies to increase MOUD access have produced suboptimal results. This study presents a qualitative system dynamics model that elucidates the complexities of accessing and staying in MOUD treatment.

Methods: We utilized a community-based system dynamics approach to modeling the MOUD treatment system. We engaged a cohort of system experts/stakeholders, including individuals who had received MOUD, treatment providers, and policymakers, in interviews and group model building to develop and refine a simulation model. We then created a qualitative causal loop diagram based on insights gained while developing the simulation model and a review of interview transcripts.

Results: The causal loop diagram captures four key factors affecting treatment initiation, retention, and leaving: (1) fraught interactions between patients and healthcare providers; (2) stigma-driven regulation of MOUD creating a culture of fear and defensive medicine; (3) a punitive culture in clinics and opioid treatment programs offering MOUD; and (4) the internalization of the abstinence narrative contributing to premature termination of treatment.

Conclusions: Our analysis highlights how interdependent and non-linear feedback processes diminish or counteract the effectiveness and sustainability of MOUD policy interventions. Due to system memory and cultural resistance to change, even rolling back reactionary policies may do little to curb established behavioral patterns. In addition, conflicting and competing strategies among various actors within the system contribute to goal misalignment and a lack of standardization of care.

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Medications for opioid use disorder; community-based system dynamics; opioid use disorder; group model building; opioid epidemic; causal loop diagram

Introduction

The United States faces a continually evolving and unprecedented opioid crisis. Opioid use disorder (OUD) is a chronic but treatable condition characterized by a problematic pattern of opioid use resulting in clinically significant physical and psychological dependence, distress, and impairment (American Psychiatric Association, 2013). There are at least two million people with OUD in the US, according to the Substance Abuse and Mental Health Services Administration (2022), though recent estimates show even higher numbers (CITE) (Lim et al. 2024). OUD is treated with evidence-based medications for opioid use disorder (MOUD). Opioid agonists, such as buprenorphine and methadone, can effectively treat OUD by eliminating withdrawal symptoms and relieving drug cravings (National Academies of Sciences, E. and M, 2019). They also effectively reduce opioid-related mortality (Larochelle et al. 2018).

However, significant issues remain in the MOUD treatment system that hinder treatment uptake and retention. There is severe underutilization of MOUD (Jones et al. 2015). In 2022, only 21.3% of those with an OUD received MOUD treatment (Substance Abuse and Mental Health Services

Administration, 2022). And, of those who initiate treatment, time in treatment is often episodic and less than the recommended minimum of six months (Stafford et al. 2022; Dong et al. 2023). Increasing MOUD treatment initiation and retention is challenging given that the MOUD system is a complex adaptive system involving diverse actors, endogenous factors (i.e. those arising from within the system), and numerous intervention points. Such complexity creates an interdependent system wherein interventions can create unforeseen outcomes (Jalali et al. 2020). Understanding the varied perspectives within this system is vital to creating lasting improvements in care for individuals with an OUD. However, it can be difficult for policymakers to visualize the broader system's various perspectives, goals, and processes.

Several studies have utilized systems science simulation models to investigate the potential impact of increased access to MOUD on fatal opioid overdoses (Savinkina et al. 2022; Chhatwal et al. 2023; Stringfellow et al. 2023). However, while useful in testing interventions and identifying the risk of policy resistance in the system, simulation models are less useful for communicating – verbally or visually – the often thorny and overlapping storylines within the system. A systems science qualitative approach, however,

successfully presents diverse stakeholder narratives while maintaining a system-level outlook.

This study utilizes a community-based system dynamics approach. Community-based system dynamics involves a participatory method that includes stakeholders with diverse perspectives and experiences in understanding and modeling changing systems while centering on feedback loops (compounding relationships between variables) within the system itself (P. Hovmand, 2014). In this study, we: (1) utilized interviews and group model building to uncover the underlying factors involved in prescribing and utilizing MOUD and (2) translated the resulting simulation model into a rich and complex causal loop diagram (CLD) to present these intersecting storylines with a focus on highlighting key feedback processes. Our findings present a sobering picture of how diverse actors' unaligned and competing goals compound to create system-level barriers that ultimately undermine the goal of effective treatment initiation and retention. By utilizing a feedback-based system science approach, we can better identify and visualize the drivers of problematic system behavior, namely, low MOUD initiation and retention. The resulting qualitative model serves as an intuitive and impactful tool to layer perspectives and demystify the broader system-level impact of multiple divergent agendas.

Methods

This CLD was developed as part of a project with the U.S. Food and Drug Administration (FDA) to build a simulation model to support MOUD planning. In the spring of 2022, two GMB workshops were held with 10 FDA staff, including MOUD experts, to define the model scope and goal. They decided to identify levers within the FDA's purview that would facilitate greater MOUD prescribing to support long-term sustainable recovery from OUD. Building on this goal and boundaries, we collaborated closely with several stakeholders outside of the FDA, including treatment providers, policymakers, and individuals who had received MOUD care. These community stakeholders participated in a rigorous and iterative process of individual qualitative interviews and group model building (GMB) to develop a simulation model for policy testing (Rouwette et al. 2002). FDA's goal framed the interviews and the GMB workshop that informed this analysis.

The current study uses the CLD to tell the story that arose during the model-building process. The CLD was synthesized based on insights provided during the interview and GMB workshop and the resulting simulation model, as well as a review of the interview transcripts. The CLD presents how the myriad of structural factors driving treatment initiation and retention interact *via* multiple feedback loops.

