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Health Research Policy and Systems (2026) 24:54
https://doi.org/10.1186/s12961-026-01491-4

Health Research Policy and Systems

RESEARCH

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Structural analysis and causal loop modelling: an integrated systems approach to analysing perinatal service delivery in carceral settings in Ontario, Canada

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Abstract

Background In Ontario, Canada, incarcerated individuals and their newborns have adverse health outcomes. Perinatal care delivery in these settings is complex and fragmented across health, social service and carceral systems. This study aimed to apply and demonstrate an integrated systems-based analytical approach to examine dynamic interactions within carceral perinatal care and to identify influential variables and leverage points for policy and service improvement.

Methods Using qualitative interview data from individuals who experienced incarceration while pregnant and from healthcare and social service providers, we applied an integrated methodological framework combining structural analysis (MICMAC) and causal loop diagramming. This stepwise approach was used to identify system variables, map causal pathways and feedback loops, and assess influence–dependence relationships within Ontario's carceral perinatal care system.

Results Our analysis identified two key variables as central drivers of system behaviour through reinforcing and balancing loops, respectively: carceral staff autonomy and availability of providers. High levels of carceral staff autonomy reinforce power imbalances by decreasing providers' autonomy, which in turn constrains perinatal care delivery. Availability of providers operates within a balancing loop, whereby increased availability strengthens incarcerated clients' autonomy and increases their knowledge of human rights. Advocacy was identified as a key leverage point for navigating power dynamics within the system.

Conclusions This study demonstrates the utility of integrating structural analysis with causal loop modelling to examine institutional dynamics, constraints and leverage points in complex health service systems. By identifying advocacy and comprehensive rights training as potentially essential interventions, alongside policy modifications, these findings highlight actionable pathways to reduce power imbalances and improve perinatal health outcomes among incarcerated individuals and their newborns. The approach provides a transferable framework for understanding complex and fragmented service delivery contexts and for informing evidence-based health policy and implementation strategies.

Keywords Carceral settings, Causal loop diagram, Health systems, Incarceration, Maternal health, Perinatal care, Reproductive justice, Service delivery systems, Structural analysis (MICMAC)

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Introduction

Since 2000, the number of imprisoned women and girls worldwide increased by 57%, compared with a 22% increase among male prisoners [1]. The majority of the imprisoned female population is under 45 years of age [2], placing them within the reproductive age range of 15–49 years [3]. The United Nations Rules for the Treatment of Women Prisoners and Non-Custodial Measures for Women Offenders (the Bangkok Rules) outline internationally recognized gender-specific health needs of incarcerated women, including expectations for providing timely and appropriate perinatal care [4]. Despite these standards, evidence demonstrates higher risk of adverse health outcomes for incarcerated pregnant people and their newborns compared with the general population [5–9].

In Canada, perinatal care for all clients is expected to align with established standards of care, including timely access to prenatal, intrapartum and postpartum services; continuity of care across systems; coordination across health and social systems; and support for informed decision-making. For example, The Society of Obstetricians and Gynecologists of Canada recommends routine ultrasounds, glucose testing, vaccinations, access to appropriate nutrition, and support and treatment for opioid use during pregnancy [10]. In Ontario, these expectations are supported through the Ontario Primary Care Act, 2025, which outlines objectives for timely access to services, coordinated care and patient empowerment through access to health information [11]. However, for individuals who experience incarceration during pregnancy, these expectations of perinatal care are not consistently met. Existing literature demonstrates how incarcerated individuals frequently face delays in accessing care [9, 12, 13]; unmet nutritional needs [12]; limited access to support and treatment for opioid use during pregnancy [12]; disruptions in continuity of care [12, 13]; and limited autonomy and access to information in decisions affecting care [12, 13], alongside increased risks of adverse maternal and neonatal outcomes [8] compared with the general population. Within carceral settings, the delivery of perinatal care is impacted by institutional structures and constraints which limit access, coordination and informed decision-making, contributing to gaps between established standards of care and the realities of carceral care delivery [12, 13].

Carceral perinatal care delivery in Ontario is fragmented across multiple agencies, disrupting continuity of care [12, 13]. These agencies include Correctional Service Canada; the Ministry of the Solicitor General (Ontario); the Ontario Ministry of Health; the Ontario Ministry of Children, Community and Social Services; and community-based agencies [13]. Incarcerated clients may need to move between these agencies over the course of their pregnancy, custody and release, resulting in changes in the entity responsible for care delivery and oversight. This context involves conflicting priorities: Correctional services focus on safety and security, while health and social services prioritize patient-centred health and well-being. These combined factors contribute to delayed and missed appointments, inconsistent access to health and social supports, limited informed consent, dehumanizing treatment and loss of autonomy for incarcerated individuals and their providers [12, 13]. Mechanisms which may contribute to these barriers include correctional officer understaffing, limiting transport to off-site appointments, and delays in processing inmate request forms containing incarcerated patients' medical concerns [12]. Research evidence from Ontario demonstrates poorer health outcomes and reduced access to care for incarcerated and formerly incarcerated individuals, compared with their never-incarcerated counterparts. Specifically, these disparities include low birth weight, high rates of preterm birth, high rates of neonatal intensive care unit admissions [8] and reduced antenatal care [9]. These findings highlight discrepancies between established standards for appropriate perinatal care and the realities of care delivery within carceral settings in Ontario, underscoring the need to examine how perinatal care is organized and delivered across these intersecting systems.

Systems-thinking facilitates the understanding of component interactions, offers approaches for analysing topics of interest and informs interventions to improve health outcomes [14]. In public health, a complex health approach recognizes poor health and health inequalities as products of numerous interconnected factors [15]. Systems thinking incorporates inter- and transdisciplinary perspectives and engages researchers and stakeholders across sectors [14]. This approach is well-suited for examining carceral perinatal service delivery across health, social and carceral ministries.

In this study, we analysed carceral perinatal care delivery in Ontario, Canada, using a systems perspective to identify key variables and feedback relationships contributing to the health outcomes of incarcerated pregnant individuals and their newborns. The objective of this study was to use a systems-thinking approach to provide insight into the structure and dynamics of the system, supporting the identification of evidence-based leverage points. These leverage points serve as potential areas of intervention capable of improving policy and system-level delivery of perinatal care to incarcerated individuals.

Methods

Study design

This research is part of a larger case study exploring the delivery of perinatal care to individuals incarcerated in Ontario, Canada. This specific study aimed to develop a causal loop diagram (CLD) to examine the dynamic interactions among key variables influencing perinatal service delivery in carceral settings. To investigate this complex system, we adopted a multi-method design integrating stakeholder interview data, structural analysis and causal loop diagramming. First, drawing on interview data, we identified and selected variables representing carceral perinatal care delivery. We then applied structural analysis to map relative influence and dependence among variables [16, 17]. This analysis subsequently informed the development of a CLD to illustrate the system's behaviour, including interactions among variables, feedback loops and levers of change [18–21]. Structural analysis and causal loop diagramming offer appropriate methods for examining how system components interact to influence carceral perinatal care delivery. These integrated methods are shown in Fig. 1 and described in detail below.

Data collection

Participants and recruitment

The structural analysis was informed by 31 semi-structured interviews conducted by the principal investigator (PI) between October 2023 and July 2024. The interviews were conducted as part of the larger case study.

