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Realistic Computational Modeling of Human Trafficking Requires Lived Experience Experts

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ABSTRACT

Computational approaches offer much promise in human trafficking research. Yet, computational approaches are only as good as the assumptions and data behind them. If divorced from grounded domain expertise, models run the risk of fuzzy conceptualizations, overgeneralizations, and use of unreliable data. This article describes how our transdisciplinary team of engineers, social scientists, and survivor-centered research partners combine our expertise to identify accurate conceptualizations, practical assumptions, limitations, and data needed to create mathematical models of sex trafficking recruitment and network operations. Even well-meaning research can cause harm if an inaccurate, partial or misleading interpretation of human trafficking data and results is used to shape policy. We make the case for the value of lived experience expertise to develop computational models of human trafficking that are realistic, practical, and use-focused so they can drive policy and practice.

KEYWORDS

Community operations research; lived experience expertise; transdisciplinary research; sex trafficking

Introduction

Computational approaches for analyzing illicit, hidden networks are emerging as potentially powerful tools to help in efforts to disrupt trafficking networks (Anzoom et al., 2021; Bright et al., 2021; Caulkins et al., 2019; Dimas et al., 2022; Gore et al., 2023; Keskin et al., 2023; Sharkey et al., 2021). While these approaches offer exciting new possibilities for transformative change, caution is needed. Computational models are only as good as the assumptions and data used to develop them. While the field of human trafficking research has made many advances over the last two decades, there is either a dearth of the kinds of data needed to populate computational models (Zhang, 2022) or doubts on whether existing data sets used by computational researchers are representative of human trafficking. For example, there is an emerging body of literature on computational approaches to analyze scraped commercial sex ads (Dubrawski et al., 2015; Freeman et al., 2022; Keskin et al., 2021; Ramchandani et al., 2025). Yet, there is a growing consensus of concern that indicators in sex ads once thought to be linked to sex trafficking are not truly indicators (Lugo-Graulich et al., 2024) and that there may be very limited connections between sex ads and sex trafficking (Giommoni, 2024).

In this paper, we show how inclusion of lived experience experts as research partners can help overcome significant challenges in creating analytics and computational modeling for sex trafficking.

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In this, we join a call from many others, including survivor-leaders (Ash & Otiende, 2023), to include lived experience expertise in research. Our team of industrial engineers from operations research (OR), social scientists, and survivor-centered research partners (the majority of whom identify as survivor-leaders) have worked together for more than seven years to articulate accurate conceptualizations, practical assumptions, limitations, and data to create computational models of recruitment into and operations of sex trafficking networks. To the best of our knowledge, we have produced the first collection of OR models (and, in general, computational models) that have been created through the inclusion of survivor-leaders *throughout the research process*. This paper contributes to the literature by going beyond a call for inclusion to showing *how* these models became more authentic and practical through a transdisciplinary approach designed for substantive and meaningful inclusion of survivor-centered research partners.

Even well-meaning research and action can cause great harms if based on fuzzy conceptualizations, overgeneralizations, or unreliable data. Given the complexity and range of experiences in human trafficking, an incomplete picture presented as fact can lead to ineffective policies that waste money and effort or even cause harm. Domain expertise from social scientists and practical expertise from those with lived experience as victims and survivors of trafficking should be at the heart of computational modeling and analytics to contextualize models of human trafficking and identify limits and gaps (Sharkey et al., 2021). Yet, people with lived experience, who have necessary expertise, are often excluded from research design and not seen as “experts.” Too often, research in computational communities (e.g., machine learning/artificial intelligence, operations research, analytics) runs ahead of deep contextual understanding which necessarily takes time. Further, the complexity of real-world exploitation and trafficking experiences often conflicts with the abstraction required to create models. Our experience shows the value in slowing down to take time to build multidisciplinary teams that equally value different types of expertise (Martin et al., 2022) and highlights how knowledge generation and research is much better with the inclusion of lived experience experts, if done in an ethical manner. Lived experience experts are coauthors on this paper.

Through this paper, we hope that more computational researchers will seek different, often marginalized, sources of expertise in ways that value and respect these critical knowledge-holders and their unique insights. Likewise, we urge human trafficking researchers to be a little more skeptical about flashy algorithms and computational models that are not grounded in the realities of trafficking. Finally, we hope to help show how important the inclusion of lived experience expertise is to human trafficking research and demonstrate that it is time for academic researchers to move beyond using lived experience experts solely as research subjects, which continue to view them through the lens of their victimization.

Background and Literature Review

Our research methods and results bring together the importance of lived experience expertise in sex trafficking research and computational modeling of sex trafficking. In this section, we provide background information and a literature review in each of these areas.

Lived Experience Expertise in Human Trafficking Research

The main idea to bring computational approaches from other fields (e.g., engineering – see Caulkins et al., 2019 or artificial intelligence – see Deeb-Swihart et al., 2022) to help address human trafficking is part of the overall trend in academia to address “wicked problems” (Rittel & Webber, 1973). This type of work requires grappling with an inherent tension between modeling, which requires abstracting real-world phenomena to explain and identify insights, and the reality of the social world, which is inherently uncertain, complex, and unpredictable. Transdisciplinary thinking goes beyond interdisciplinary thinking by integrating knowledge *and* methods from different fields, rather than working in side-by-side silos (Lotrecchiano & Misra, 2018; Martin et al., 2022). A transdisciplinary approach is ideal for

creating computational models for human trafficking networks since it allows for domain experts to understand how the models are conceptualizing the operations, building models, and gathering data and allow computational researchers to do these with a grounded knowledge of the domain. However, transdisciplinary research currently tends to focus on integrating *academic forms of knowledge*.

A stronger approach to address the challenges of building computational approaches for human trafficking, which has been advocated for within academia (Deeb-Swihart et al., 2022; Konrad et al., 2023; Sharkey et al., 2021) and outside of it (Boyd, 2022) is to co-create models based on lived experience expertise. This expertise can provide unique insights into the potential unintended consequences of interventions into human trafficking networks and the impacts that computational models may have on those that have experienced trafficking. From a survivor-leader perspective, Boyd (2022) describes concerns about tech created without survivor-informed approaches, stating that “tools created with trafficking survivors are exponentially smarter and more effective than without us” (Boyd, 2022, paragraph 14). Similar concerns are raised by survivor-leader Mull (2023) about individuals entering the anti-trafficking space: “What’s more disconcerting is unqualified individuals consistently inserting themselves into the anti-trafficking movement due to fleeting motivations, such as being moved by a movie” (Mull, 2023, paragraph 4).

Within academia, there is a concerted call for engaged scholarship to make research more responsive to and impactful in real-world applications (Boyer, 1991; Holland & Malone, 2019; Sandmann & Jones, 2023). In this vein, we advocate moving well beyond viewing those with lived experience solely as research subjects or only included to provide feedback on the results of the research, after academics conduct it. Human trafficking research should meaningfully engage people with lived experience expertise as research partners who contribute to *all phases* of the project to enhance applicability, reliability, and accuracy. This meaningful engagement throughout the computational modeling process is a cornerstone of the field of *community operations research* (Johnson, 2011; Johnson et al., 2018). Inclusion of lived experience experts as equals in research teams requires careful attention to process, broadening the notion of expertise, and specific strategies to recognize and equalize power dynamics (Beaulieu et al., 2018; DeJonckheere et al., 2019; Gerassi et al., 2017; Martin et al., 2022; Tuhiwai Smith, 2012; Wallerstein et al., 2019). This approach is commonly referred to as community-based participatory research (CBPR) (Israel et al., 2013) or action research (AR) (Bradbury, 2015).

An emerging consensus suggests that participatory approaches are particularly salient for enhancing implementation science (Sánchez et al., 2021), advancing public health (Ortiz et al., 2020), and expanding equity and impact of research to improve the lives of people (Brush et al., 2020). Our approach is broadly participatory. We believe that a promising approach to create computational models for sex trafficking is to do so in a community-engaged, transdisciplinary manner in close, ongoing partnership with people with lived experience (Martin et al., 2022). In this paper, we present concrete evidence of the improvements to computational models that resulted from this type of research approach. Given the mixing of computational modeling (that is, by its nature, quantitative) and community-engaged research (which often involves qualitative methods and data), our research approach is mixed methods (Creswell & Plano Clark, 2018). Lived experience expertise has significantly helped to provide context and nuance to computational models, while also helping to collect and analyze quantitative data used to populate models. Therefore, our approach integrates lived experience expertise into mixed methods research.

The inclusion of lived experience expertise into computational modeling follows the emerging trend in the broader field of human trafficking research of including lived experience experts as research partners. Martin et al. (2022) provide a framework to build trust among teams of academic researchers and lived experience experts in order to conduct research on disrupting human trafficking operations. Ash and Otiende (2023) and Balch and Kiconco (2023) provide frameworks to ensure meaningful and equitable engagement of those with lived experience expertise in human trafficking during research projects. Keighley et al. (2023) provide best practices in terms of engaging with lived

experience experts as research partners and emphasize the need to continually adapt research methods to meet the needs of those with lived experience expertise.