Causal loop diagram

Causal loop diagrams are visual tools that depict interactions between system components using feedback loops

(Richardson & Pugh, 1981). A CLD incorporates causal links, where positive links signify relationships with the same directional changes (i.e. an increase in one variable leads to an increase in another variable, and vice versa), and negative links indicate opposite directional changes. These connecting links form reinforcing (R) loops, which amplify trends, and balancing (B) feedback loops, which counteract changes and promote system stability. Stocks (accumulations) and flows (processes and actions that change the value of the stocks) are also utilized to represent population accumulations and movements through the system, respectively (Richardson & Pugh, 1981). The CLD development was an intensive process that involved a detailed analysis of interview and GMB transcripts until the system structure was fleshed out (Gullett et al. 2022).

Participant stakeholder enrollment

The participant stakeholder selection process was purposive to ensure the representation of providers, policymakers, and patients in the MOUD system (P. S. Hovmand, 2014; Yadama et al. 2010; Yuliani & Tasrif, 2006). The research team identified participant stakeholders working in addiction care and harm reduction, and then participants recommended additional individuals. Participants were compensated \$150. The Mass General Brigham institutional review board exempted the study from review.

Study process

After the GMB workshops with the FDA to define the boundaries and goal of the model, the FDA was updated on, but not closely involved in, model development. Thus, the study participants included those who were engaged after the model boundary and goal had been established, but when the structure of the model was still in flux. Nine study participants, including five who had received MOUD treatment, provided input into the model structure through semi-structured individual interviews (each approximately 1.5 hours long) and/or participation in a collaborative GMB workshop (three hours long). Eight of the nine participants were part of the GMB, and one individual who participated in the GMB was not interviewed separately. Group size of 5–15 are common in GMB, where a balance is needed between group heterogeneity and group efficiency, especially for online dialogue (Wilkerson et al., 2020). Interviews and workshops were held virtually using Zoom from November 2022 to February 2023. Verbal notes and audio recordings were taken during the interviews and workshop (Rouwette et al. 2002).

Iterative process: individual interviews, group model building, and thematic analysis

Based on the goal and boundary discussed above, we developed an initial preliminary simulation model with only stocks and flows (no feedback loops) showing patients moving through the health care and MOUD treatment system. The lead facilitator then introduced the preliminary model to the participants to guide discussion and assist in

visualizing the system. During the interviews, participants were asked to provide feedback on the model structure, followed by probing questions to uncover new feedback loops. Based on this input, the lead modeler would then make real-time adjustments on a shared screen.

Following the interviews, participants were invited to attend a GMB workshop to collectively review the simulation and provide additional feedback in a structured discussion-based format with real-time adjustments and refinement. This process allowed participants to review and challenge each other's perspectives on factors affecting MOUD utilization until agreement was reached on the model structure. This iterative process resulted in a detailed and highly complex simulation model.

Finally, the simulation model was translated by the modeling team into a qualitative CLD that could effectively present the rich storylines presented by participants. This process involved reviewing interview and GMB transcripts to continually modify the CLD with a focus on appropriately capturing feedback loops and endogenous (arising within the system) relationships, as presented by participants. While the simulation model emphasizes people moving through the system, the CLD emphasizes the feedback loops found within the narratives of participants. To the extent possible, we use participants' language in the final product. To create a more insightful CLD, we simplified the synthesized diagram and combined related concepts, similar to traditional qualitative coding and analysis approaches.

The findings in the next section are based on stakeholder feedback, reflecting their perceptions of MOUD prescribing and access, with a focus on the feedback loops that emerged during the GMB process. As stakeholders were asked to discuss both their own experiences and those of others, this resulted in general, rather than specific, descriptions of dynamics. Accordingly, we report their language as fact, including in the Figures, in a manner consistent with qualitative research articles where participants' perspectives are presented without citations or qualifications. However, throughout the results section, we will occasionally remind readers that we are reflecting on what was discussed in the GMB workshops.

Additionally, CLDs are developed to aid in conceptualizing simulation models (Sterman, 2000); hence, they are inherently designed with concepts such as stock and flow in mind. If we accept the logical relationship between stock and flow, this reflects a mathematical reality. For instance, if people transition into a state at a steady rate, the total number of people in that stock will still increase over time, as more will accumulate even if the entry rate remains constant, assuming all other factors stay the same. We follow this logic when we report the discussions on stocks and flows.

Results

Initiating treatment

We start with people with untreated OUD and people who are in MOUD treatment at any given time. People with

untreated OUD can enter (inflow) the MOUD 'stock' by initiating MOUD and leave (outflow) when they exit, voluntarily or involuntarily, from MOUD treatment without having achieved remission (Figure 1). While some people exit treatment in remission, they are not the focus of the current model. We assume a closed system in which there is no new development of OUD. The structure presented in Figure 1 depicts patients not meeting a clinical definition of success, when they exit treatment without remission. However, as we discuss below, participants' definition of success is more nuanced.

One key balancing loop drives MOUD initiation, labeled **B1: Treatment needs are met** (Figure 2). As the number of people with untreated OUD increases, their contacts with healthcare systems are also expected to increase. With greater contacts, referrals to treatment rise, increasing the flow of MOUD treatment initiation. As more people initiate, people in MOUD treatment increase, which decreases the number of people with untreated OUD, thus creating a balancing loop. However, as more patients enter MOUD treatment, capacity constraints will emerge unless capacity is increased. Assuming capacity cannot increase indefinitely, capacity constraints will emerge, leading treatment initiation to eventually fall and untreated OUD to slow its decline (**B2: Current patients reduce availability for future patients**).