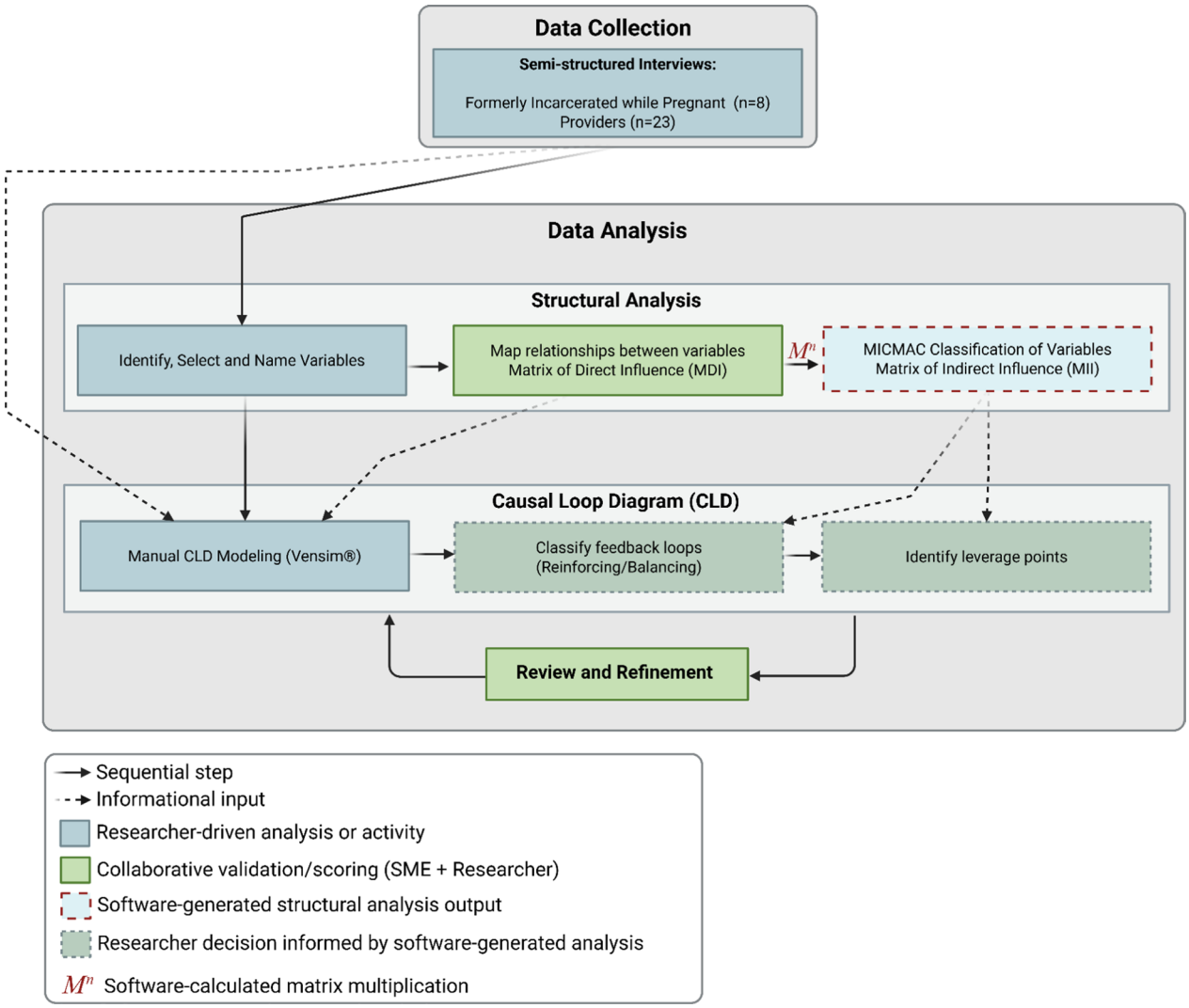

Fig. 1 Methods flowchart. Sequential diagram of the integration of semi-structured interviews, structural analysis and causal loop diagram (CLD) development. Created with BioRender.com

Interview participants were recruited using a combination of purposive and snowball sampling strategies. For purposive sampling, we identified and approached professional associations and colleagues with experience in perinatal care in carceral settings. These associations and colleagues disseminated emails containing recruitment posters and study information to social service providers and healthcare providers (e.g. midwives, nurses and physicians) within their networks. Snowball sampling was used by inviting both participants who had experienced incarceration while pregnant and provider participants to share study information with individuals who met the inclusion criteria and who might be interested in participating. For instance, social service providers with experience working in correctional facilities shared the study information with colleagues, and formerly incarcerated participants shared study information with peers who had experienced pregnancy during incarceration. Participants included 8 individuals who experienced incarceration in Ontario, Canada, while pregnant and 23 social service and healthcare providers with experience delivering perinatal services to individuals incarcerated in Ontario, Canada. As a token of appreciation for their time and contribution, participants who experienced incarceration received a $50 (Canadian dollars [CAD]) Interac e-Transfer, while social service and healthcare providers received $25 (CAD) in compensation, provided as an Interac e-Transfer, gift card or donation to a charity of their choosing.

Interviews

Two interview guides were developed: one for individuals formerly incarcerated during pregnancy, and one for social service and healthcare providers. Open-ended interview questions focused on the experiences of receiving (formerly incarcerated participants) and delivering (providers) perinatal care within carceral environments. Examples of questions included: "To begin, tell me the story about your experience of being pregnant while incarcerated" (formerly incarcerated participants) and "Tell me about a time when you provided care to a person who was pregnant while incarcerated, and the care situation was difficult or did not go well. Please describe the process you went through when making difficult decisions about the care of the individual who was pregnant while incarcerated" (providers). These questions were intended to elicit a broad range of experiences, from which system variables were subsequently identified across the datasets. Informed consent was obtained, and interviews were conducted via Microsoft Teams or Zoom. Interviews ranged from 27 to 125 min in duration, with a median duration of 61 min. The PI transcribed the interviews verbatim. Anonymized transcripts were stored on the university's password-protected server and were accessible only to the PI and last author (W.E.P.). Additional details pertaining to participant demographics, data collection and analysis, and the respective interview guides used with formerly incarcerated individuals and social service and healthcare providers are reported elsewhere [12, 13], respectively.

Ethical approval

Ethical approval for the study was granted by the University of Ottawa Research Ethics Board (ethics file no. H-01–23-8376).

Data analysis

Structural analysis

Structural analysis facilitates the description of a system by identifying its principal variables and the interconnections between them [22]. This approach provides a comprehensive representation of the system and simplifies it into its essential variables [16]. Structural analysis involves three steps [16]:

1. Identification of variables.
2. Mapping relationships among variables.
3. Classification of variables using the Matrice d'Impacts Croisés Multiplication Appliquée à un Classement (Matrix of Crossed Impact Multiplications Applied to a Classification [MICMAC]) method [23].

Variables – identification, selection and naming The first step of the structural analysis involves identifying and defining the system's variables. Using qualitative data for system mapping offers detailed and wide-ranging information specific to the system in question, highlighting a key advantage of this approach [20]. To identify a comprehensive list of variables describing the system being analysed, all avenues of inquiry are considered from the outset, and diverse methods of brainstorming and creative exploration are actively encouraged [16]. However, boundaries must be drawn to ensure focus and manage the level of complexity of the CLD by including only variables critical to understanding the situation of interest [24]. For this study, the boundary was defined as variables pertaining to perinatal care delivery to individuals incarcerated in Ontario, Canada. We used Nvivo 14 software to manage and code the qualitative interview data. We followed Braun and Clarke's [25] reflexive thematic analysis framework to guide a systematic, inductive analysis of the data, supporting the identification, organization and interpretation of participants' narratives. Initial coding was conducted by X.B., who systematically reviewed tran-

scripts from both providers and formerly incarcerated participants to generate preliminary codes. W.E.P. independently double-coded a subset of these transcripts. X.B. and W.E.P. met weekly to review and refine codes, with discrepancies discussed and resolved through consensus. X.B. then reviewed and compared coded data across provider and formerly incarcerated participant transcripts in NVivo to identify key concepts. Codes were interpreted and grouped into concepts on the basis of their salience across both datasets. These concepts were subsequently defined and formalized as system variables [26, 27].

Matrix of direct influence (MDI) – mapping the relationship among variables The second step of structural analysis involves constructing a matrix of direct influences (MDI) to quantify direct relationships among variables [16]. The PI facilitated a 3-h and 15-min session with two other subject matter experts (A.M. and Z.H.), midwives with 12 years of combined experience delivering perinatal care to formerly incarcerated and incarcerated individuals. To ensure consistent interpretation throughout the workshop, the subject matter experts (SME) received a data dictionary defining each variable and outlining the influence scoring scale (0 = no influence to 3 = strong influence) before developing the MDI. The assignment of influence scores combines qualitative judgment regarding the existence of relationships with quantitative weighting of their strength [16]. The group then discussed examples of relationships warranting 1 (low influence) and 2 (medium influence) scores and agreed on their definitions. During the workshop, SME reviewed each variable, discussed its potential influence on other variables and assigned scores through consensus. Following Godet's [16] procedure, we completed the matrix by row, assessing the influence of each driving variable on the dependent variables listed across the columns. Following the session, and as part of the analysis process, the PI contacted the SME via email to clarify specific variables' scores and adjusted scoring on the basis of their responses. After finalizing the MDI, it was used as input for the computation analysis, generating the matrix of indirect influences (MII) using the MICMAC method.

Matrix of indirect influence (MII) – MICMAC classification of variables In the third step of the structural analysis, we applied the MICMAC method to the completed MDI to identify key variables and assess their influence (drive) and dependency within the system [16]. As such, the PI entered the MDI into the MICMAC—Analyse structurelle online tool [28]. The software raises the MDI to successive powers (e.g. M^2, M^3, M^n), thereby calculating the MII. This process assesses each variable's influence and dependence on other variables by considering the number of indirect pathways and the length of feedback loops associated with a given variable [16]. It utilizes Boolean iterations, mathematically validating the propagation of influences across the system [16]. While the MDI classifications reflect short-to-medium-term impacts (fewer than 10 years), the MII-derived variable rankings account for the mathematically projected cumulative effects of pathways and feedback loops manifesting over the medium to long term (10–15 years) [16].

Quadrant map The MICMAC computation subsequently categorizes variables according to their driving and dependency power, positioning them within one of four quadrants on a map. Figure 2 shows a blank version of the MICMAC driving–dependence quadrant grid and the grey zone.

Quadrant I: Independent variables Quadrant I includes low driving power and low dependence variables, referred to as independent variables. Independent variables have little driving force on the system's dynamics, and over the medium term do not become controlling elements within the system under study [29]. These variables can be excluded from the analysis of the system [17].

Quadrant II: Dependent variables Quadrant II contains dependent variables with low driving power and high dependency, impacted by driving variables found in quadrants III (relay variables) and IV (influential variables) [17].

Quadrant III: Relay variables Quadrant III includes variables with high driving power and high dependency, referred to as relay variables. These variables are unstable, as any action upon them will simultaneously affect other variables in the system and create feedback on themselves, thereby profoundly modifying the overall dynamic of the system [17].

Quadrant IV: Influential variables Quadrant IV includes variables with high driving power and low dependency, referred to as influential or driving variables. These serve as key drivers, shaping the development and interaction of other elements within the system and establishing the system's conditions and boundaries. Whenever possible, they are prioritized for action [17].

Grey zone: average driving power and dependence variables The grey area within the driving–dependence map (Fig. 2) represents variables with average levels of driving and dependency power. They are insufficiently characterized to draw any conclusion about their role in the system [17].