Computational Modeling of Human Trafficking

Computational models of human trafficking require three critical ingredients (1) proper conceptualization and framing of trafficking, (2) accurate assumption-building of the proposed models, and (3) reliable data to use for analysis. We refer the interested reader to Morris (1967), Willemain (1994, 1995), Pidd (1999), and Hillier and Lieberman (2015) for an overview of the modeling process in these three areas and Sharkey et al. (2021) for the importance of domain expertise in these steps for computational modeling of human trafficking applications. Proper conceptualization requires contextual knowledge of the phenomena to provide the appropriate scope and scale of the piece of the problem to be addressed with the model. The possible impacts of such models are dependent on the underlying assumptions used to create them. The quality of the resulting analysis depends on the extent to which the collected data is representative of the actual properties of the illicit network. In other words, a computational model is only as useful as the conceptualization of the problem that led to its creation and the authenticity of its assumptions. Analysis using a computational model is only as accurate as the available data allows. There are challenges in each of these three critical ingredients that must be overcome to create effective and impactful computational approaches for disrupting human trafficking.

On Proper Conceptualizations and Assumption-Building. Konrad et al. (2023) argue that for OR, a type of computational modeling, to responsibly create models to help address human trafficking, survivor-informed approaches are critical, but does not explain how including lived experience expertise influences OR models. A similar argument appears in Deeb-Swihart et al. (2022) for designing artificial intelligence methods for disrupting sex trafficking networks; yet that paper also does not illustrate exactly how the inclusion of lived experience expertise can be done and how it influences computational approaches. Therefore, there is a need for research methods, like ours, that can incorporate such expertise into computational modeling. Our research belongs to the field of community operations research (Johnson, 2011; Johnson et al., 2018; Midgley et al., 2018), which is a field where OR is applied with meaningful engagement with the community most impacted by the models and/or research. Johnson et al. (2018) discusses that an important new frontier for community OR is “big and difficult data” (Johnson et al., 2018, p. 1186), especially in situations where there is a “lack of consensus on sources, variables, and uses of data” (Johnson et al., 2018, p. 1186). There is a significant gap in terms of reliable data on sex trafficking, and we would further argue that there is a lack of consensus on when certain modeling choices and assumptions are applicable to the nuances of a particular type, setting or context of sex trafficking. Therefore, we believe that community OR with lived experience expertise is necessary to help capture the nuances of sex trafficking. Examples follow with respect to limited (or improper) conceptualizations and assumption-building in the context of computational modeling of human trafficking.

Related to conceptualization, a particular computational model may only address a narrow set of human trafficking operations while failing to acknowledge the limitations. For example, Keskin et al. (2021) provide analytics to understand movements and circuits of individuals selling sex on commercial sex websites. Keskin et al. (2021) highlight that some individuals may have elected to participate in sex work and discuss how law enforcement (at the time) stated,

It is effectively impossible, short of interviewing the victim and establishing the facts of their statements, to determine whether an individual is offering services voluntarily or a victim of trafficking. As a result, they approach each case as a potential instance of sex trafficking. (p.1113)

From a conceptualization perspective, Giommoni (2024) makes a strong case that there are limited opportunities to learn about sex trafficking through the analysis of commercial sex ads. Even if one disagrees with the arguments of Giommoni (2024), the work of Keskin et al. (2021) does not discuss

the types of sex trafficking operations that would consistently post ads on websites, an important conceptualization that provides nuance to the types of operations their analysis most impacts. For example, closed-buyer operations would not post ads since their set of buyers is identified through careful vetting. Lived experience expertise could help to better classify the types of operations where the methods of Keskin et al. (2021) are applicable.

Related to the use of commercial sex ad data, Ramchandani et al. (2025) seek to produce analysis of recruitment-to-sales pathways using data collected from the deep web, which is part of the web that is unindexed by traditional search engines (e.g., Google). They use commercial sex ad data as the sales data and, therefore, the arguments of Giommoni (2024) also apply to their data. They then use potentially deceptive non-sexual recruitment offers (e.g., modeling jobs), posted on the same commercial sex websites as the ads for commercial sex, as the recruitment data. Ramchandani et al. (2025) define potentially deceptive to mean entities (e.g., phone numbers) that post these non-sexual recruitment offers and also post ads selling commercial sex. The authors relay:

One may not a priori expect that significant recruitment activity occurs on websites that primarily advertise commercial sex. We learned of this behavior from our law enforcement partners (e.g., when running a phone number associated with a criminal case through the TellFinder tool, one partner found that the number was associated with both sales posts and deceptive recruitment offers on the same website, thereby providing supporting evidence that this was likely a human trafficking case). (Ramchandani et al., 2025, p. 702)

However, this discussion focuses on whether a potentially deceptive recruitment offer exists on the site and does not discuss whether or not a person interested in such offers would be using the commercial sex website to find noncommercial sex-related job opportunities. Therefore, a fundamental assumption of the computational analysis presented by Ramchandani et al. (2025) is people interested in the offers made in the potentially deceptive recruitment ads will use the deep web (and commercial sex websites, in particular) to find job opportunities. The authors seem to recognize this flaw in their data as they attempted to augment their deep web data by examining open web data (like Craigslist) but they only found four instances where metadata from commercial sex ads appear on the open web; they found 369 potentially deceptive recruitment-related posts from the deep web (overall, the data set had millions of sex ad posts).

The work of Ramchandani et al. (2025) requires one to disagree with the arguments of Giommoni (2024) and, even then, their methods can only be applied to sex trafficking operations that post both potentially deceptive recruitment offers and commercial sex ads. Ramchandani et al. (2025) do not provide conceptualizations on the behaviors of traffickers that would operate in this manner. Further, they apply their methods to a data set that requires that those susceptible to potentially deceptive recruitment offers are using commercial sex websites on the deep web to find job opportunities and, thus, their analysis requires this fundamental assumption.

In terms of assumption-building, OR models may be created that could suggest resource allocation decisions that have little to no impact on human trafficking or produce analysis that may not be representative of reality. For example, one of the core underlying assumptions of the work of Sen et al. (2022) is that law enforcement will invest resources¹ to disrupt the transit of victims of sex trafficking through the U.S. interstate system. Practically, this assumption seems to be quite a stretch since resources may be better used to investigate cases of trafficking rather than hope to identify a case at a checkpoint.

On Reliable Data. Taking the reliable data need as an example, the systematic review of Dimas et al. (2022) found that only 2.9% of operations research (OR) and analytics papers focusing on sex trafficking from 2010 through 2021 used data collected directly from anti-HT organizations or by researchers using interviews and surveys. The two most prevalent data sources for computational analysis are scraped web data (Coxen et al., 2023; Dubrawski et al., 2015;

¹The authors use this term broadly and suggest that “road checkpoints” are the most likely implementation.

Freeman et al., 2022; Keskin et al., 2021; Li et al., 2023; Ramchandani et al., 2025; Tobey et al., 2024; White et al., 2024) and law enforcement case files (Cockbain, 2018; Eryarsoy et al., 2024; Xie & Aros-Vera, 2022). Neither of these sources provide sufficient and well-rounded data describing sex trafficking operations (Barrick et al., 2025; Kosmas et al., 2024), especially as they are either publicly available (scraped web data) or collected for other purposes (case files). With respect to commercial sex ads, care needs to be taken to understand which characteristics of them are indicators of sex trafficking (Lugo-Graulich et al., 2024) and computational researchers should be careful about the implications of their research as a result. Giommoni (2024) makes a strong case that current human trafficking research based on scraped web-based sex ads is not accurate.

There are benefits of understanding trafficking networks through law enforcement case files, but there are also very specific limitations of such analysis since the goal of these files is to prove that a crime was committed (Bright et al., 2021; Cockbain et al., 2020). For example, in our own interviews with law enforcement related to sex trafficking network operations (Barrick et al., 2025, p. 16), this limitation was mentioned multiple times, including comments from a county prosecutor about cases without victim testimony: “You’re kind of just piecing it together through ads that are posted, through similar numbers that they’re seeing and things like that. So, you know people are connected, but you’re not necessarily knowing how.” As another example, a significant concern with relying on case file data is that it may not be representative of all sex trafficking networks since there may be selection bias in terms of cases pursued by law enforcement (Childress & Maass, 2024; Cockbain et al., 2020). In general, these sources represent only a sliver of the larger picture of how traffickers operate their networks (Barrick et al., 2024).