Figure 2 shows the process of patients entering treatment and how the system may react to this increase in treatment utilization. However, MOUD treatment constitutes a complex adaptive system (Jalali et al. 2020) with many more interacting factors. Based on interviews and GMB insights, we identified four key factors that interact with these balancing loops by either decreasing the initiation rate or increasing the exiting without remission rate, often resulting in undermining the 'treatment needs are met' loop. These four factors identified by participants are (1) fraught interactions between patients and healthcare providers; (2) stigma-driven regulation of MOUD that creates a culture of fear and defensive medicine; (3) a punitive culture within clinics that offer MOUD, including opioid treatment programs; and (4) the internalization of the abstinence narrative contributing to early termination of treatment. We discuss these four factors in detail below. We highlight how the goals of patients, policymakers, and clinicians are misaligned and can lead to

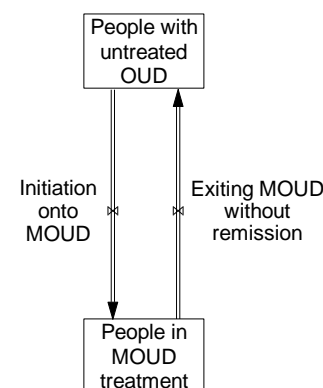


Figure 1. Stocks of individuals with OUD entering and exiting (flowing) between being untreated and being on MOUD.

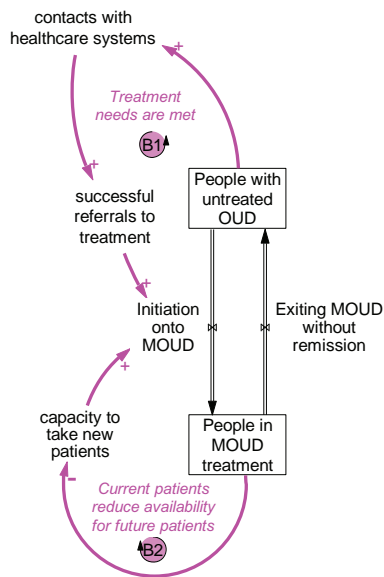


Figure 2. When treatment needs are met, untreated OUD decreases but capacity constraints arise.

The links establish a connection between two variables, where the direction of the arrow represents which variable impacts the other. The polarities ('+' and '-' signs on the arrows) indicate the relationship, showing whether an increase or decrease in one variable will affect the other variable in a similar or opposite manner, respectively. A series of links that begin and conclude with the same variable form a loop, which can be balancing, as represented in the figure marked with 'B'. Numbers following the letter indicate the order loops are described in the article. In a balancing loop, a change in one variable leads to changes in subsequent variables in the loop in such a way that the final effect counters the initial change. While flows do not have link polarity symbols, they do play a role in determining whether the loop is balancing or reinforcing. In this context, an outflow decreases the stock where an inflow increases it.

more episodic care, involuntary or voluntary premature discharge from treatment, and dissatisfaction with treatment.

Fraught patient-healthcare provider interactions: opportunity or deterrent?

When patients exit treatment without remission, this can lead to unintended consequences, undermining the **B1** loop. As more people leave treatment without remission, this increases the number of individuals with untreated OUD. As clinical staff in various healthcare settings more frequently see the chaos that can be associated with untreated OUD, participants described how this reinforced preexisting stigma toward people with opioid use disorder (PWOUD) (reinforcing loop **R1: Pessimism about OUD traps people with OUD**) (see Figure 3). (In interviews and the workshop, stigma was often discussed as the perception that PWOUD are either untrustworthy, troublesome, or incurable, so we use this language to be specific about how it manifests in these circumstances and to distinguish it from other forms of stigma, like self-stigma.)

This negative perception of PWOUD can then decrease successful referrals to treatment:

You can mandate all you want, but you'll end up with a bad mandate because if people don't believe in it or don't want to do it, they will do it but to the lowest denominator and not actually try to make it successful.

With fewer successful referrals to MOUD, there are more people in the population with untreated OUD.

The pessimism about OUD may extend to all PWOUD, such that they are seen not as individuals, but as representatives of a group of people who are collectively untrustworthy, troublesome, or incurable: "Oh, you are just one of those people, and this is what you do," ... without really trying to make an attempt to get them help'.

In addition to this loop, participants noted that overdose fatalities seem to lead to greater presence of law enforcement in medical facilities, blurring the lines between law enforcement and health care:

[T]here is more surveillance because more people are dying. Anytime you have people dying and the hospitals are flooded [...], they want to keep order. I think it is connected to people feeling pressure to reduce death.

This was perceived as a factor that can increase the pre-existing PWOUD distrust of health care settings and increase the possibility of them leaving against medical advice, which further contributes to the perception that PWOUD are untrustworthy, troublesome, and/or incurable.

Thus, more frequent contact with the healthcare system may not always produce effective treatment referrals if the medical facilities feel like a route to criminalization, stigma, and mistreatment for PWOUD. However, leaving against medical advice or having frequent contact with the healthcare system can frustrate medical providers, leading to more stigma and thus fewer genuine efforts to connect people to MOUD.

Yes, this pessimism is further increased by more frequent contacts as well as people leaving against medical advice. I think you do that a couple of times, and there is an assumption made, right or wrong, that you don't care.