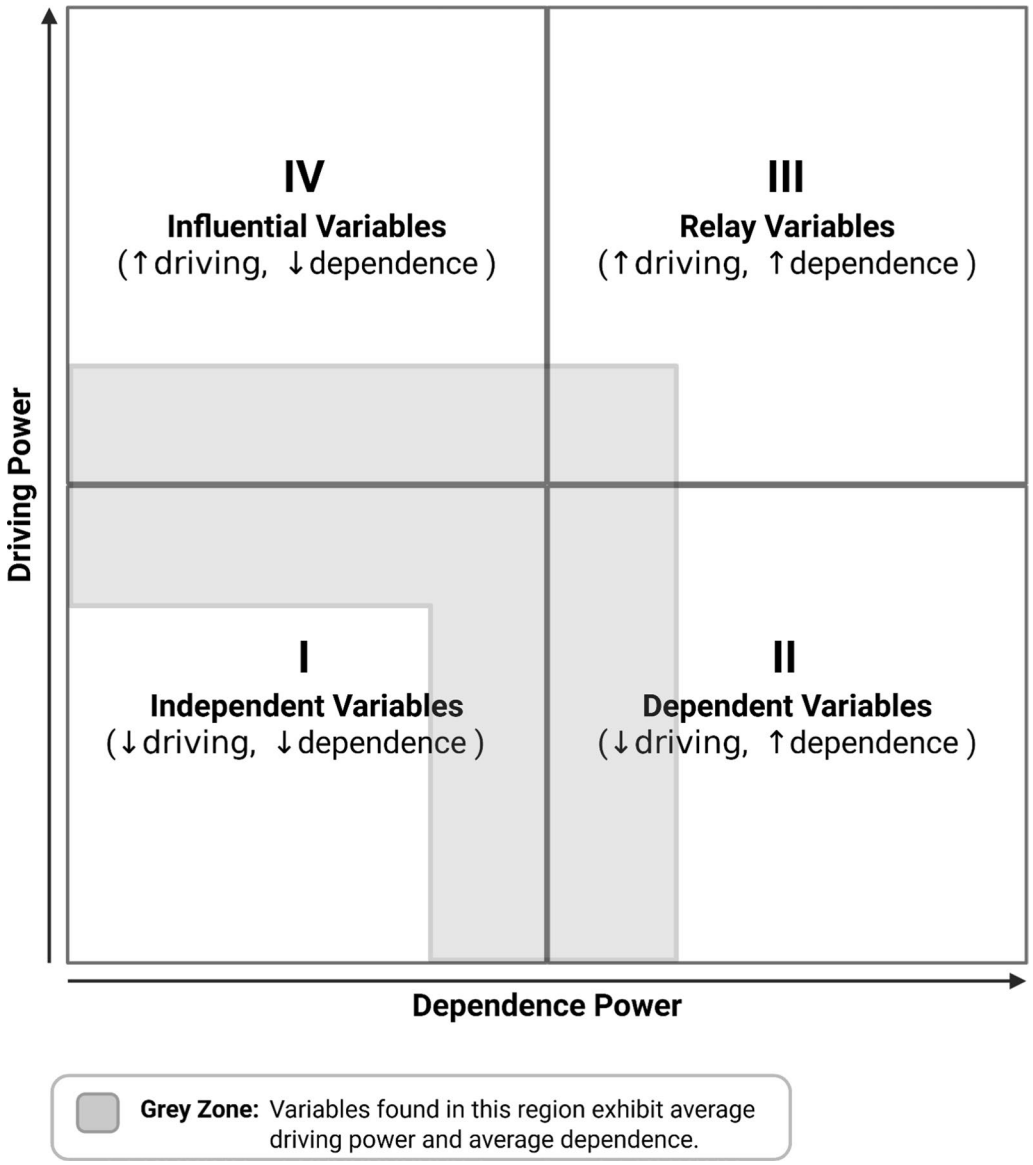

Fig. 2 Conceptual representation of the MICMAC driving–dependence quadrant map. Created with BioRender.com

MICMAC ranking of driving variables The MICMAC structural analysis software also ranks variables on the basis of the frequency and intensity of their influence and dependency relationships. By computing the MII, the tool identifies so-called hidden variables—factors appearing secondary in the MDI which exert significant system-wide impact through indirect pathways. Comparing these two rankings reveals how indirect influences shift a variable's importance [16]. We used these MICMAC results to identify key variables and relationships shaping the system's behaviour, directly informing the development of the CLD.

Causal loop diagram (CLD) CLDs are a systems mapping approach helping analysts and researchers understand phenomena of interest by examining the structures, relationships and behaviour within a system [26]. CLDs focus on causal relationships with the strongest influence on the system's behaviour [21]. Key components of CLDs include feedback loops, organizing complex systems and incorporating several concepts and variables [20]. CLDs are particularly useful for understanding how feedback mechanisms shape system behaviours [21]. They capture and illustrate stakeholders' representations of systems, including their percep-

tions of the relationships and interactions among the system's elements [30].

In CLDs, arrows indicate the cause-and-effect relationships between variables. An arrow with a positive polarity (+) signifies a change in the same direction for both variables (i.e. when A increases, B increases, and when A decreases, B decreases). In contrast, an arrow with a negative polarity (−) indicates a change in the opposite direction (i.e. when A increases then B decreases, and vice versa) [26, 30]. Reinforcing (R) and balancing (B) feedback loops are labelled with circular arrows surrounding either the letter "R" or "B". In a reinforcing loop, the behaviour amplifies or snowballs since all arrows within the loop have the same polarity (all positive [+] or all negative [−]) [31] or an even number of arrows with a negative polarity [26]. In contrast, in a balancing loop, the behaviour stabilizes because the loop includes an odd number of arrows with a negative polarity, producing feedback counteracting the initial change [26]. Delays in influences of one variable on another are represented by a pair of lines (//) [26, 30]. When a balancing loop has a delay, actions may take place only after circumstances have already changed. For example, delays in the timeliness of perinatal care can exacerbate the rate of adverse perinatal outcomes. By the time adverse outcomes are detected, and providers increase monitoring or escalate care, the individual's condition may already have deteriorated. These delayed responses and subsequent adjustments can produce a back-and-forth pattern in the system, known as oscillation [18]. Figure 3 shows an example of a simple CLD and its components. As depicted in Fig. 3, access to perinatal care facilities directly influences timeliness of perinatal care, and through this relationship, it indirectly influences the rate of adverse perinatal outcomes.

On the basis of the analysis of the semi-structured interviews and the MDI, we determined the relationship between the variables [26, 30]. The PI established the polarity of each causal link on the basis of the interview data. For example, since the data indicated that an increase in provider workload resulted in a decrease in provider health, a negative polarity (−) was assigned between these variables. Conversely, when variables moved in the same direction, a positive polarity (+) was assigned. The PI then manually drew the CLD using Vensim® PLE 10.4.0 software [32]. Once the structural links were drawn, we analysed the system to identify, classify and name the resulting feedback loops.

Classifying and naming feedback loops The MICMAC results served as a filter to manage system complexity and to avoid creating an overly busy diagram, prioritizing high influence and relay variables. This ensured the CLD focused on the feedback loops most critical to the system's behaviour and potential for change. Following the determination of these structural links, we classified

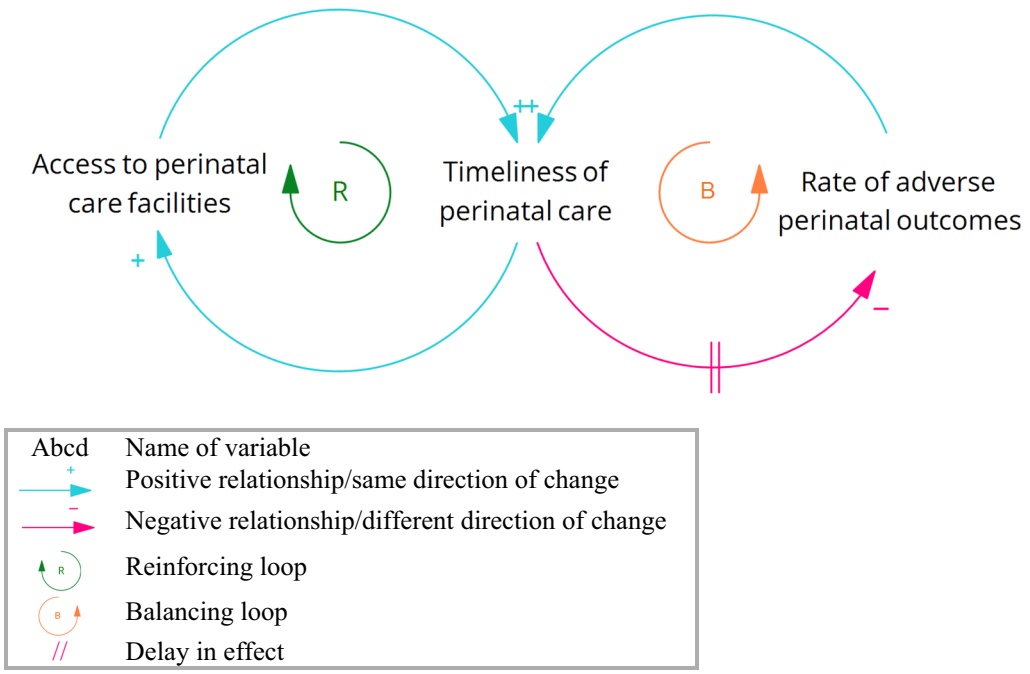

Fig. 3 Example of simple causal loop diagram depicting the relationship between access to perinatal care facilities, timeliness of perinatal care and rate of adverse perinatal outcomes

the resulting feedback loops as either reinforcing (R) or balancing (B) [30]. The PI then utilized Vensim® to review and verify the variables and their associated loops. This systematic approach supported the identification of key leverage points within the system.