Methods: Our Framework to Co-Create Operations Research Models of Sex Trafficking with Lived Experience Expertise

Team Members

Inclusion of lived experience expertise in the creation of OR models of sex trafficking is a new and novel approach to this type of work. The research framework we describe here was designed to include lived experience expertise. The team includes three industrial engineers, with a combined 20 years of experience applying OR to illicit trafficking, two social scientists that have been working in the human trafficking space for a combined 35 years, and a five-member survivor-centered research team that have over 90 years of combined experience in advocacy and survivor support. The survivor-centered team includes five people, a majority of whom identify as survivors of sex trafficking and all of whom have held professional positions that provide support to survivors. Therefore, their expertise comes from both their own lived experiences and in learning about the experiences of other survivors. The team took great care and intention to develop a process for integrating team members across expertise and perspectives, based on trust-building, learning each other’s language, developing shared values and goals, care and value for each other, healing-focused practices, unearthing power dynamics, and taking time to get know each other. We refer the interested reader to Martin et al. (2022), which provides more details on this process.

We refer to the “academic team members” as those in academic research and the “survivor-centered research team members” (S-CR team members) as those with practical human trafficking knowledge (from their own lived experience and/or as professionals who serve people with lived trafficking experience) to help highlight our partnership. We do note that in previous research (e.g., Clark et al., 2023; Martin et al., 2022) the S-CR team members were referred to as an “advisory group,” which reflects our initial plans for their role in the research. However, as we reflected about how their role grew very rapidly in the context of our research, we have updated our terminology to reflect their contributions as co-equal research partners.

Guiding Values

Working with lived experience experts necessitates close attention to the process and collaboration procedures to assure inclusion, respect, privacy, transparency, and mutual benefit. It is uniquely important to be attentive to trauma when academics co-create models with people who have lived experience who gained their knowledge through trauma. In our team, we value their expertise, while recognizing the traumatic ways they gained that expertise. We do not ask for their lived experience stories but ensure our research process is trauma-informed and promotes healing and recovery. For example, we make sure our research meetings involve breath work, check-ins and support. We use a consistent and iterative process to bring modeling, domain expertise, and lived experience expertise together (Martin et al., 2022). Lived experience experts are compensated at the maximum allowable federal rate that other experts outside the organizations funded by a research grant are paid. We also recognize lived experience expertise in publications by including the survivor-centered research team members as coauthors (including this paper). We derive mutual benefits by working together to scope projects so that everyone is learning and that our work contributes to the field.

OR Modeling Process

With the aforementioned guiding values in place, our process to build an OR model starts with a joint discussion involving the entire team, which centers around generating research ideas or under-studied research areas in the trafficking space. Once a research area is identified that could benefit from an OR model, the OR experts provide initial modeling ideas in the area. The social scientists first review these initial ideas and provide feedback. Then, the OR experts bring the model for discussion with the S-CR team members at monthly standing meetings with the S-CR team members. Prior the meeting the academic team prepares a short pre-reading for the S-CR team members that is sent to them about a week before the meeting to introduce a particular modeling idea or question that we plan to discuss. The S-CR team members are paid for reading and meeting time.

This process generates significant insights and ideas across many different layers associated with modeling including our conceptualizations, our modeling assumptions, and potential data to populate the models for analysis, examples of which will be provided in our results section. We employ this process throughout the life of the research to continuously refine the research questions, conceptualizations, approach, data, and results interpretation. We further use this process to identify ways to disseminate the results of our research. Overall, this process not only improves our OR models but also increases our knowledge about sex trafficking in general. As an example, which will be discussed more in our results section, this process has helped to offer a different way of conceptualizing commercial sex markets by focusing on the power dynamics between sellers and buyers, rather than the market venue or location (e.g., street-based).

Our research process ensures that we are meaningfully working with the S-CR team members as equal partners. In the context of community-based research, we are working *with* the community and not just “on” or “in” the community (Wallerstein et al., 2020). To the best of our knowledge, we are the first team to incorporate lived experience expertise into community OR (e.g., see our past work in Clark et al., 2023; Martin et al., 2024; Tezcan et al., 2025) on sex trafficking and this paper contributes to the emerging literature on OR (broadly) applied to sex trafficking by demonstrating the value of the inclusion of lived experience expertise through our S-CR team members.

Results: On the Value of Lived Experience Expertise in OR Models

This section provides two examples to show how our computational models became better through inclusion of lived experience expertise to demonstrate the *concrete value* of lived experience expertise. We first provide a brief overview of the two models used as case studies in this discussion. We then demonstrate the value of lived experience expertise within four key areas of model development and

use: 1) conceptualization; 2) modeling assumptions and limitations of those assumptions; 3) data collection and limitations of data collection; 4) interpretation and dissemination of model results. The main result of our research methods, highlighted here, is the added knowledge provided by lived experience expertise in each of these four areas.

The OR modeling process (e.g., Hillier & Lieberman, 2015; Morris, 1967) involves mathematically abstracting reality and, therefore, only offers a narrower view of reality. Behavioral operations research (e.g., Hämmäläinen et al., 2013) recognizes the potential issues and biases that could occur when using OR to aid in group decision-making. Problem structuring methods can help make progress with ill-structured applications and offer an alternative viewpoint to more classic quantitative OR paradigms (Smith & Shaw, 2019), especially OR models created in processes that view the modeler as the authority with respect to the application domain. Therefore, our research method has brought in ideas from problem structuring methods in order to integrate diverse viewpoints with respect to key modeling features.

OR Models

Model One: Youth Susceptibility to Trading Sex

We created a Markov Chain model, and populated it with data, of how youth's life circumstances and access to basic needs affects their susceptibility to trading sex (Martin et al., 2024; Tezcan et al., 2025). In general, a Markov Chain is a mathematical model that captures how a situation (in our model, this is the life circumstances of the youth) changes over time. A *state* in a Markov Chain is a potential option for the situation. When the situation is in a particular state, there is a probability (or likelihood) that it will *transition* to another state. There could be a probability that the state transitions back to itself, meaning that the situation did not change in the transition. An important type of state is an *absorbing state*, which is a state that can only transition to itself. In other words, if the situation reaches an absorbing state, then it will never leave, and we can view this state as "terminal." For example, an absorbing state in a Markov Chain could include circumstances when a youth is no longer in a position to be susceptible to trading sex.

Initially, we started developing the Markov Chain model in the context of adult sex trafficking. Through our engagement with the S-CR team members, we realized the data for many populations of adults involved in sex trafficking was extremely limited and better data existed on the susceptibility of sex trading among youth² in the child welfare system. According to the United States Trafficking Victim Protection Act, the involvement of youth in sex trading is categorized as a form of sex trafficking and is viewed as inherently exploitative as minors are not legally able to consent to trading sex. We intend our model to be applicable specifically to the context of sexual exploitation of youth, and not to the context of consensual adult sex work. Many of the modeling assumptions (but not the collected data) can be applied to sex trafficking more broadly should more reliable data become available. The model captures (i) that a person's susceptibility can change over time as life circumstances change and that youth can move in and out of trading sex, and (ii) improving access to services and other interventions could reduce the chance that a youth will trade sex.

Figure 1 provides an overview of this model, particularly highlighting where the model started based on academic expertise and where it ended through the inclusion of lived experience expertise. Each state (oval in Figure 1) captures a different situation that a youth may find themselves in, where the absorbing states are the seven different states labeled "Exit." These absorbing states represent the situations that youth find themselves in as they exit out of the Markov Chain model. The transitions out of a state are represented by the lines leaving that state. As mentioned previously, our initial goal was to build a Markov Chain model of recruitment into and exits out of sex trafficking and the states and assumptions of Figure 1 could be adapted to this goal. However, data to identify the probability of moving between different states (or situations) was limited for this goal and, therefore, we refined the

²We use the term "youth" to mean any minor under the age of 18.



Figure 1. An overview of the Markov Chain model before and after the inclusion of lived experience expertise (those labeled with “exit” are absorbing states).

focus of our data collection and analysis to focus on youth (under the age of 18) trading sex. In the following sections, we highlight the areas where the S-CR team helped identify assumptions for the initial goal (sex trafficking) and helped gather data on the narrower focus of youth trading sex that have had experience in the child welfare system.

Model Two: Forced Criminality

We also created an operational model of a sex trafficking network that captures the situations where victims are forced to participate in commercial sex markets and other criminal activities, such as illegal drug trafficking, committing theft, and committing fraud (Clark et al., 2023). The idea for this topic came directly from the S-CR team members. The model considered how interventions into different illegal activities impact the ability of the trafficking network to generate revenues through commercial sex acts and forced criminality. It uses the idea that “flow” through the network (a common OR concept) models the control that a trafficker has over their victims (Kosmas et al., 2024). Figure 2 provides an overview of this model, again emphasizing where it began and where it ended through the inclusion of lived experience expertise.