Stigma-driven regulation of MOUD that creates a culture of fear and defensive medicine

More people with untreated OUD means could result in more fatal overdoses. Participants reflected that the increase in overdoses, in turn, may increase fear-driven public health surveillance. This was described as rushed policy implementation driven by intense emotion or uncertainty surrounding the public health crisis. Within the realm of the opioid epidemic, participants believed this has led to the development of strict DEA regulations in parallel and the use of 'red flags for diversion' (when people who are prescribed it give it away or sell it to others) language by medical boards and regulatory bodies. Providers and pharmacists subsequently express liability concerns regarding buprenorphine diversion (see Figure 4) and may engage in defensive medicine:

Pharmacists will refuse to stock or refuse to fill [...] these life-saving medications because of DEA limits and concerns around contributing to diversion [...]. They are so driven by their fear of regulatory action against their license and the pharmacy that they view everything through a diversion-first lens instead of a patient-centered perspective.

With providers and pharmacists participating only reluctantly, if at all, access to treatment decreases and thus the MOUD initiation rate falls, ultimately contributing to more fatal overdoses (reinforcing loop **R2: Reactionary policies reduce access**).

Fraught interactions between patients and healthcare providers

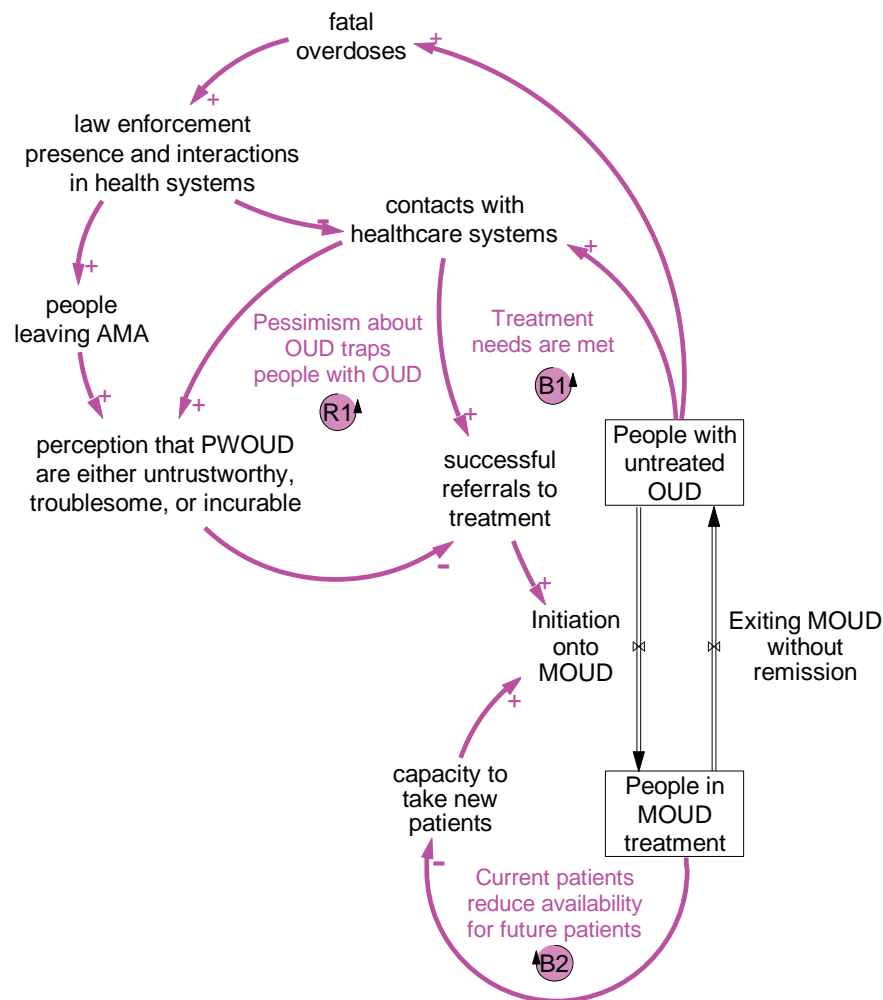


Figure 3. Fraught patient-provider interactions within the healthcare system hinder initiation to treatment.

A loop can also be reinforcing, as represented in the figure with 'R'. In a reinforcing loop, a change in one variable leads to changes in subsequent variables in the loop in such a way that the final effect amplifies the initial change. AMA: against medical advice.

When providers use defensive medicine, thereby limiting access to MOUD treatment, participants described how this could increase the demand for diverted medications.

We do not have enough treatment, and we have people accessing a drug that makes them live longer from people who are privileged or lucky enough to be able to access it themselves in a somewhat consistent fashion.

Ironically, therefore, fear of diversion can lead to actual diversion, which only serves to amplify liability concerns (reinforcing loop **R3: Restricted MOUD access increases diversion**).

Participants frequently mentioned the effect of stigma on access. For example, among providers and pharmacists deciding whether to offer buprenorphine care, stigma can manifest either by outright refusing to participate in MOUD care, or by using regulations as an 'excuse' not to participate, when in fact stigma is likely at play. Provider and pharmacist stigma can decrease the rate of initiation, which increases contacts with the healthcare system by untreated PWOUD, and can,

therefore, reinforce stigma (i.e. the perception that they are untrustworthy, troublesome, or incurable) (reinforcing loop **R4: Stigma drives defensive medicine**).