Identifying leverage points In this study, the MICMAC analysis identified points of prioritization for action [16], defined as structurally influential variables (quadrant IV) serving as candidates for further examination in the CLD analysis. Accordingly, our approach distinguishes between structurally influential variables identified through MICMAC computation and dynamic leverage points identified through CLD feedback loops.

Leverage points represent areas within a system where a modification can lead to important changes in the system's behaviour [19]. To identify these points, we examined CLD feedback structure while drawing on MICMAC results to contextualize variable influence. Variables were assessed on the basis of their connections to structurally influential variables, their position within feedback loops, their involvement in reinforcing and balancing dynamics, and their ranking in the MII. Loop structures were reviewed to trace how changes to a specific variable could alter the overall system behaviour. This process supported the identification of leverage points with the potential to shift the delivery of perinatal care in carceral settings.

Reviewing and refining the CLD Critical components of the CLD development process include refining the CLD and validating it with SMEs [30]. We continuously reviewed and refined the CLD on the basis of the analysis of qualitative data, MDI and MII. Following the MDI mapping session (see p. 14), the PI presented a draft CLD to the SMEs to validate the model and to identify any missing or misrepresented variables. The SMEs suggested newborn apprehension be included as a variable. The PI reviewed the interview data concluding that neither providers nor formerly incarcerated individuals discussed this topic in depth. We did not include newborn apprehension as a standalone variable; however, its implications were captured within parental bonding opportunities. The PI sent a revised CLD to the SMEs via email to validate the accuracy of the connections and polarity between variables.

Results

Structural analysis

Variables – identified, selected and named

Through the analysis of the qualitative interview data, several key factors shaping the carceral perinatal care delivery system were identified, informing the identification, selection and naming of variables. Through the analysis of the qualitative interview data, we identified a final list of 21 variables describing the carceral perinatal care delivery system (Table 1).

Matrix of direct influence (MDI) – mapped relationships among variables

Figure 4 shows the MDI completed during the session with the SMEs, mapping the system's driving and dependent variables.

Figure 4 shows the row and column sums of the MDI for each variable. The sum of each driving variable's row represents the total strength of its direct influence on other variables in the system. The sum of each dependent variable's column represents the total strength of direct influence it receives from other variables in the system. Therefore, a higher sum indicates a higher level of driving or dependency for the associated variable. The five variables with the highest driving scores (driving sum), identified in black, are availability of providers, advocacy, application of human rights, availability of carceral employees and carceral staffs' autonomy. Changes to these variables strongly affect the behaviour of the system [16]. In contrast, the six variables with the highest dependency scores (dependency sum) are parental bonding opportunities, provider workload, maternal health, provider health, coordination of care, and newborn/infant health. They are the most sensitive to changes within the system [16].

Matrix of indirect influence (MII)—MICMAC-classified variables

Quadrant map Figure 5 shows the MICMAC direct–indirect displacement map for the 21 variables included in the analysis of carceral perinatal care delivery. The larger dot represents the variable's position within the direct plane (MDI) while the smaller dot represents its position in the indirect plane (MII). The line connecting the two dots represents the variable's displacement between planes. The following discussion related to the quadrants focuses on the white areas of the map, excluding the grey zone except where specified.

Quadrant I: Independent variables None of the variables of the carceral perinatal care delivery system fell within this area.

Quadrant II: Dependent variables Four variables in our system were in quadrant II: newborn health (NewbHealth), parental bonding opportunities (ParBondOpp), fetal health (FetalHeal) and volume of inmate request forms (VolReqForm).

Table 1 Number (No.), name, abbreviation and definition of each variable identified through data analysis

No.	Variable name	Variable abbreviation	Definition
1	Adherence to clinical appointments	AdAppoint	Incarcerated individuals' ability to attend scheduled perinatal health visits within or outside the carceral facility
2	Advocacy	Advocacy	Actions taken by providers, family, friends or allies to promote, defend or advance the rights and needs of incarcerated pregnant individuals in relation to perinatal care and other areas of concern
3	Application of human rights	ApplHumRig	The extent to which human rights principles are upheld, protected and enacted in relation to perinatal care access and/or delivery, within and across different systems (e.g. carceral, clinical and community)
4	Availability of carceral employees	AvCarEmplo	Carceral employees' availability to escort or otherwise facilitate incarcerated individuals' access to perinatal services
5	Availability of providers	AvProvider	Healthcare or social service providers' availability to deliver perinatal or other services to incarcerated individuals
6	Carceral staff autonomy	CarStafAut	The level of discretionary decision-making authority exercised by nonmedical carceral staff over aspects of perinatal care for incarcerated individuals
7	Continuity of perinatal care	ContCare	The consistent and uninterrupted delivery of the incarcerated individuals' perinatal services over time and across different systems (e.g. carceral, clinical and community), ensuring that care is maintained across transitions
8	Coordination of care	CoorCare	The deliberate and effective organization and collaboration among carceral staff and health or social service providers to align the incarcerated individual's perinatal care activities, ensuring safe, timely and effective access to services
9	Fetal health	FetalHeal	The overall state of the fetus's well-being and normal development during pregnancy
10	Formal supports	FormSuppor	Organized/structured resources and services offered by compensated professionals (e.g. social workers, legal aid and nongovernmental organizations [NGOs]) available to support perinatal needs of incarcerated individuals
11	Incarcerated clients' autonomy	IncarClAut	The level of discretionary decision-making authority exercised by the incarcerated individuals over aspects of their perinatal care and bodies
12	Informal supports	InforSuppo	Uncompensated resources provided by family, friends or community members, contributing to the incarcerated (or formerly incarcerated) individual's well-being
13	Knowledge of human rights	KnowHumRig	An incarcerated individual, provider or carceral employee's level of awareness of their rights relevant to perinatal care access and/or delivery within and across different systems (e.g. carceral, clinical and community)
14	Maternal health	MatHealth	The physical and mental well-being of the incarcerated individual during the perinatal period
15	Newborn/infant health	NewbHealth	The physical and developmental well-being of the newborn (≤ 28 days of age) or infant following birth and in early life
16	Parental bonding opportunities	ParBondOpp	The opportunities for an incarcerated individual to build and develop emotional and physical connections with their child
17	Provider health	ProvHealth	The physical and mental well-being of healthcare and social service providers working with incarcerated perinatal clients
18	Provider workload	ProvWorklo	The volume and intensity of tasks required of providers delivering perinatal care in different systems (e.g. carceral, clinical and community)
19	Providers' autonomy	ProvAutono	The level of discretionary decision-making authority exercised by healthcare and social service providers over aspects of perinatal care for incarcerated individuals
20	Timeliness of perinatal care access	TimePerCar	The perceived promptness with which incarcerated individuals can access needed perinatal services following an identified service need or request
21	Volume of inmate request forms	VolReqForm	The number of inmate request forms completed and submitted by incarcerated individuals to access perinatal care, healthcare and other available services, and to request items

Quadrant III: Relay variables Eleven variables were in quadrant III: advocacy (Advocacy), application of human rights (ApplHumRig), coordination of care (CoorCare), continuity of perinatal care (ContCare), provider workload (ProvWorklo), formal supports (FormSuppor), timeliness of perinatal care access (TimePerCar), maternal health (MatHealth), incarcerated clients' autonomy (IncarClAut), provider health (ProvHealth) and providers' autonomy (ProvAutono). In the MDI, providers' autonomy was on the boundary of quadrants II and III,

Driving Variables	Dependent Variables: 1: Adherence to clinical appointments	2: Advocacy	3: Application of human rights	4: Availability of carceral employees	5: Availability of providers	6: Carceral staffs' autonomy	7: Continuity of perinatal care	8: Coordination of care	9: Fetal health	10: Formal supports	11: Incarcerated clients' autonomy	12: Informal supports	13: Knowledge of human rights	14: Maternal health	15: Newborn/infant health	16: Parental bonding opportunities	17: Provider health	18: Provider workload	19: Providers' autonomy	20: Timeliness of perinatal care access	21: Volume of inmate request forms	**Driving Sum**
1: Adherence to clinical appointments		1	0	0	0	0	3	3	3	2	2	0	1	3	3	3	0	2	1	3	2	32
2: Advocacy	3		3	0	3	1	2	3	2	3	2	1	2	3	3	3	3	3	2	3	3	**48**
3: Application of human rights	3	3		0	0	0	3	3	2	3	3	0	2	3	3	3	3	3	3	3	3	**46**
4: Availability of carceral employees	3	1	1		0	2	3	3	3	3	3	2	0	3	2	3	2	3	3	3	3	**46**
5: Availability of providers	3	2	3	0		0	3	3	3	3	3	1	1	3	3	3	3	3	3	3	3	**49**
6: Carceral staffs' autonomy	2	2	3	0	0		2	2	1	3	3	3	0	3	3	3	3	3	3	3	3	**45**
7: Continuity of perinatal care	0	2	1	0	0	0		3	3	3	3	1	1	3	3	3	3	3	3	3	3	41
8: Coordination of care	3	2	1	0	0	0	3		3	3	3	1	1	3	3	3	3	3	3	3	3	44
9: Fetal health	0	3	0	0	0	0	2	2		1	0	0	0	3	3	3	1	2	1	1	1	23
10: Formal supports	2	3	3	0	0	0	3	3	2		2	2	1	3	3	3	2	2	1	2	2	39
11: Incarcerated clients' autonomy	0	2	1	0	0	0	0	2	2	2		2	2	3	3	3	3	3	3	0	3	34
12: Informal supports	0	2	2	0	0	0	0	2	0	3	3		1	3	3	3	2	2	3	2	3	34
13: Knowledge of human rights	0	3	1	0	0	0	2	2	0	2	3	0		3	3	3	3	0	1	0	3	29
14: Maternal health	0	2	2	0	0	2	0	2	3	0	3	1	0		3	3	3	3	2	2	3	34
15: Newborn/infant health	0	2	0	0	0	0	0	3	0	3	2	3	0	3		3	2	3	2	0	1	27
16: Parental bonding opportunities	0	0	0	0	0	3	0	3	2	0	2	3	0	3	3		3	3	0	0	1	26
17: Provider health	0	2	3	0	3	1	2	2	1	2	2	0	0	1	1	2		3	3	3	0	31
18: Provider workload	0	3	3	0	3	1	3	3	1	3	3	3	0	1	1	2	3		2	3	3	41
19: Providers' autonomy	0	2	2	0	0	1	3	3	0	3	1	1	0	1	1	2	3	3		3	0	29
20: Timeliness of perinatal care access	0	0	2	0	2	0	3	3	3	3	2	0	1	3	3	2	3	3	0		1	34
21: Volume of inmate request forms	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	0	3		9
Dependency Sum	19	37	31	0	11	11	37	**50**	34	45	45	24	13	**51**	**50**	**53**	**51**	**53**	39	43	44	