Value in Conceptualization

Lived experience expertise has provided several new conceptualizations for not only our research in sex trafficking, but also for the research field as a whole. For example, our S-CR team members identified that sex trafficking victims experience other forms of forced criminality, such as being made to sell or transport drugs, commit fraud, or shoplift. They believed that knowledge about forced criminality was missing both in the research community and in practice. They suggested that we include it as a research question for a National Science Foundation grant that was submitted and funded in Summer 2020. The academic team members confirmed that this was indeed a research gap since the literature was sparse and only emerged over the past several years. An early work describing issues of arrests of sex trafficking victims

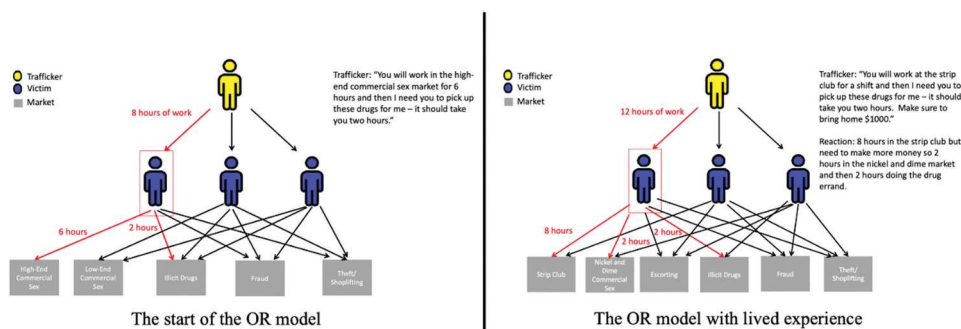


Figure 2. A visual overview of the network model for forced criminality before and after the inclusion of lived experience expertise. The right figure provides more context with respect to quotas, presents a more realistic number of hours worked, and uses better terminology for the markets (note that the model includes the concept of required activities but this visual does not) and was included in Clark et al. (2023).

for other crimes outside of commercial sex was done by survivor-leader Jacobs (Jacobs, 2016). At the time, the main academic work was on “trick rolls” (Roe-Sepowitz et al., 2020) and discussions around vacatur laws (Devaney, 2022; Mullins, 2019). Later related academic research discusses the victim-offender overlap (Bouche et al., 2025; Henderson & Rhodes, 2022). Similar to our S-CR team members’ expertise, a roundtable of survivors indicated that they encountered forced criminality in their trafficking experiences (Roe-Sepowitz, 2019). To demonstrate the value of this conceptualization, we observe that our S-CR team members identified forced criminality as under-studied in Summer 2020 and that the United States National Institute of Justice included forced criminality as a topical area under its Research and Evaluation on Trafficking in Persons opportunity for the first time in 2023 (United States National Institute of Justice, 2023). This is an excellent example of how lived experience expertise can help identify areas where academic knowledge is lacking. Another way to demonstrate this value is that the combined work of the academic and S-CR team members in Clark et al. (2023) has been published in the peer-reviewed *Journal of Human Trafficking*. To the best of our knowledge, this paper presents the first OR model created and published with people with lived experience expertise as partners.

Another example of lived experience expertise helping to conceptualize issues around sex trafficking comes from our inclusion of *the nickel and dime commercial sex market*. We were exploring how to include the different types of commercial sex markets a victim may be forced to participate in into our OR model on forced criminality. The academic team members initially thought about including “high-end” and “low-end” commercial sex activities to represent different revenue markets, as this is typically how the academic literature discusses differences in settings and pricing (Finn & Stalans, 2016; Horning et al., 2020). The S-CR team members expressed concern that this hierarchical language could imply that certain victims are more important or valuable. Further, there were comments that certain situations in what the academic team members called “low-end” (such as street-based commercial sex) could generate significant revenues. For example, a “regular” in the low-end activity may generate more revenue than work in the so-called high-end activity, even if typical interactions in the low-end activity resulted in lower revenue.

The academic team members then proposed three markets, each associated with different venues, typically studied in the academic literature: street-based commercial sex, selling sex in strip clubs, and escorting. However, as we were discussing what we intended with the street-based commercial sex, we were not satisfied with the term since it did not represent all the interactions we were trying to capture. One S-CR team member used the term “nickel and dime” to describe situations across venues (e.g. street-based, online escort ads, or strip clubs) in which the buyers tended to have more power

in this market and would often try to “nickel and dime” a victim when negotiating the price for a sex act. The other S-CR team members confirmed that this was an insightful and accurate way to describe such a market. This is an important breakthrough in conceptualization: rather than focus on the venue of the commercial sex market, we could focus on its operating conditions and/or power dynamics of the market.

Value in Modeling Assumptions and Limitations

Lived experience expertise ensures that OR models are grounded and present the realities of sex trafficking in an ethical, responsible manner. This expertise helps to identify what we know and do not know (well enough) about trafficking experiences and allows OR models to authentically represent sex trafficking. Further, lived experience expertise helps to ensure that modelers do not oversell their modeling contributions and properly discuss its limitations.

In terms of the Markov Chain model, our first focus was on ensuring that the concepts of being in a certain “state” and transitioning to other states could be a way to understand how a person may be recruited into sex trafficking. This would help verify that the underlying assumptions of a Markov Chain could be potentially applied to a person that may or may not experience sex trafficking. The authenticity of this approach was discussed by the S-CR team members:

Looking at the model, I get it, and I like how you do the flow back and forth. It happens on the regular. That’s what we see on a regular basis. There are so many underlying layers. If we don’t have a proper response from the services, they could go back. (S-CR Team Member 1, August 2021 meeting)

We talk about this all the time in the group that this movement happened, and it can go anyway. This is a great visual [referring to the inner part of [Figure 1](#)] to see what we’ve been talking about with our words, conversations, and stories. (S-CR Team Member 2, September 2021 meeting)

The S-CR team members provided important feedback in our initial Markov Chain modeling. The initial model started only with states discussing different levels of susceptibility (high, medium, low) for those that have yet to be trafficked and survivors of trafficking, as well as a state that focused on being actively trafficked. The S-CR team members’ feedback was to ensure that detailed information regarding the factors on susceptibilities were included, especially since some susceptibilities are based on a person’s prior life events (e.g., childhood abuse) – thus challenging the memoryless assumption of Markov chains – and other susceptibilities are created by lack of access to basic needs (e.g., housing policies). The S-CR team members resonated with the transitions that showed there was a chance someone could go from any susceptibility state into trafficking. They emphasized that healing from exploitative situations is an ongoing journey for survivors and that re-exploitation can occur, even for someone in a low- susceptibility state. This discussion then led to the realization that the Markov Chain model needed to include a variety of so-called absorbing states (a state a person reaches and never leaves), which can help model what happens to people in the long term, and that there should be states associated with various institutions (e.g., incarceration, substance use disorder treatment facilities) that a person could be in that would impact their transitions. [Figure 1](#) highlights how much the inclusion of lived experience expertise shaped the Markov Chain model.

In terms of the forced criminality network model, lived experience expertise helped shape its assumptions and limitations in several ways that were attuned to the “nickel and dime” market segment we identified. The initial OR modeling attempt focused on assuming that a victim had a capacity on the number of hours that they could work across a week in revenue-generating activities and that the trafficker directly controlled the number of hours a victim would work. The S-CR team members emphasized that it was not about the number of hours worked but how much money a victim would be expected to make, i.e., a quota. Further, the S-CR team members had concerns about capping the number of hours worked by a victim since there were activities that may come up that would always be done by a victim no matter how long they had worked that day and expressed

concerns about the fact that a cap could indicate that the victim was free during the other hours of the day.

Based on these critiques, the model was updated and limitations were more clearly identified. Rather than incorporate quotas, the OR model was updated to use a day as the time unit, which allowed for more variability in the hourly revenue generated in each illegal activity. If certain activities on a day had less revenue, then our data could increase the capacity on the number of hours worked to approximately capture a quota. We introduced the concept of required activities that must be done on a particular day into the model.

Further, clarifications were added to the “capacity on the number of hours a victim could work.” In particular, the term “capacity on uptime” was used to describe time spent in revenue-generating activities. This would help to signify that the victim may still be working other activities for the trafficker during “downtime” and still be under the control of the trafficker – i.e., they are always being trafficked but not in ways that impact the model. As the OR model was updated, the team continued to recognize that the model would not be perfect but wanted to make it useful for *certain contexts*, e.g., situations where the trafficker directly controls the victims. During this model-building process, both the S-CR and academic team members were understanding how important the collaborations across this space were in terms of the resulting OR model, as S-CR Team Member noted, in a June 2022 meeting, about the updated model, “It is nice to see this with the charts and graphs and you get it. You are really onto something here, this is good.” An Academic Team Member responded:

I want to reiterate that it is us that are onto something. I want you to remember what it [the model] was like before [referring to the first OR model] ... I just want to reiterate that this is really a testament to us. [as a community-engaged transdisciplinary team]

Value in Data Collection and Limitations

Lived experience expertise also helps to ensure that modelers do not oversell the contributions of their analysis and properly discuss its limitations by offering important critiques of how transferable data may be between different types of trafficking environments, and experiences of commercial sex outside of trafficking. This expertise helps us to be smarter (and more realistic) about the scope of our analysis, thereby better representing sex trafficking. It can further be used to strategically build out additional data or triangulate multiple sources of data for inputs into models.