Punitive clinic culture: an impediment to treatment retention

Here the CLD shifts from factors that primarily obstruct treatment access and initiation toward those that hinder retention. A punitive clinic culture is unappealing and burdensome for patients, potentially leading to more sporadic and short-term treatment. The term 'punitive' was used by participants to describe clinics' use of punishment when patients fail to meet their high compliance expectations. Expectations can include requiring frequent office visits or urine screenings and regular attendance at group therapy. Participants said that when patients fail to meet these expectations, providers may respond by reducing their dosage, requiring more frequent office visits, or premature discharge. Participants believed this culture is likely to continue

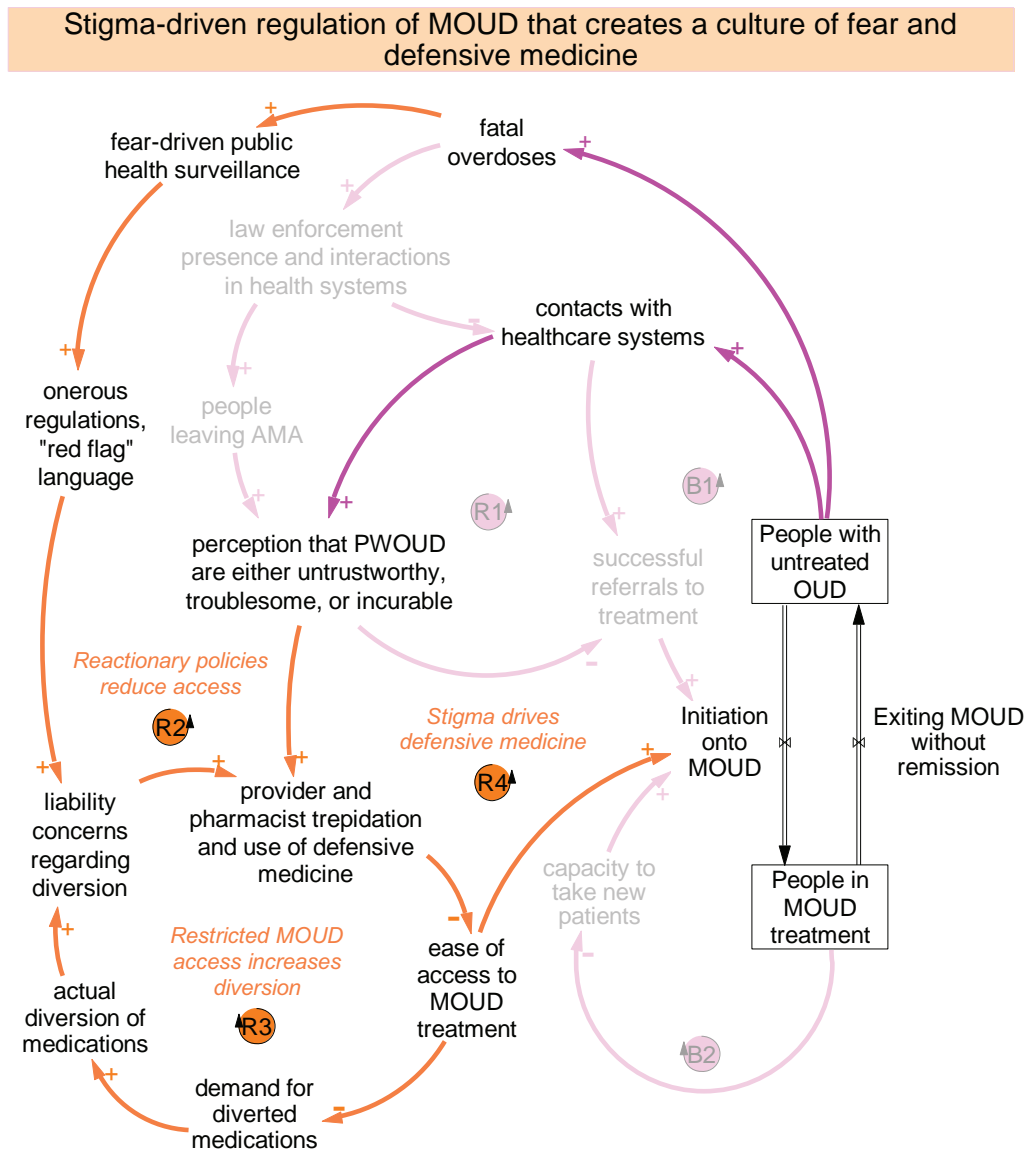


Figure 4. Liability and diversion concerns may increase the use of defensive medicine on the part of prescribers and pharmacists.

even if proposed changes to federal methadone regulations are changed:

It's not just if those regulations [codifying the flexible take-home doses so that a patient could get up to 7-day doses in the first 14 days that they join the opioid treatment program (OTP) (SAMHSA, 2022)] actually get finalized and adopted, but it's also how do we change the culture in the OTPs that they honor and listen to the evidence [which says that] if you are less stable you can get up to 14 doses and if you are more stable you can get up to 28 doses.

Specifically, even though punitive practices are not evidence-based, clinics may reinforce this culture by hiring like-minded individuals or by training new staff in the existing culture (see [Figure 5](#) reinforcing loop **R5: Punitive culture is passed down**).

Many PWOUD continue to use drugs, including opioids and stimulants, even after they initiate MOUD treatment (Krawczyk et al. 2021). However, ongoing street use is at odds with clinics that have high expectations of abstinence;

any ongoing drug use will likely be interpreted as failure to comply. (Note that a reduction in ongoing street use is one way that we incorporated participants' view of success in treatment into the model structure, with its emphasis on harm reduction rather than abstinence.)