Fig. 4 Matrix of direct influences (MDI) for variables related to carceral perinatal care delivery, developed from subject matter experts' ratings of direct influences on a scale from 0 (no influence) to 3 (strong influence)

indicating no clear assignment to either category. Following the MICMAC computation, the MII positioned this variable within quadrant III – relay variables.

Quadrant IV: Influential variables Three variables were in quadrant IV: availability of providers (AvProvider), availability of carceral employees (AvCarEmplo) and carceral staff autonomy (CarStafAut).

Grey zone: average driving power and dependence variables Three variables fell within the grey zone: informal supports (InforSuppo), adherence to clinical appointments (AdAppoint) and knowledge of human rights (KnowHumRig).

MICMAC-ranked driving variables The top five driving variables remained the same, with only two vari-

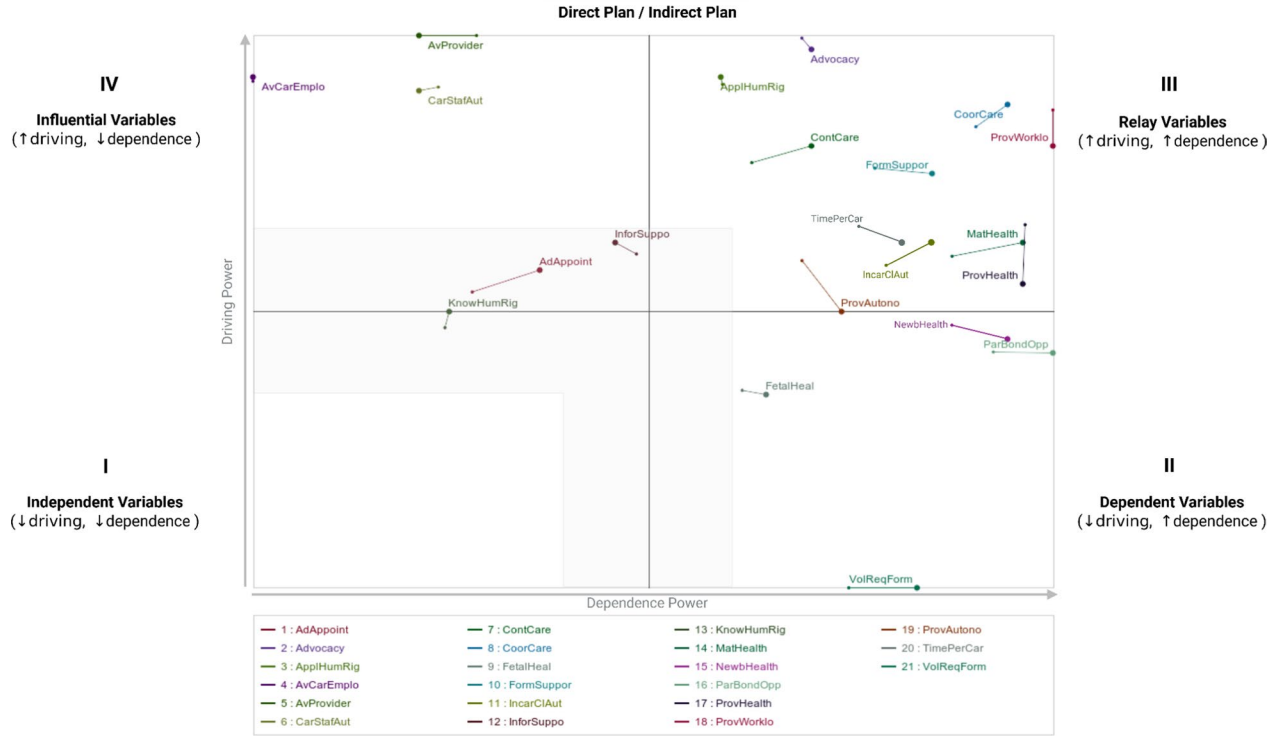

Fig. 5 Direct–indirect displacement map of the 21 variables related to carceral perinatal care delivery (figure generated by MICMAC—Analyse structurelle online tool; modified using BioRender.com)

ables changing rank (Table 2). Availability of providers, advocacy and carceral staff autonomy maintained their initial influential rankings of first, second and fifth respectively, indicating that their relative influence within the system remained stable. Application of human rights decreased in ranking from third to fourth, while availability of carceral employees increased from fourth to third, suggesting that its systemic influence becomes slightly more pronounced when considering indirect relationships.

In our study, no hidden variables were identified. While changes in rankings were observed, notably for provider health (increase) and incarcerated clients' autonomy (decrease), these shifts did not cause any variables to migrate between quadrants on the influence–dependence plane (Fig. 5). Consequently, the system demonstrates high structural stability, with the MII confirming the initial MDI classifications.

Influential variables (quadrant IV) identified through the MICMAC computation informed our selection of the feedback loops described below. The CLD examines how the variables interact to influence carceral perinatal care delivery.

Causal loop diagram

System overview and diagram presentation

Given the inherent complexity and interconnectedness of systems, no single figure can depict an entire system [26]. Figure 6 depicts the variables and relationships most significant to perinatal care delivery in Ontario carceral settings.

Classification and naming of feedback loops

Each component of a system and their interconnections are important to the system's functions [18]. Through the MICMAC analysis, three influential variables were identified in quadrant IV of the MII: availability of providers, availability of carceral employees and carceral staff autonomy. Because the CLD contains numerous feedback loops, we prioritized those containing these influential variables. Availability of carceral employees was not associated with any feedback loops, whereas availability of providers and carceral staff autonomy were each involved in more than 50 feedback loops. The exact number of loops cannot be determined in Vensim® PLE since it displays a maximum of 50 per

Table 2 Comparison of variable rankings by the level of influence in the matrix of direct influences (MDI) and matrix of indirect influences (MII), with corresponding change in ranking (Δ Influence) and interpretation of change

Variable	MDI	MII	Δ Influence	Interpretation
Availability of providers	1	1	→ 0	Stable influence
Advocacy	2	2	→ 0	Stable influence
Availability of carceral employees	4	3	↑ 1	Slight increase in influence
Application of human rights	3	4	↓ 1	Slight decrease in influence
Carceral staff autonomy	5	5	→ 0	Stable influence
Provider workload	8	6	↑ 2	Slight increase in influence
Coordination of care	6	7	↓ 1	Slight decrease in influence
Continuity of perinatal care	7	8	↓ 1	Slight decrease in influence
Formal supports	9	9	→ 0	Stable influence
Provider health	15	10	↑ 5	Major increase in influence
Timeliness of perinatal care access	13	11	↑ 2	Slight increase in influence
Informal supports	11	12	↓ 1	Slight decrease in influence
Maternal health	12	13	↓ 1	Slight decrease in influence
Providers' autonomy	17	14	↑ 3	Increase in influence
Incarcerated clients' autonomy	10	15	↓ 5	Major decrease in influence
Adherence to clinical appointments	14	16	↓ 2	Slight decrease in influence
Newborn health	18	17	↑ 1	Slight increase in influence
Knowledge of human rights	16	18	↓ 2	Slight decrease in influence
Parental bonding opportunities	19	19	→ 0	Stable influence
Fetal health	20	20	→ 0	Stable influence
Volume of inmate request forms	21	21	→ 0	Stable influence

↑ Gained systemic influence

→ Maintained influence

↓ Lost systemic influence

variable. Given the high volume of loops, we discuss only two key loops in detail and then describe their interactions.

Rights reinforcing loop (R) The rights loop (R1) (Fig. 7) is a virtuous reinforcing cycle as it strengthens a desirable positive feedback process [21]. We selected this reinforcing loop since it includes the influential variable carceral staff autonomy. When human rights are effectively applied in carceral settings, providers' autonomy increases, and the discretionary authority (autonomy) of carceral staff is constrained. Providers' autonomy acts as a safeguard on carceral staff's discretionary authority, helping ensure decision-making remains within human-rights boundaries. This decreases the likelihood of mistreatment and contributes to an environment where incarcerated clients' autonomy can increase. As incarcerated clients experience greater autonomy through the protection of their rights and increased involvement in decisions about their care, they are more likely to seek additional knowledge about their rights. This increased knowledge further strengthens the application of human rights.