Although initially designed to model recruitment into sex trafficking, we ultimately decided to populate the Markov Chain model with a focus on data related to youth in the child welfare system and their susceptibility to trading sex. This choice was informed by the fact that youth with different life experiences will have different susceptibilities to trading sex; therefore, the S-CR team members suggested that our model would provide more insightful results if we clarified who our model was trying to model. Ultimately, the population with the most data that existed related to our modeling needs focused on youth in the child welfare system. Unfortunately, even for this population, the type of data needed to populate our Markov Chain was absent from the literature. The literature was sparse related to (1) whether factors such as housing, mental health, and substance use were equally influential in a youth’s susceptibility to trading sex, (2) how the *co-occurrence* of these factors impacts a youth’s susceptibility to trading sex, and (3) the causal relationship between these factors and susceptibility. For example, the Minnesota Student Survey (MSS) data, where we focused on the survey of ninth and eleventh grade students, has questions about susceptibilities and about trading sex (Minnesota Department of Education [MDE], 2023), but it only has “point in time” data (e.g., it did not provide data such as whether a youth traded sex before or after being without housing). To fill these gaps, the academic team members designed seven vignettes and used an information elicitation exercise to elicit knowledge from the S-CR team members’ expertise (Hartley & French, 2017). For example, we used the following

vignette to guide a discussion about whether housing or substance use had more of an impact on a person's susceptibility.

Chelsea and Thea are 16-year-old classmates with similar economic backgrounds from the same neighborhood. Chelsea recently started having problems with housing due to problems with her family but doesn't drink or use drugs. Thea lives with her family but recently started using drugs and alcohol to get through the day.

For each vignette, we asked questions related to how susceptible the youth were, whether one youth was more susceptible than the other, and whether there was any additional information the S-CR team members would want to know about the youth to decide. These vignettes helped to collect some information to inform the transition probability input data and served an important role in understanding how limited our analysis would become based on available data. In particular, the responses of the S-CR team members to these vignettes highlighted the principle that so much depends on the person and their situation. When discussing how vulnerable Thea is in the example vignette, a S-CR team member responded, "It depends. Where is Thea getting drugs from?" (April 2022 Survey Response).

In another vignette related to how vulnerable a 16-year-old who is highly dependent on drugs, in a severe mental health crisis, and sometimes couch surfs or sleeps on the streets is to trading sex, the S-CR team members agreed that the 16-year-old was highly vulnerable to trading sex but that "it depends on the support system like whose house is she couch surfing? I know for some places, like some people might be staying with a loving and supporting person like an aunt or something." In response, a S-CR team member noted that it depends on whether "their aunt [would] let them do their drugs? ... And for how many nights would the aunt let them be there?"

These responses help to understand just how limited the current data that exists related to OR model data requirements and inspired new research methods to overcome these challenges. One of the major challenges we had was determining the 186 transition probabilities needed to run the Markov Chain model from the literature. To address this, the OR team members investigated a novel use of inverse optimization, which is a type of optimization problem that seeks to understand how to change parameters in the smallest way possible while also meeting a certain desired characteristic (Ahuja & Orlin, 2001), to calibrate the gathered transition probabilities based on the data that was available in the literature and the insights gained from the S-CR team members. For example, Tueller et al. (2023) estimated that the child welfare sex trading percentage was between ~3% to ~17%. This corresponds to the likelihood that a youth starts in the never traded sex states and eventually trades sex (i.e., the Markov Chain concept of the "youth trading sex" *hitting probability* – which is the correct mathematical term, but the "hitting" connotation could have harmful unintended consequences in this research area, and we only use it here to illustrate the correct mathematical concept).

Using data from the literature, insights from the S-CR team members, hitting probability equations, and inverse optimization, we were able to determine the underlying 186 transition probabilities. Throughout this process it was clear that new data collection techniques were necessary to fully explore how susceptibilities impact the potential of youth to trade sex or, more generally, for people to be recruited into sex trafficking. As a result, our team is now piloting the use of a novel qualitative interview technique called life history calendars (Vollinger, 2022) to improve our knowledge of the pathways that people take into sex trafficking that will be at the level of detail needed for OR modeling. In general, Zhang (2022) provides additional directions for data collection with respect to human trafficking.

For our forced criminality model, the data collection process, again, helped us to understand the scope of what analysis would be possible. We initially surveyed the S-CR team members about four key pieces of information: (1) the number of hours that victims will be forced to work in "up-time" activities, (2) which activities the victim will potentially participate in, how long they could participate in a day, and how many days of the week they could participate in it, (3) the revenue that the victim

will generate by doing an activity in a particular market, and (4) whether or not there is a “required” activity and what that required activity is. The S-CR team members’ responses, again, highlighted how *it depends* on the specific context of the operation.

The questions are asking for range of numbers of hours and days of participating in a week. You have all the markets listed. There are so many variables that it’s hard to answer that. Street based commercial sex, like, ok. It depends on if you’re using drugs, if you’re not using drugs, if you’re addicted to a substance that’s going to affect how many hours you can work, because you’re spending some amount of time using that substance the only time you work is when you need more money for that substance. (S-CR Team Member 1)

It depends on the pimp, it depends on the city, the location. If the pimp is looking to get a Benz or Maserati you might be working a few weeks straight. It depends on his game and his goal. (S-CR Team Member 2)

Through these discussions, we were ultimately able to scope the work of Clark et al. (2023) to focus on analyzing sex trafficking networks with forced criminality where the primary commercial sex market was the nickel and dime market and that the victims would tend to have substance use issues since we were able to combine the lived experience expertise with the academic literature on this type of market (Dank et al., 2014; Horning et al., 2020).

Value in Interpretations and Dissemination

The inclusion of our S-CR team members into the research process has also resulted in us thinking broadly about dissemination efforts, especially those that would reach the anti-trafficking practitioner community. For example, the video of Maass et al. (2023) presents the key ideas behind Markov Chain modeling of sex trafficking recruitment in an accessible manner without using any detailed terminology regarding Markov Chains. Figure 3 presents a screenshot from Maass et al. (2023) that describes how a youth may move between different situations related to susceptibilities and trading sex and “visualizes” these movements along the lines of transitions in Markov Chains. The accessibility of this video is important in the sense that it does not require an OR background to understand and, therefore, allows the ideas to be used in innovative manners. For example, the PRIDE program of the Family Partnership has used the video and the Markov Chain model presented in Figure 1 to help train new staff that will provide support services to survivors of sex trafficking.

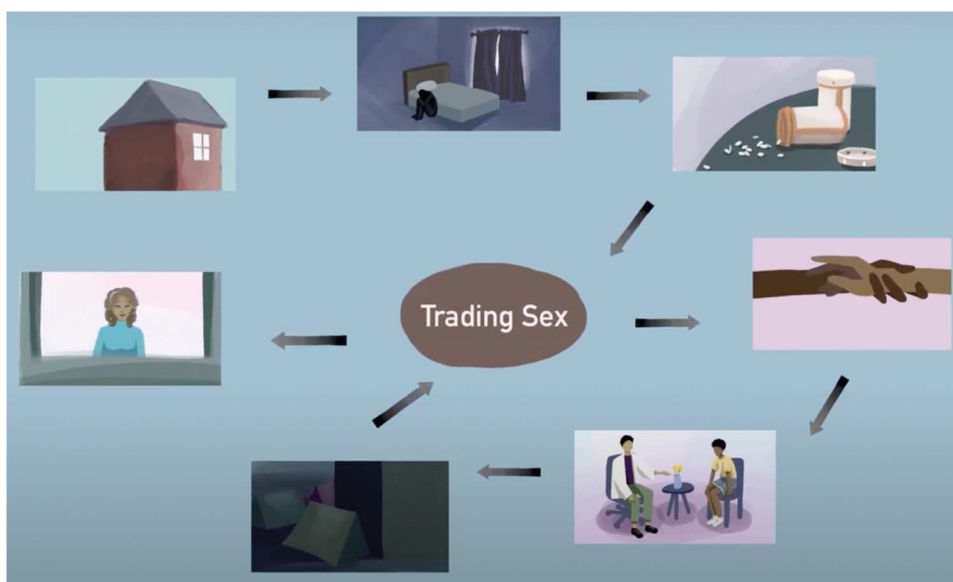


Figure 3. Screenshot from Maass et al. (2023) highlighting the ideas behind Markov Chain modeling of sex trafficking recruitment.