Nonetheless, failure to comply with clinic rules can be met with punishment including reducing or temporarily withholding the MOUD dose. As more patients have their medication dose reduced, the average gap between the physiological needs of patients and the doses they receive increases, potentially leading to more ongoing street use, including of illicit opioids, which increases the likelihood that compliance expectations are not met, reinforcing the use of punishment for failed compliance (reinforcing loop **R6: Unrealistic patient expectations**): 'They are punishing people mostly because people are testing positive for other drugs and opioids, but they can't stop using until they are on a stable dose'.

Besides reducing doses, participants noted punishment might include premature discharge. Alternatively, the

A punitive culture within clinics that offer MOUD

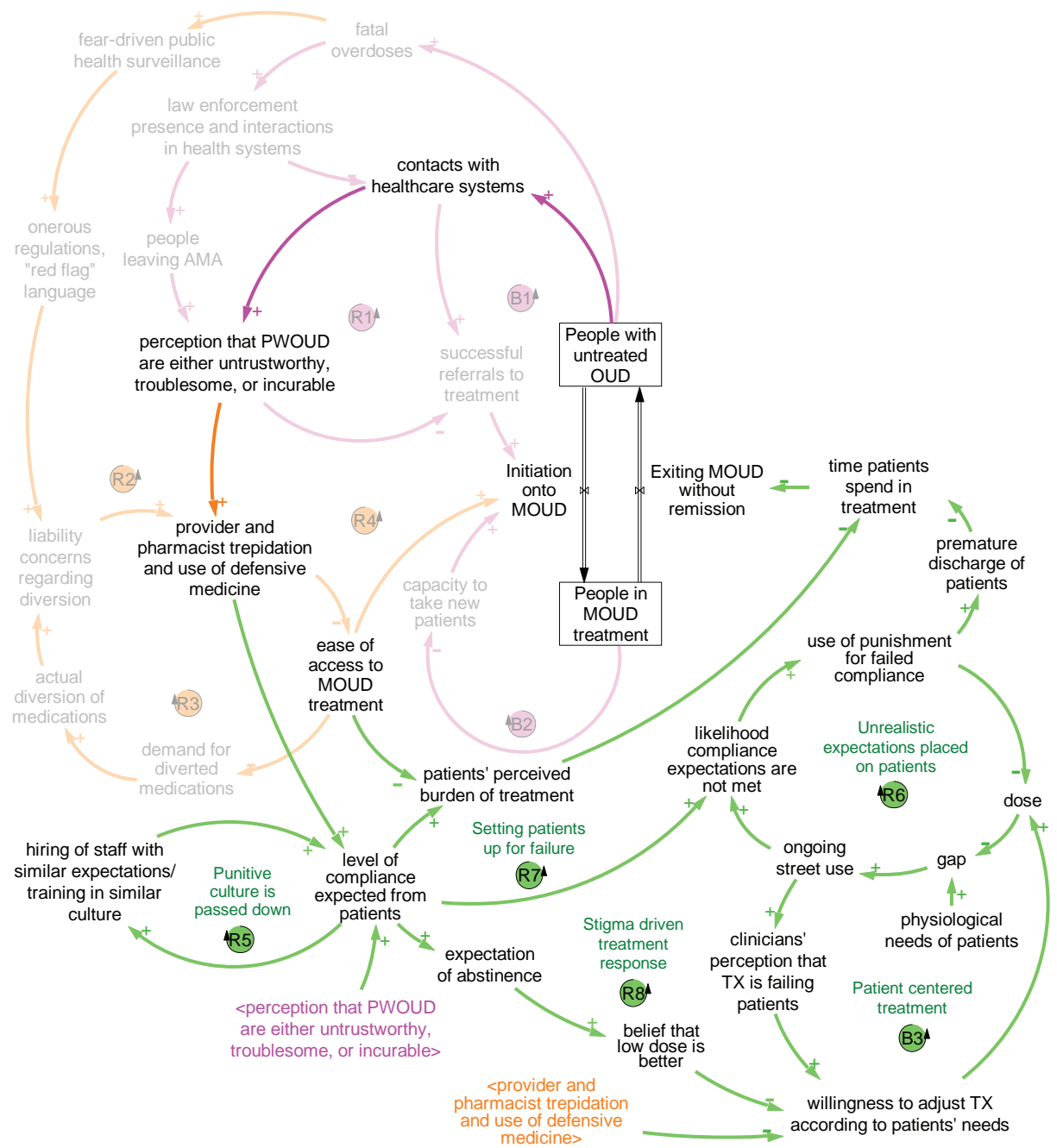


Figure 5. A punitive culture reduces evidence-based care and can increase discharge.

punitive culture itself could become so burdensome that patients leave treatment even if they would prefer not to. In both situations, high levels of compliance expectations (or what participants called a ‘punitive culture’), through various pathways, can eventually contribute to an increase in the population of people with untreated OUD.