Provider balancing loop (B) The Provider balancing loop (B1) (Fig. 8) includes two quadrant IV influential variables: availability of providers and carceral staff autonomy. In this loop, incarcerated clients' knowledge of human rights increases the volume of inmate request forms as individuals become more aware of the care and services to which they are entitled. Because these forms may not be processed immediately [12], a delay occurs between the submission of requests and their impact on provider workload. Once processed, the rising workload reduces the availability of providers, who must address the growing backlog and health conditions which may have worsened because of the delay (oscillation).

As availability of providers decreases, providers experience heightened stress and reduced capacity, leading to declines in their overall health. Declining provider health impacts their autonomy as it reduces their capacity to push against institutional constraints, enabling carceral staff autonomy to increase. Carceral staff autonomy rises, and the application of human rights decreases, reducing incarcerated clients' autonomy. This decrease in incarcerated clients' autonomy then

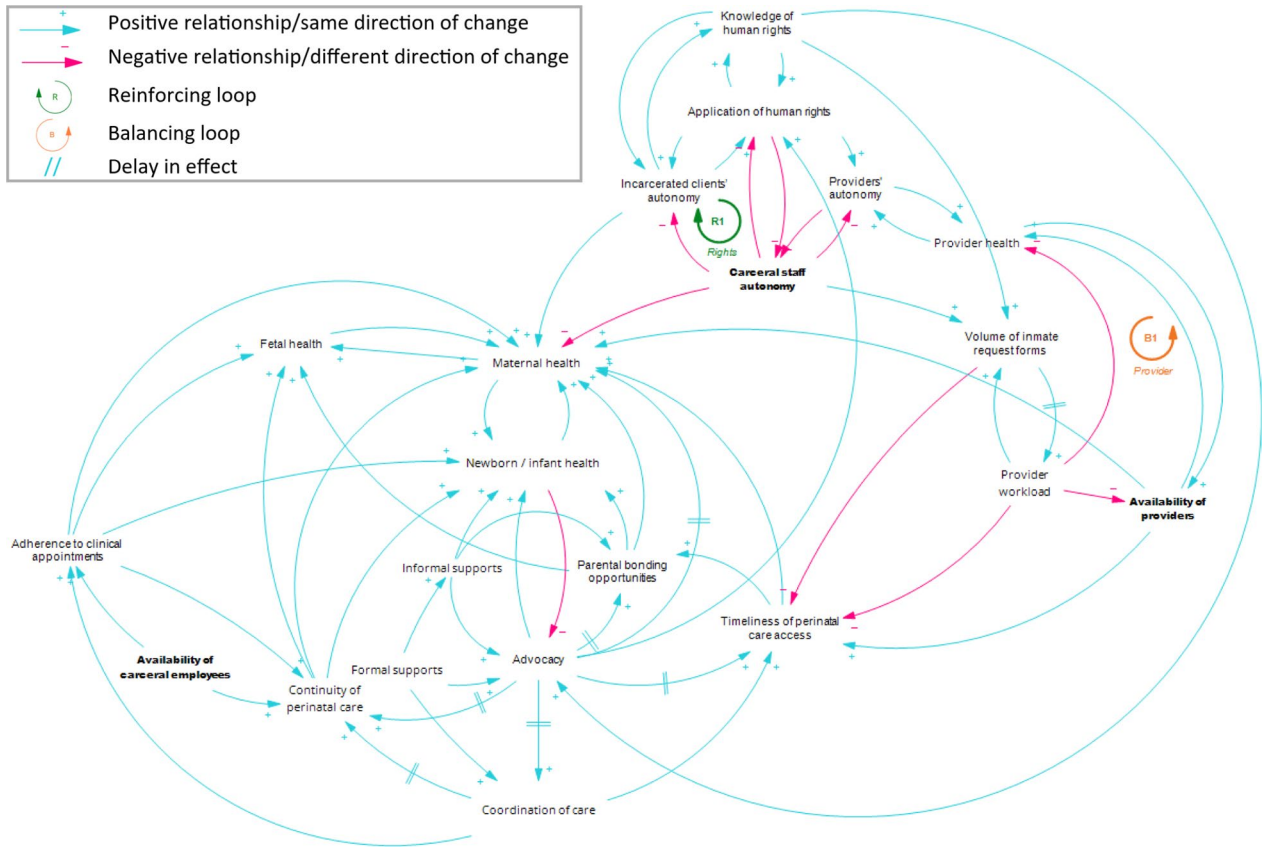

Fig. 6 Causal loop diagram (CLD) of carceral perinatal care delivery in Ontario, Canada. Key influential variables – availability of providers, availability of carceral employees and carceral staff autonomy – are emphasized in bold font

suppresses the growth in request forms, counteracting the initial increase and completing the balancing loop.

Interconnections between loops We combined the rights loop (R1) (Fig. 7) and the provider balancing loop (B1) (Fig. 8) to identify points of interconnectivity, as modifying these interconnected relationships typically produces systemic behavioural changes [18]. Figure 9 shows the combined loops and their shared components, including the influential variable – carceral staff autonomy; relay variables – application of human rights, incarcerated clients' autonomy and providers' autonomy; and the grey zone variable – knowledge of human rights (Fig. 5).

The intersections of the rights (R1) and the provider (B1) loops highlight structural conflicts where the R1 loop drives the positive acceleration of application of human rights, while the B1 loop acts as a counterforce, potentially limiting this growth by influencing variables such as providers' autonomy. The shared variables are subjected to two opposing forces: one promoting rights application and the other a stabilizing force. Crucially, the influential variable carceral staff autonomy is directly connecting these two dynamics, confirming its status as a high-leverage point where a small change can shift the system's dominant behaviour toward either reinforcing growth or balancing stability.

Identified leverage points

On the basis of the system analysis, we identified three potential leverage points: availability of providers, carceral staff autonomy and advocacy. Carceral staff autonomy is a key influential variable, positioned at a critical point in the combined rights (R1) and provider (B1) loops (Fig. 9). As such, a small change in carceral staff autonomy can either accelerate the application of rights (R1) or strengthen the stability of the counterforce of the provider (B1) loop.

The MICMAC analysis identified advocacy as a relay variable, ranked second in both the MDI and MII (Table 2). This high ranking in both matrices confirms its potential to profoundly modify the overall system dynamic [17]. In the CLD (Fig. 6), the R1 and B1 loops share the variable application of human rights (Fig. 9), which increases as advocacy increases. This causal chain provides a path to indirectly influence the system's counteracting forces (R1 versus B1) governed by the influential

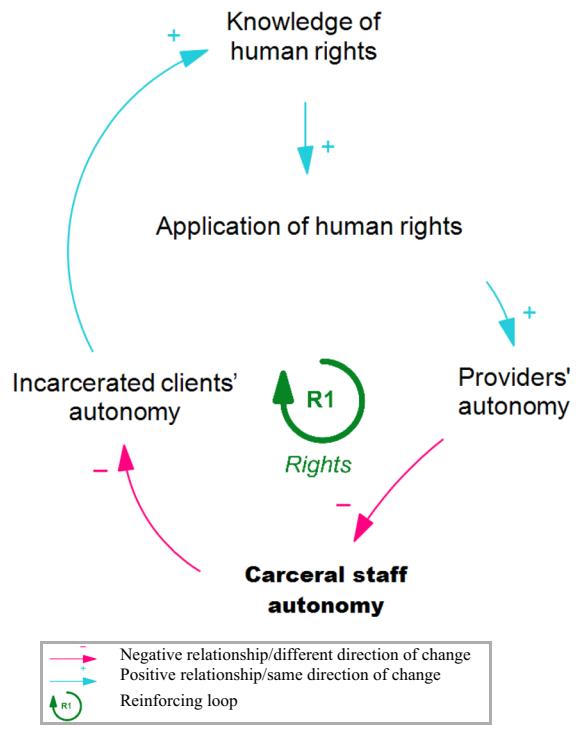

Fig. 7 Detailed view of the reinforcing (R1) rights feedback loop and its variables connected by arrows indicating the direction of the relationship. Influential variable emphasized in bold font

variable, carceral staff autonomy. These leverage points inform where small, targeted interventions could result in meaningful changes in system dynamics governing perinatal care delivery in carceral settings.

The identification of availability of providers, carceral staff autonomy and advocacy were identified as leverage points on the basis of their position within key reinforcing and balancing loops of the CLD, as well as their influential and relay positions within MII. They provide targeted areas of intervention capable of modifying feedback processes shaping perinatal care. Combined, these findings explain how interventions exerted on these leverage points could strengthen the application of human rights in the delivery of perinatal care to incarcerated individuals, thereby improving the health outcomes of mothers and their newborns.

Discussion

The integrated structural analysis and causal-loop analysis identified availability of providers, carceral staff autonomy and advocacy as key leverage points within the perinatal carceral setting. Carceral employees, through their discretionary authority (autonomy), are positioned as linchpins in the power dynamics inherent of the carceral setting. While they prioritize safety and security, healthcare and social service providers prioritize patient-centred care delivery [33–35]. Carceral employees also hold hierarchical power over incarcerated individuals, which can result in mistreatment [12, 36, 37]. Our findings suggest advocacy could serve as an important mechanism for balancing these conflicting power dynamics, mitigating negative outcomes associated with carceral hierarchy.