The S-CR team members have emphasized that the Markov Chain modeling of sex trafficking recruitment is incredibly useful as it focuses on the situations that lead to youth trading sex or sex trafficking, which allows people to begin understanding the underlying susceptibilities whose prevention could help to disrupt recruitment processes. For example, during one conversation about the Markov Chain model, an S-CR team member remarked:

It [the model] is active and very realistic I did like that. Visually, I loved looking at it . . . It solidified it and showed it in a way that was comprehending. And made it more realistic. It showed how and why it could take place . . . Seeing it really helped me grasp it from non-survivors. Looking at different ways to deliver the same information. And being mindful of explaining it to someone else. Making sure it's something tangible. (S-CR Team Member, January 2022 meeting)

Discussion and Conclusion

There is a famous axiom, often attributed to George Box, that “all models are wrong, some are useful” (Box, 1979, p. 202). This axiom would typically be focused on assumption-building in models in the sense that the assumptions often reflect the abstraction required to move from the real world to the mathematics modeling it. In the area of sex trafficking, Sharkey et al. (2021) suggested two important addendums to this axiom:

Addendum 1: “All models are wrong, some are useful *for the right context and if the unintended consequences are carefully considered.*”

Addendum 2: “All models are wrong, some are useful *if you have data to populate them.*”

Any model of sex trafficking is abstracting trauma and cannot possibly capture all the complexities of lived experience. Context matters and identifying the accurate context for models is critical for them to be useful. It is necessary to have deep knowledge of specific circumstances such that models are nuanced enough to have valid, practical assumptions and account for potential unintended consequences within specific and delimited situations. We need to recognize that identifying the right context requires expertise. This raises the question of how to define expertise related to sex trafficking. There are academic researchers that have studied the problem of sex trafficking. There are practitioners, such as law enforcement, that hope to intervene and disrupt sex trafficking operations. There are practitioners, such as service providers, that support the healing processes of those with lived experience. There are those with lived experience that can directly speak to the context and can conceptualize sex trafficking in a unique, eye-opening way. We believe that our results show that ignoring, marginalizing, or minimizing lived experience expertise in research on sex trafficking is equivalent to ignoring, marginalizing, or minimizing these other sources of expertise.

As important, interventions into sex trafficking should do no more harm to trafficking victims and survivors than they have already experienced. In OR, what we do not model, we do not control. Therefore, there may be consequences of these approaches outside of the control of the model. Of the many forms of knowledge related to sex trafficking, we believe that those with lived experience are the most qualified to think through what the unintended consequences of well-meaning actions are and how they affect those that have experienced trafficking. Further, inclusion of lived experience experts can also serve as a guardrail for overgeneralizing modeling features and data, since it is possible to discern the contexts that lived experience experts either know or do not know based on their expertise. For example, in our own work, the team could provide enough context and nuance to be confident that our analysis for the Markov Chain model could be applied to youth who have had experience in the child welfare system trading sex. In the forced criminality model, enough data could be collected for operations that focused on the nickel and dime commercial sex market but we found that there was not enough expertise to collect data on trafficking operations that focused primarily on other commercial sex markets (e.g., escorting).

Overall, this paper describes how the integration of research partners with lived expertise into a transdisciplinary team using principles of community-based participatory research was essential to more accurately capture the complexities of sex trafficking networks and advance knowledge in this area. Key principles of this approach include valuing multiple ways of knowing, supporting meaningful participation of experts outside of academia (specifically lived experience experts), seeking transformation and justice, and actionability. The focus of this paper has been on the benefits of lived experience expertise into computational modeling and reflections from the S-CR team also offer the value that being a researcher brings to them. In these reflections, a theme of empowerment emerged, similar to the survivors that participated in the Photovoice study of Lockyer and Koenig (2022). For example, in an April 2025 meeting, one survivor-leader on the team stated, “Being a researcher put me in a place of power that I would not have been previously and gave me a voice in a different anti-trafficking space.” In assessing the potential of other survivors to become engaged with research, one member said, “Be authentic with what you are bringing to research. You have different expertise and you should know it is as important as everyone else’s expertise,” (S-CR Team Member, March 2025 meeting).

We believe that our research framework addresses concerns about tech and advancements in computational approaches applied to sex trafficking (or other social phenomena) created without lived experience expertise raised by survivor-leader Boyd (2022). Computational approaches created without this expertise may prioritize anti-trafficking approaches that are not aligned with what survivors view as important in their healing and recovery journeys, including, as discussed by Boyd (2022), sacrificing privacy of victims and survivors in anti-trafficking efforts. This approach requires computational researchers to slow down and ensure that their well-intended work has the correct conceptualizations, assumptions, engaged, transdisciplinary, survivor-centered research process has resulted in significant improvements to the scope, conceptualizations, and authenticity of OR models to help disrupt sex trafficking. Inaccurate or wrongly applied models can waste resources and cause real harm to actual people. Properly applying accurate models in this area requires careful scoping and clarity about what is or is not included in the model, with the goal of presenting the issue in realistic ways.

Sweeping claims about the impact of computational models or applying proven computational approaches to new contexts, requires domain and lived experience expertise. In short, we have presented a strong argument for why and how inclusion of lived experience expertise is ethically important and critical to OR modeling because it improves accuracy and applicability. Our inclusive research process takes time, careful thought, and trust-building and results in models that our team believes are ethical and representative of the realities of the experiences of those that have lived through the situations being modeled. This is best captured with a thought from an S-CR team member when discussing how lived experience expertise feedback was incorporated into the Markov Chain model:

I feel like based on what was presented, they have taken what we said and shared, and I feel like they were able to ethically present it. They presented the lived experience in an ethical way, and that’s important to me, and I’m sure all of us here. (S-CR Team Member, September 2021 meeting)

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References

- Ahuja, R. K., & Orlin, J. B. (2001). Inverse optimization. *Operations Research*, 49(5), 771–783. <https://doi.org/10.1287/opre.49.5.771.10607>
- Anzoom, R., Nagi, R., & Vogiatzis, C. (2021). A review of research in illicit supply-chain networks and new directions to thwart them. *IISE Transactions*, 54(2), 1–59. <https://doi.org/10.1080/24725854.2021.1939466>
- Ash, C., & Otiende, S. (2023). *Meaningful engagement of people with lived experience: A framework and assessment for increasing lived experience leadership across the spectrum of engagement*. Global Fund to End Modern Slavery and National Survivor Network- CAST.
- Balch, A., & Kiconco, A. (2023). *Towards principles for equitable engagement: Six research projects*. Modern slavery & human rights policy & evidence centre. Retrieved February 8, 2024, from <https://modernslaverypec.org/assets/downloads/Equitable-engagement-summary.pdf>
- Barrick, K., Farrell, C., Matthias, A., & Martin, L. (2025). Assessing the use of law enforcement and prosecutorial case files to understand sex trafficking: Caveats and considerations. *Forthcoming in the Journal of Human Trafficking*, 1–16. <https://doi.org/10.1080/23322705.2025.2542071>
- Barrick, K., Maass, K. L., Sharkey, T. C., Song, Y., & Martin, L. (2024). Expanding our understanding of traffickers and their operations: A review of the literature and path forward. *Trauma, Violence & Abuse*, 25(3), 2348–2362. <https://doi.org/10.1177/15248380231210937>
- Beaulieu, M., Breton, M., Brousselle, A., & Harris, F. (2018). Conceptualizing 20 years of engaged scholarship: A scoping review. *PLOS ONE*, 13(2), e0193201. <https://doi.org/10.1371/journal.pone.0193201>
- Bouche, V., Van Dyk, S. S., & Kamdem, A. (2025). Trafficker or trafficked? Predicting victim versus offender status of female defendants in federal sex trafficking prosecutions using the TRAP typology. *Victims & Offenders*, 1–26. <https://doi.org/10.1080/15564886.2024.2440763>
- Box, G. E. (1979). Robustness in the strategy of scientific model building. In *Robustness in statistics* (pp. 201–236). Academic Press.
- Boyd, S. (2022). *Privacy is safety: Amazon's tech against trafficking summit*. Retrieved January 10, 2024, from <https://sabra-boyd.medium.com/privacy-is-safety-amazons-tech-against-trafficking-summit-7a2d558a8402>
- Boyer, E. (1991). *Scholarship reconsidered: Priorities of the professoriate*. The Carnegie Foundation for the Advancement of Teaching.
- Bradbury, H. (Ed.). (2015). *The sage handbook of action research*. Sage.
- Bright, D., Brewer, R., & Morselli, C. (2021). Using social network analysis to study crime: Navigating the challenges of criminal justice records. *Social Networks*, 66, 50–64. <https://doi.org/10.1016/j.socnet.2021.01.006>
- Brush, B. L., Mentz, G., Jensen, M., Jacobs, B., Saylor, K. M., Rowe, Z., Israel, B. A., & Lachance, L. (2020). Success in long-standing community-based participatory research (CBPR) partnerships: A scoping literature review. *Health Education and Behavior*, 47(4), 556–568. <https://doi.org/10.1177/1090198119882989>
- Caulkins, J. P., Kammer-Kerwick, M., Konrad, R., Maass, K. L., Martin, L., & Sharkey, T. C. (2019). A call to the engineering community to address human trafficking. *The Bridge*, 49(3), 67–73.
- Childress, C., & Maass, K. L. (2024). *The unintended negative consequences of partial information in human trafficking network interdiction*. Technical report.
- Clark, M., Sharkey, T. C., Ayler, T., Forliti, T., Friedman, J., Mariotti, M., Nelson, C., & Martin, L. (2023). Modeling disruptions for sex trafficking networks with multiple forced illegal activities. *Forthcoming in the Journal of Human Trafficking*, 1–27. <https://doi.org/10.1080/23322705.2023.2277103>
- Cockbain, E. (2018). *Offender and victim networks in human trafficking*. Routledge.
- Cockbain, E., Bowers, K., & Vernon, L. (2020). Using law enforcement data in trafficking research. *The Palgrave International Handbook of Human Trafficking*, 1709–1732.
- Coxen, J. O., Castro, V., Carr, B., Bredin, G., & Guikema, S. (2023). COVID-19 pandemic's impact on online sex advertising and sex trafficking. *Journal of Human Trafficking*, 1–18. <https://doi.org/10.1080/23322705.2023.2215362>
- Creswell, J. W., & Plano Clark, V. L. (2018). *Designing and conducting mixed methods research* (3rd ed.). SAGE Publications.
- Dank, M. L., Khan, B., Downey, P. M., Kotonias, C., Mayer, D., Owens, C., Pacific, L., & Yu, L. (2014). *Estimating the size and structure of the underground commercial sex economy in eight major US cities*. Urban Institute.
- Deeb-Swihart, J., Endert, A., & Bruckman, A. (2022). Ethical tensions in applications of AI for addressing human trafficking: A human rights perspective. *Proceedings of the ACM on Human-Computer Interaction*, 6(CSCW2), 1–29. <https://doi.org/10.1145/3555186>