However, participants described how other providers offer low-barrier care that does not require abstinence. These providers tend to have lower expectations of compliance, which reduces the expectation of abstinence and the

belief that a lower dose is better. Their approach, instead, is to provide low-threshold patient-centered care, which is more flexible and aimed at meeting patient needs. Providers in these clinics are more likely to interpret any ongoing drug use as an indicator of unmet physiological needs, making them more willing to increase the dose. Participants noted that as the average dose prescribed increases, the gap between dose and physiological need decreases. The logic of the model structure suggests this could lead to less supplementation with street opioids – either due to fewer patients

supplementing or because less of their dose is supplemented. (However, we do not account for all factors that might lead to patients continuing to use, including simply wanting to do so.) As patients' physiological needs are met, fewer providers perceive that treatment is not working, creating a balancing loop (balancing loop **B3: Patient-centered treatment**) that can offset, on a population level, R6.

However, to the extent that R6 ('unrealistic patient expectations') is stronger than B3 ('patient-centered treatment'), more people are likely to leave MOUD treatment without remission from OUD. More people with untreated OUD leads to more of them having contact with the healthcare system which, as mentioned previously, can increase the perception that individuals with OUD are untrustworthy, troublesome, or incurable, thereby potentially reinforcing the increase in provider and pharmacist trepidation, use of defensive medicine, and higher compliance expectations that are unlikely to be met. All of this perpetuates loop R6 and creates an even larger reinforcing loop that involves patients both in and out of MOUD (**R7: Setting patients up for failure**). Likewise, **R8: Stigma driven treatment response**, is also triggered when these higher compliance expectations and expectations of abstinence are reinforced *via* defensive medicine. Abstinence expectations can reinforce the perception that a lower dose is better, potentially decreasing providers' willingness to increase doses even when patients' physiological needs are not being met. As too low a dose may increase patients' likelihood of ongoing street use, high compliance expectations are not met and punishment for failed compliance likely ensues, yet another perpetuation of loop R6. Loops R7 and R8 present a reinforcing effect where patients are continuously cycling in and out of treatment, leading to more untreated OUD and reinforced stigma.

Abstinence narrative

When patients stay in treatment and start to see improvements in their stability and quality of life while on MOUD (another part of the definition of treatment success according to participants), they may express a desire to taper off. This desire can be driven by internalized, intervention, and provider-based stigma (Madden, 2019) as well as 'absorption' of a prevalent abstinence narrative that permeates our society and can come from many sources:

Often the stigma that they have towards the medication is one that they have internalized from someone else having stigma and talking to them about it, including a medical provider, a nurse, a family member, the Narcotics Anonymous, and the Alcoholics Anonymous. You hear it all the time from people trying to stop using, 'Well I don't want to take another drug just to deal with my use'.

Whether individuals and providers espouse the abstinence-based narrative or that of long-term treatment, they may inadvertently impact the length of time a patient may want to stay on treatment (see Figure 6).

As individuals spend more time in treatment, they notice improvements in stability, which can increase the likelihood of leaving treatment because they do not want to be on 'another drug'. (balancing loop **B4: Positive outcomes can make patients feel ready to leave treatment**):

We have created [a] situation that people stigmatize themselves for being on a medication that actually works.

[P]eople always think in the beginning, 'Oh, I will just get better, and then I will leave because I don't want to be on this thing for the rest of my life', and there are those [external] pressures to leave. But then you get on it, and you drop out, and you immediately relapse (which happens 90% of the time, at least within 6 months), and eventually [...] you realize that leaving doesn't work and [...] decide to stay on treatment.

Thus participants described that it is often only over time and potentially many episodes of treatment, that many PWOUD are able to stay in long enough to not only see their stability improving, but also to focus on long-term goals (a primary aspect of participants' definition of success), making them more likely to attribute their success to treatment, which decreases the desire to quit MOUD (reinforcing loop **R9: Positive outcomes make patients decide to stay in treatment**).

Discussion

By integrating the perspective of stakeholders with varying viewpoints on the system, we identified four critical factors affecting the use of MOUD: (1) fraught interactions between patients and healthcare providers; (2) stigma-driven regulation of MOUD that creates a culture of fear and defensive medicine; (3) a punitive culture within clinics that offer MOUD, including opioid treatment programs; and (4) the internalization of the abstinence narrative contributing to early termination of treatment.

We described the interactions between these factors and highlighted how the combined effect of stigma, criminalization, and reactive regulations can sow seeds of distrust between providers and patients, diminishing treatment initiation and, even when it is started, leading to defensive medicine and episodic care. Also, we discussed how the internalization of the narrative of total abstinence by patients and providers, which also coincides with punitive policies in MOUD treatment, can reduce treatment retention and thus hinder patients' long-term stability. Additionally, we reflected on the varying goals for using MOUD and definitions of abstinence create a system filled with conflicting ideological viewpoints and an inflexibility in care that makes MOUD unappealing. By utilizing punitive methods that prioritize total abstinence as the principal goal, providers potentially run the risk of perpetuating intervention stigma (Madden, 2019) and can deter all except the most desperate or determined from treatment. And though not highlighted in this model, discrimination and racism could strengthen the vicious reinforcing feedback loops – or weaken the helpful balancing feedback loops such as patient-centered care – thus reinforcing disparities in treatment outcomes for minority patient populations.