Perinatal care providers supporting people experiencing incarceration in Ontario have reported feelings of powerlessness, due in part to correctional power imbalances between healthcare providers and nonmedical carceral employees [13]. These power dynamics can negatively affect provider retention, contributing to reduced provider availability [13]. Reduced provider availability then disrupts continuity of perinatal care for incarcerated people [12, 38, 39]. These disruptions occur within a fragmented care system where providers witness dehumanizing treatment. Moreover, providers report gaps in their knowledge concerning carceral policies, as well as their own legal rights and those of their clients [13].

These dynamics are reinforced by a dissonance between written and applied carceral rules. Correctional officers' discretion impacts whether carceral polices are applied, a practice deeply embedded in the culture of incarceration [40, 41]. Current carceral structure does not account for the circumstances surrounding pregnancy such as perinatal needs or bodily autonomy [42, 43]. International standards and certain national regulations and policies specify pregnant individuals' rights, including nutritional requirements, timely medical appointments, appropriate medical care and support for substance use [4, 44–46]. However, individuals formerly incarcerated in Ontario and carceral perinatal care providers routinely witness or experience violations of these rights [12, 13]. Consequences for mistreatment or rights violations involving incarcerated pregnant people must be transparent. On 1 December 2025, Correctional Service of Canada released its first Annual Report on Addressing Wrongdoing and Misconduct, publicizing a transparent account of staff misconduct and organizational wrongdoing. The report details actions taken to address these issues [47]. At the provincial level, the Ministry of the Solicitor General does not currently publish a comparable report [48, 49]. Independent oversight committees should be established in Ontario to investigate rights violation complaints. Reports must be released to the public annually, describing the types of complaints received and the actions taken to address them.

The Corrections and Conditional Release Regulations specify administrative procedures and standards of Canadian federal correctional institutions and community supervision [50]. Ontario does not have regulations

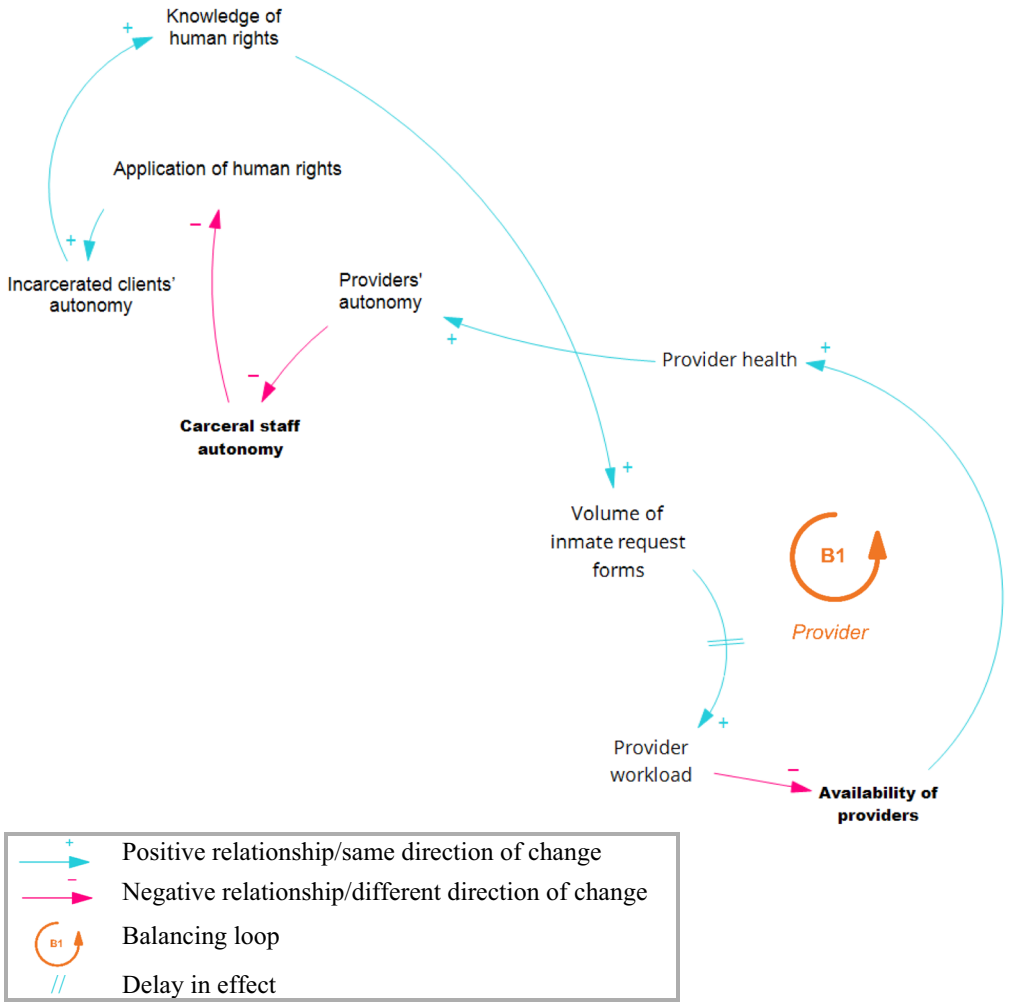

Fig. 8 Detailed view of the balancing (B1) provider loop and its variables connected by arrows indicating the direction of the relationship. Influential variables emphasized in bold font

mirroring the scope of the federal Corrections and Conditional Release Regulations. Ontario's correctional system operates under the Ministry of Correctional Services Act [51]. This framework offers fewer protections than the Correctional Services and Reintegration Act, 2018, which is not yet in force [52]. Because Ontario legislation does not specify which rights are removed versus upheld, this contributes to ambiguity and inconsistent interpretation [53]. This ambiguity was echoed by Ontario carceral healthcare and social service providers, as well as formerly incarcerated pregnant individuals [12, 13]. It contributes to gaps in stakeholders' knowledge and the imbalance of power in carceral settings.

To address these gaps and mitigate imbalances in power, all parties should operate with consistent definitions of rights, grounded in Canadian federal and Ontario provincial legal frameworks. These should include the right to informed consent and bodily autonomy under the Health Care Consent Act [54], and protections against discrimination in access to services under the Ontario Human Rights Code [55]. A shared understanding and consistent application of these rights across stakeholders would support the prioritization of care for individuals experiencing incarceration while pregnant, particularly in contexts where fragmented governance structures may limit access to timely and coordinated perinatal care, rather than allowing access to perinatal care to be influenced by discretionary decision-making within carceral settings. Operationalization may involve the integration of standardized rights-based policies and procedures across carceral, social and healthcare systems. For example, pregnant individuals could be routinely informed of their rights upon intake and throughout their sentence, consent should be obtained and documented prior to any medical intervention, and accessible mechanisms should be

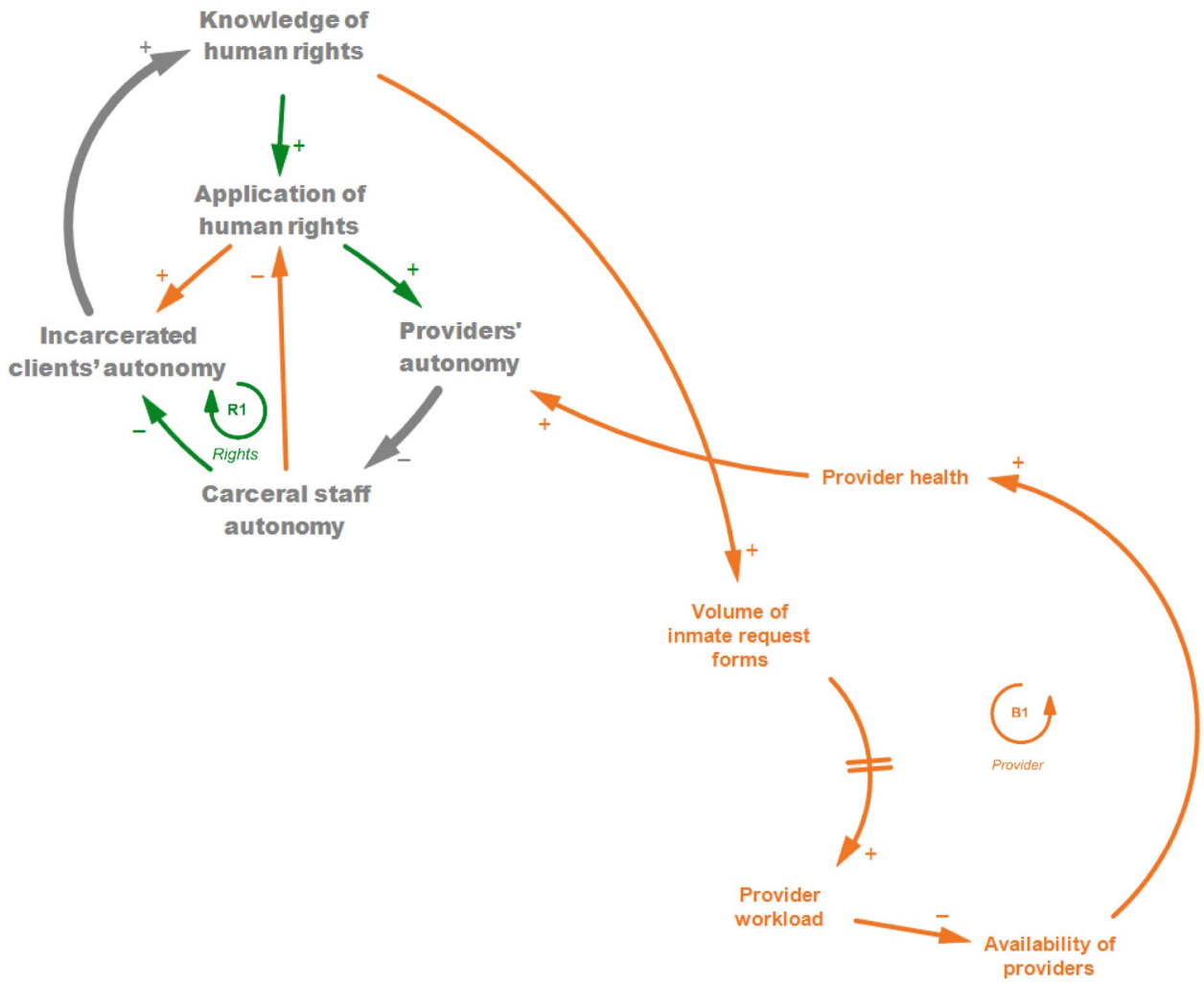

Fig. 9 Combined rights loop (R1) and provider balancing loop (B1) identifying components common to both loops emphasized in bold grey font

established to escalate concerns when rights are perceived to be violated.