- DeJonckheere, M., Lindquist-Grantz, R., Toraman, S., Haddad, K., & Vaughn, L. M. (2019). Intersection of mixed methods and community-based participatory research: A methodological review. *Journal of Mixed Methods Research*, 13(4), 481–502. <https://doi.org/10.1177/1558689818778469>
- Devaney, S. (2022). Justice for all? Impeding the villainization of human trafficking victims via the expansion of vacatur laws. *Pepperdine Law Review*, 49, 241–248.
- Dimas, G. L., Konrad, R. A., Maass, K. L., Trapp, A. C., & Kuo, Y.-H. (2022). Operations research and analytics to combat human trafficking: A systematic review of academic literature. *PLOS ONE*, 17(8), e0273708. <https://doi.org/10.1371/journal.pone.0273708>
- Dubrawski, A., Miller, K., Barnes, M., Boecking, B., & Kennedy, E. (2015). Leveraging publicly available data to discern patterns of human-trafficking activity. *Journal of Human Trafficking*, 1(1), 65–85. <https://doi.org/10.1080/23322705.2015.1015342>
- Eryarsoy, E., Topuz, K., & Demiroglu, C. (2024). Disentangling human trafficking types and the identification of pathways to forced labor and sex: An explainable analytics approach. *Annals of Operations Research*, 335(2), 761–795. <https://doi.org/10.1007/s10479-023-05520-1>
- Finn, M. A., & Stalans, L. J. (2016). How targeted enforcement shapes marketing decisions of pimps: Evidence of displacement and innovation. *Victims & Offenders*, 11(4), 578–599. <https://doi.org/10.1080/15564886.2016.1187694>
- Freeman, N. K., Keskin, B. B., & Bott, G. J. (2022). Collaborating with local and federal law enforcement for disrupting sex trafficking networks. *INFORMS Journal on Applied Analytics*, 52(5), 446–459. <https://doi.org/10.1287/inte.2022.1126>
- Gerassi, L., Edmond, T., & Nichols, A. (2017). Design strategies from sexual exploitation and sex work studies among women and girls: Methodological considerations in a hidden and vulnerable population. *Action Research*, 15(2), 161–176. <https://doi.org/10.1177/1476750316630387>
- Giommoni, L. (2024). Why we cannot identify human trafficking from online advertisements. *Journal of Human Trafficking*, 1–15. <https://doi.org/10.1080/23322705.2024.2435198>
- Gore, M. L., Griffin, E., Dilkina, B., Ferber, A., Griffis, S. E., Keskin, B. B., & Macdonald, J. (2023). Advancing interdisciplinary science for disrupting wildlife trafficking networks. *Proceedings of the National Academy of Sciences*, 120(10), e2208268120. <https://doi.org/10.1073/pnas.2208268120>
- Hämäläinen, R. P., Luoma, J., & Saarinen, E. (2013). On the importance of behavioral operational research: The case of understanding and communicating about dynamic systems. *European Journal of Operational Research*, 228(3), 623–634. <https://doi.org/10.1016/j.ejor.2013.02.001>
- Hartley, D., & French, S. (2017). Elicitation and calibration: A Bayesian perspective. In L. C. Dias, A. Morton, & J. Quigley (Eds.), *Elicitation: The science and art of structuring judgement* (pp. 119–140). Springer International Publishing.
- Henderson, A. C., & Rhodes, S. M. (2022). “Got sold a dream and it turned into a nightmare”: The victim-offender overlap in commercial sexual exploitation. *Journal of Human Trafficking*, 8(1), 33–48.
- Hillier, F. S., & Lieberman, G. J. (2015). *Introduction to operations research*. McGraw-Hill.
- Holland, B., & Malone, M. (2019). Editorial: Institutional engagement: Intentional, innovative and rigorous. *Gateways: International Journal of Community Research and Engagement*, 12(2), 1–6. <https://doi.org/10.5130/ijcre.v12i2.6984>
- Horning, A., Thomas, C., Marcus, A., & Sriken, J. (2020). Risky business: Harlem pimps’ work decisions and economic returns. *Deviant Behavior*, 41(2), 160–185. <https://doi.org/10.1080/01639625.2018.1556863>
- Israel, B. A., Eng, E., Schulz, A. J., & Parker, E. A. (2013). *Methods for community-based participatory research for health*. Jossey-Bass.
- Jacobs, B. (2016). *National survivor network members survey: Impact of criminal arrest and detention on survivors of sex trafficking*. National survivor network. Retrieved February 1, 2024, from <https://nationalsurvivornetwork.org/wp-content/uploads/2017/12/VacateSurveyFinal.pdf>
- Johnson, M. (2011). Community-based operations research: Introduction, theory, and applications. In *Community-based operations research: Decision modeling for local impact and diverse populations* (pp. 3–36). Springer New York.
- Johnson, M. P., Midgley, G., & Chichirau, G. (2018). Emerging trends and new frontiers in community operational research. *European Journal of Operational Research*, 268(3), 1178–1191. <https://doi.org/10.1016/j.ejor.2017.11.032>
- Keighley, R., Sanders, T., Saunders, L., & Agg, H. (2023). Participatory action research: Developing a collaborative approach to modern slavery research with survivors of exploitation. *Methodological Innovations*, 16(3), 393–404. <https://doi.org/10.1177/20597991231208441>
- Keskin, B. B., Bott, G. J., & Freeman, N. K. (2021). Cracking sex trafficking: Data analysis, pattern recognition, and path prediction. *Production & Operations Management*, 30(4), 1110–1135. <https://doi.org/10.1111/poms.13294>
- Keskin, B. B., Griffin, E. C., Prell, J. O., Dilkina, B., Ferber, A., MacDonald, J., Hilend, R., Griffis, S., & Gore, M. L. (2023). Quantitative investigation of wildlife trafficking supply chains: A review. *Omega*, 115, 102780. <https://doi.org/10.1016/j.omega.2022.102780>
- Konrad, R., Maass, K. L., Dimas, G., & Trapp, A. C. (2023). Perspectives on how to conduct responsible anti-human trafficking research in operations and analytics. *European Journal of Operational Research*, 309(1), 319–329. <https://doi.org/10.1016/j.ejor.2022.12.028>