Stigma toward people with OUD and resulting security within hospital, clinic, and pharmacy settings have the potential to increase criminalization and distrust and deter patients from interacting with these essential points of contact. Strict regulatory oversight of and dispensing restrictions regarding MOUD creates regulatory barriers that limit access

chaotic or unmanageable use. These individuals may never desire complete abstinence and, as such, continue to use other substances such as cannabis, stimulants, or other opioids. This, however, is misaligned with the clinical goals in abstinence-based settings with high expectations of compliance. MOUD patients' co-use of opioids with stimulants like methamphetamine and cocaine often leads to inappropriate denial of and premature discharge from MOUD treatment (Tsui et al. 2020; Ware et al. 2021) while also decreasing engagement in treatment and increasing the risk of relapse to opioids (Frost et al. 2021; Cook et al. 2023). For these individuals to engage in treatment, they may constantly bounce from one clinic to the next until they can find a treatment option that aligns with their immediate goal of less use rather than abstinence. Some may never find such an option near them and choose to remain out of treatment altogether. Participants argued that even patients attempting to stop illicit use entirely could be deterred by abstinence-based, high compliance clinics as these providers may reduce dosing as a punitive measure. These high compliance expectations can result from the perception of PWOUD as untrustworthy or incurable, as well as legal liability fostering defensive medicine. Consequently, patients are not stabilized, may continue to have cravings, and potentially begin to supplement with illicit drugs. Stakeholders, particularly those with lived experience, explained that patients are then more likely to leave or be prematurely discharged from treatment, as continuing to use illicit drugs becomes the easier, less complicated option than staying in treatment. It may be the safer option as well, as recent research suggests that PWOUD who receive abstinence-only treatment are more likely to die than people who receive no treatment at all (Heimer et al. 2024).

Others, especially those who have internalized the abstinence narrative, may use MOUD short-term with the expectation that they can quickly taper off while preventing relapse or return to disorder. However, long-term MOUD retention is associated with better outcomes (Hser et al. 2016; Larochelle et al. 2022; Stafford et al. 2022). Termination before fully benefiting from MOUD treatment can lead to an elevated risk of relapse and limit improvements (Wakeman et al. 2020; Golan et al. 2022). These benefits include reduced risk of overdose, immediate improvements in cravings, and the ability to focus on long-term goals, such as finding employment or regaining custody of their children (Substance Abuse and Mental Health Services Administration (SAMHSA), 2021).

While the four overarching factors are important when analyzed separately, they do not operate in silos. Without clear understanding of how conflicting feedback loops interact, unaligned and competing system goals will ultimately undermine policy effectiveness. For instance, if we were to remove stigmatizing regulatory language we might expect a decrease in the use of defensive medicine. However, this does not overcome the damage already introduced to the system through the initial implementation of such guidance (i.e. the system has a memory). Even removing them now may do little to curb defensive medicine and these

behavioral patterns among prescribers and dispensers may continue. Going forward, instead of fear-driven public health surveillance in response to fatal overdoses, policymakers could instead take measured steps to assess the potential policy effect on the system prior to implementation including through the use of system dynamics models. In this case, at least two loops would be removed entirely (**R2** and **R3**), which include the use of defensive medicine. While this would not undo the past damage, tempered responses could mitigate future damage that fear-driven policies cause further downstream in the healthcare system.

Reducing the use of defensive medicine could lead providers to rely less on high compliance expectations to mitigate legal liability. Currently, providers remain pulled in three directions: toward the aims of policymakers and regulators, the patient's needs and desires, and their own inherent bias and opinion on treatment. The conflicting objectives – such as patients working toward stability, whether or not that includes abstinence, and many providers and policymakers working only toward abstinence – inform the behavior of actors within the system. Without goal alignment, standardization of care cannot be established, and it becomes more episodic due to involuntary, punitive discharge from treatment, or patients choosing to leave because of the punitive culture. This culture arguably presents the most significant obstacle to low-barrier care as it cannot simply be educated or mandated away but instead requires an ethos shift.

Our model builds upon previous addiction research by engaging diverse stakeholders to understand better the factors that impact improved MOUD initiation and retention. In particular, we approach the assessment of MOUD as a system itself and not just as an intervention within the broader opioid epidemic. While several simulation models have been developed to identify interventions to reduce opioid overdoses or improve MOUD utilization, our study attempts to present the varying perspectives within the MOUD system using collaborative modeling and presented in CLD format.

This study has limitations. First, despite our efforts to include stakeholders from diverse backgrounds, we did not adequately reach minoritized people. Structural racism could introduce additional feedback loops related to racial inequities in access, initiation, and retention to treatment. In addition, certain stakeholder groups are missing within the model, including people from the criminal justice system, lawmakers, or individuals who identified strongly with the abstinence-based, high compliance orientation that was frequently spoken about. Lacking this perspective, there could be additional insight that would point to novel intervention points that we missed. As the findings are based on input received from the individuals who participated in the current study, they cannot necessarily be generalized beyond this sample. A different set of participants could have resulted in a different model, with different foci. For example, as the participants with lived experience had more often received methadone treatment, experiences unique to buprenorphine might have been missed. Furthermore,

certain factors, such as mental illness, homelessness, social determinants of health, and polysubstance use, were discussed during the interviews and workshop, but added significant detail and visual complexity to the CLD without fundamentally altering the dynamics that make MOUD treatment difficult to initiate and stay in. For instance, mental illness and homelessness exacerbate the stigma experienced but do not change the direction of influence. The connections presented do not exhaust all possible links that could exist between parameters in the CLD.

Despite these limitations, this study still provides valuable insight into how beneficial changes in the system are undermined by obstinate negative feedback processes. This presents an example to policymakers of how mitigating actions, which appear sensible in isolation, might produce contradictions when interacting with other system-level factors. When presented with the complexity of the MOUD system's many interacting feedback loops, it is understandable why barriers persist regarding treatment uptake and retention. This highlights the importance of a community-based systems approach to provide a comprehensive picture of competing dynamics.

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