Training enhances stakeholders' knowledge of incarcerated pregnant people's rights, human rights and the applications of both, thereby supporting self-advocacy and advocacy for others. Training must be mandatory and ongoing for carceral employees, social service and healthcare providers, and incarcerated individuals. Training materials should be tailored to each stakeholder group. Carceral employees should receive training on their legal obligations, duty of care and the application of human rights within carceral settings. Healthcare and social service providers should receive training that emphasizes advocacy, an understanding of correctional officers' roles and duties and strategies to navigate carceral constraints while supporting continuity of perinatal care across systems. Incarcerated individuals should receive training focused on their rights, legal literacy,

access to legal supports and mechanisms for self-advocacy. The training curriculum should emphasize legal literacy and the importance of upholding rights protected by the Canadian Charter of Rights and Freedoms [56] and the Ontario Human Rights Code [55]. Additionally, trainees must learn international standards of care for incarcerated people as presented in the Bangkok Rules [4] and the Mandela Rules [44]. The United Nations Office on Drugs and Crime offers a Mandela rules e-learning training designed specifically for carceral employees and other stakeholders working in carceral settings [57]. Stakeholders must be aware of the legal instruments available to uphold them. Additionally, Canadian courts recognize a legal duty of care, a key tool for protecting the health and safety of those in custody, including pregnant individuals [58–60].

Training alone does not equate to protection for incarcerated individuals. Advocacy, identified as a key leverage point, is a necessary mechanism for transforming knowledge of rights and standards of care into justice-oriented praxis. Advocacy must therefore be institutionalized to protect and empower advocates who challenge witnessed injustices and incarcerated individuals who self-advocate. Institutional policies must explicitly protect healthcare and social service providers and incarcerated individuals from punitive retaliation when advocating for rights and standards of care. These protections will encourage disclosure, empower advocates and reduce power asymmetry within carceral settings.

Although this study was grounded in the Ontario context and focused on perinatal care delivery to incarcerated individuals, the approach is transferable to settings characterized by fragmented governance structures and the involvement of multiple care systems. This may be particularly relevant in settings such as child welfare, substance use treatment, mental health services and homelessness-related service systems, as well as other complex health service contexts, where care delivery is shaped by fragmented governance, competing institutional mandates and constraints that limit the coordination of person-centred care [61–65]. This study demonstrates the value of integrating structural analysis with causal loop modelling as a systems-based approach to examining complex health service delivery. Structural analysis provides a systematic approach to identifying the relative influence and dependence of variables [16, 17], while causal loop diagramming illustrates the feedback processes through which these variables interact over time [18–21]. Their integration enables a comprehensive analysis of system dynamics, thereby clarifying how institutional dynamics, constraints and feedback processes collectively shape care delivery. By visually representing relationships between system actors, the distribution of decision-making authority and the feedback processes influencing outcomes, this approach supports the identification of leverage points and may inform evidence-based policy and strengthen the organization and delivery of health services.

Strengths and limitations

This research has several important strengths. We employed a rigorous approach to select variables and construct the CLD. Specifically, semi-structured interviews with providers and formerly incarcerated pregnant individuals provided a comprehensive list of variables related to carceral perinatal care in Ontario. Furthermore, the use of MICMAC analysis to identify potential leverage points provided an objective method for prioritizing variables as points of intervention to improve the delivery of care in carceral settings. Additionally, the involvement of SMEs in the development of the MDI strengthened its validity by incorporating first-hand experience working with incarcerated and formerly incarcerated people. Finally, the MDI exercise provided the SMEs with a new system-level perspective of carceral perinatal care delivery, allowing them to identify previously unconsidered levers of change, notably, engaging informal supports (e.g. clients' friends and family) to strengthen continuity of care.

The current study also includes limitations. The information used to populate the MDI was gathered exclusively from midwives and the PI's knowledge of the perinatal care in carceral settings. Consequently, the perspectives of other stakeholder groups – specifically other healthcare and social service providers, correctional officers and individuals incarcerated during pregnancy – were not represented in the development of the MDI. This exclusion potentially influenced the resulting MII and the prioritized leverage points derived from the matrix. Secondly, CLDs cannot capture all system components [21] or depict an entire system in a single figure. [26]. While the SMEs identified "newborn apprehensions" as a highly important aspect of care, it was not explicitly included as a variable in the CLD. Finally, the CLD and identified intervention points were developed using carceral data specific to Ontario, Canada, limiting the generalizability of the findings.

Future research

Future research should be conducted to gather insight from correctional officers. Interviews with this population would inform the identification of new variables and validate those included in our CLD. Future studies should gather data on newborn apprehension by interviewing formerly incarcerated individuals, social service and healthcare providers, and correctional officers. This

approach would provide a comprehensive understanding of the lived experiences of families and the systemic challenges encountered by professionals. A CLD specific to newborn apprehension could then be developed. Future research should also explore the development of CLDs in other Canadian provinces and territories, and internationally, to contribute to the development of interventions aimed at improving perinatal care delivery in carceral settings. Finally, future research should examine how the identified leverage points can be optimized to promote positive system dynamics and improve health outcomes for incarcerated individuals requiring perinatal care and their newborns.

Future research should further apply and test the integration of structural analysis and causal loop modelling in other contexts to strengthen health systems research and inform evidence-based health policy. Applying this approach across diverse settings may support the identification of context-specific and cross-cutting leverage points, and provide insight into how diverse groups of social services and healthcare providers can collaborate to improve delivery of health services.

Conclusions

In this study, we conducted a rigorous structural analysis to inform the construction of a CLD of Ontario's carceral perinatal care delivery system. The resulting model identifies three key leverage points for improving perinatal care delivery: advocacy, provider availability and carceral staff autonomy. Through indirect pathways and multiple feedback loops, these leverage points influence variables shaping perinatal care in carceral settings. Policy changes and advocacy training are potentially effective interventions to address the inherent power dynamics of carceral settings. Implementing these changes could improve health outcomes for incarcerated pregnant individuals and their newborns.

This study demonstrates how structural analysis and causal loop modelling can be used to examine complex health service delivery. The identification of influential variables combined with the identification of reinforcing and balancing loops facilitates an understanding of the dynamics, constraints and leverage points involved in care delivery. This integrated approach may be applied to strengthen health system research and inform evidence-based health policy and service delivery in various contexts, particularly in settings where governance structures result in fragmented service delivery, hindering the timeliness and coordination of care.

Abbreviations

CLD	Causal loop diagram
MDI	Matrix of direct influences
MICMAC	Matrice d'Impacts Croisés Multiplication Appliquée à un Classement
MII	Matrix of indirect influences
SME	Subject matter experts

Acknowledgments

We thank Zahrah Hajali for generously contributing her time, experiences and insights to the data collection process.

Author contributions

X.B. conceived and designed the study, developed the methodology, secured funding, managed the project and conducted the investigation. W.P. provided supervision throughout the study. X.B. curated the data, led the formal analysis and prepared the visualizations, with A.M. contributing to data analysis and validation. X.B. wrote the first draft of the manuscript. X.B., A.M., L.M., A.F.P. and W.P. revised the manuscript. All authors have read and approved the content of the manuscript.

Funding

This work was supported by the Institut du Savoir Montfort Bourse de Doctorat (doctoral scholarship) and the Ontario Graduate Scholarship.

Data availability

The datasets generated and/or analysed during the current study are not publicly available owing to the sensitive nature of formerly incarcerated individuals' and providers' experiences but are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate

The study was approved by the University of Ottawa Research Ethics Board (REB) under ethics file no. H-01-23-8376. Participants received an electronic copy of the consent form when the interview was scheduled and were asked to review the document in advance. On the day of the interview, each participant was asked whether they had read the consent form and if they had any questions. They were reminded that participation was voluntary, they were under no obligation to answer any question and they could withdraw from the interview at any time. Participants were also informed that they could ask questions at any point during the interview. Oral informed consent was obtained from each participant prior to recording their interview. In alignment with the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS2 2022), which notes that "where consent is not documented in a signed consent form, researchers may use a range of consent procedures, including oral consent", the use of oral consent was considered appropriate given the virtual format of the interviews and the robust procedures used to ensure participants' understanding and voluntary participation. This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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Received: 29 January 2026 Accepted: 7 May 2026
Published online: 28 May 2026

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