- Kosmas, D., Melander, C., Singerhouse, E., Sharkey, L., Barrick, K., Maass, K. L., & Martin, T. C. (2024). A transdisciplinary approach for generating synthetic but realistic domestic sex trafficking networks. *IIEE Transactions*, 56(3), 340–354. <https://doi.org/10.1080/24725854.2023.2169418>
- Li, R., Tobey, M., Mayorga, M. E., Caltagirone, S., & Özalpın, O. Y. (2023). Detecting human trafficking: Automated classification of online customer reviews of massage businesses. *Manufacturing & Service Operations Management*, 25(3), 1051–1065. <https://doi.org/10.1287/msom.2023.1196>
- Lockyer, S., & Koenig, C. J. (2022). At the intersection of method and empowerment: Reflections from a pilot photovoice study with survivors of human trafficking. *Journal of Human Trafficking*, 8(4), 390–409. <https://doi.org/10.1080/23322705.2020.1809300>
- Lotrecchiano, G. R., & Misra, S. (2018). Transdisciplinary knowledge producing teams: Toward a complex systems perspective. *Informing Science*, 21, 051–074. <https://doi.org/10.28945/4086>
- Lugo-Graulich, K., Meyer, L. F., Souza, K., Tapp, S. N., Maryfield, B., & Bostwick, L. (2024). Improving sex trafficking victim identification: Indicators of trafficking in online escort ads. *Journal of Human Trafficking*, 1–22. <https://doi.org/10.1080/23322705.2024.2349447>
- Maass, K. L., Tezcan, B., Hodsden, M., Zhang, M., Cheung, R., Farrell, A., Sharkey, T., Barrick, K., Matthias, C., Williams, M., Brown, C., Florey, M., Ayler, T., Friedman, J., Nelson, C., Forliti, T., Mariotti, M., & Martin, L. (2023). *Reducing susceptibility to sex trafficking requires community support and resources*. <https://tinyurl.com/CommunityInterventionsVideo>
- Martin, L., Gupta, M., Maass, K. L., Melander, C., Singerhouse, E., Barrick, K., Samad, T., Sharkey, T. C., Ayler, T., Forliti, T., Friedman, J., Nelson, C., & Sortillion, D. (2022). Learning each other's language and building trust: Community-engaged transdisciplinary team building for research on human trafficking operations and disruption. *International Journal of Qualitative Methods*, 21, 16094069221101966. <https://doi.org/10.1177/16094069221101966>
- Martin, L., Maass, K. L., Barrick, K., Sharkey, T., Farrell, A., Matthias, C., Tezcan, B., Williams, M., Ayler, T., Forliti, T., Friedman, J., Mariotti, M., Nelson, C., Brown, C., & Florey, M. (2024). *Identification of effective strategies to disrupt recruitment of victims in human trafficking: Qualitative data, systems modeling, survivors and law enforcement*. National Institute of Justice. Technical Report (NCJ 308701; Grant # 2020-MU-MU-0040).
- Midgley, G., Johnson, M. P., & Chichirau, G. (2018). What is community operational research? *European Journal of Operational Research*, 268(3), 771–783. <https://doi.org/10.1016/j.ejor.2017.08.014>
- Minnesota Department of Education. *Minnesota student survey*. Retrieved August 13, 2023, from <https://education.mn.gov/mde/dse/health/mss/>
- Morris, W. T. (1967). On the art of modeling. *Management Science*, 13(12), B–717. <https://doi.org/10.1287/mnsc.13.12.B707>
- Mull, S. (2023). *The multi-billion dollar business of human trafficking non-profits*. Retrieved February 1, 2024, from <https://www.janeschool.org/blog/kutcher>
- Mullins, K. (2019). A path to protection: Collateral crime vacatur for Wisconsin's victims of sex trafficking. *Wisconsin Law Review*, 1551–1558. <https://doi.org/10.2139/ssrn.3457956>
- Ortiz, K., Nash, J., Shea, L., Oetzel, J., Garoutte, J., Sanchez-Youngman, S., & Wallerstein, N. (2020). Partnerships, processes, and outcomes: A health equity-focused scoping meta-review of community-engaged scholarship. *Annual Review of Public Health*, 41(1), 177–199. <https://doi.org/10.1146/annurev-publhealth-040119-094220>
- Pidd, M. (1999). Just modeling through: A rough guide to modeling. *Interfaces*, 29(2), 118–132. <https://doi.org/10.1287/inte.29.2.118>
- Ramchandani, P., Bastani, H., & Wyatt, E. (2025). Unmasking human trafficking risk in commercial sex supply chains with machine learning. *Manufacturing & Service Operations Management*, 27(3), 700–719. <https://doi.org/10.1287/msom.2022.0304>
- Rittel, H. W., & Webber, M. M. (1973). Dilemmas in a general theory of planning. *Policy Sciences*, 4(2), 155–169. <https://doi.org/10.1007/BF01405730>
- Roe-Sepowitz, D. (2019). *Child sex trafficking survivor roundtable*. U.S. Department of Justice, Office of Justice Programs AMBER Alert Training and Technical Assistance Program.
- Roe-Sepowitz, D., Greene, E., Bruist, K., Dirks, S., Walters, J., Gallagher, J., Bracy, K., Hogan, K., Lul, B., Byun, J., & Duffield, V. (2020). *Trick roll study: Forced criminality in sex trafficking situations*. Retrieved February 1, 2024, from https://socialwork.asu.edu/sites/default/files/2022-08/asu_lvmpd_amber_alert_trick_roll_report_january_2020-reduced.pdf
- Sánchez, V., Sanchez-Youngman, S., Dickson, E., Burgess, E., Haozous, E., Trickett, E., Baker, E., & Wallerstein, N. (2021). Cbpr implementation framework for community-academic partnerships. *The American Journal of Community Psychology*, 67(3–4), 284–296. <https://doi.org/10.1002/ajcp.12506>
- Sandmann, L. R., & Jones, D. O. (Eds.). (2023). *Building the field of higher education engagement: Foundational ideas and future directions*. Taylor & Francis.
- Sen, A., Adeniye, S., Basu, K., Ravishankar, S., Sefair, J., Roe-Sepowitz, D., Helderop, E., Grubestic, T., & Sen, A. B. (2022). Human trafficking interdiction problem: A data driven approach to modeling and analysis. 2022 *IEEE International Symposium on Technologies for Homeland Security (HST)* (pp. 1–8). IEEE.

- Sharkey, T. C., Barrick, K., Martin, A., Maass, K. L., Farrell, L., & Song, Y. (2021). Better together: A transdisciplinary approach to disrupt human trafficking. *ISE Magazine*, 51(11), 34–39. <https://doi.org/10.21428/cb6ab371.c4eb821a>
- Smith, C. M., & Shaw, D. (2019). The characteristics of problem structuring methods: A literature review. *European Journal of Operational Research*, 274(2), 403–416. <https://doi.org/10.1016/j.ejor.2018.05.003>
- Tezcan, B., Maass, K. L., Ayler, T., Forliti, T., Friedman, J., Mariotti, M., Martin, L., Nelson, C., & Sharkey, T. C. (2025). Modeling youth's susceptibility to trading sex using Markov chains.
- Tobey, M., Li, R., Özaltn, O. Y., Mayorga, M. E., & Caltagirone, S. (2024). Interpretable models for the automated detection of human trafficking in illicit massage businesses. *IIE Transactions*, 56(3), 311–324. <https://doi.org/10.1080/24725854.2022.2113187>
- Tueller, S. J., Gibbs, D. A., & Kluckman, M. N. (2023). Estimating unidentified sex trafficking in the child welfare population. *Journal of Human Trafficking*, 9(2), 181–193. <https://doi.org/10.1080/23322705.2020.1870093>
- Tuhiwai Smith, L. (2012). *Decolonizing methodologies: Research and indigenous peoples*. Zed books.
- U.S. National Institute of Justice. (2023). *Fy23 research and evaluation on trafficking in persons*. Retrieved February 15, 2024, from <https://nij.ojp.gov/funding/opportunities/o-nij-2023-171574>
- Vollinger, L. (2022). *The process of leaving sex trafficking: Using life history calendar methods to understand the role of formal systems and support*. Michigan State University.
- Wallerstein, N., Muhammad, M., Sanchez-Youngman, S., Rodriguez Espinosa, P., Avila, M., Baker, E. A., Duran, B., Belone, L., Golub, M., Lucero, J., Mahdi, I., Noyes, E., Nguyen, T., Roubideaux, Y., Sigo, R., & Duran, B. (2019). Power dynamics in community-based participatory research: A multiple-case study analysis of partnering contexts, histories, and practices. *Health Education and Behavior*, 46(1_suppl), 19S–32S. <https://doi.org/10.1177/1090198119852998>
- Wallerstein, N., Oetzel, J. G., Sanchez-Youngman, S., Boursaw, B., Dickson, E., Kastelic, S., Koegel, P., Lucero, J. E., Magarati, M., Ortiz, K., & Parker, M. (2020). Engage for equity: A long-term study of community-based participatory research and community-engaged research practices and outcomes. *Health Education and Behavior*, 47(3), 380–390.
- White, A., Guikema, S., & Carr, B. (2024). Why are you here? Modeling illicit massage business location characteristics with machine learning. *Journal of Human Trafficking*, 10(1), 20–40. <https://doi.org/10.1080/23322705.2021.1982238>
- Willemain, T. R. (1994). Insights on modeling from a dozen experts. *Operations Research*, 42(2), 213–222. <https://doi.org/10.1287/opre.42.2.213>
- Willemain, T. R. (1995). Model formulation: What experts think about and when. *Operations Research*, 43(6), 916–932. <https://doi.org/10.1287/opre.43.6.916>
- Xie, X., & Aros-Vera, F. (2022). An interdependent network interdiction model for disrupting sex trafficking networks. *Production & Operations Management*, 31(6), 2695–2713. <https://doi.org/10.1111/poms.13713>
- Zhang, S. (2022). Progress and challenges in human trafficking research: Two decades after the Palermo Protocol. *Journal of Human Trafficking*, 8(1), 4–12. <https://doi.org/10.1080/23322705.2021.2019528>