

Intrinsic risks to pregnant women in homeless situations: a scoping review

Riscos intrínsecos às grávidas em situação de rua: uma revisão de escopo

Riesgos intrínsecos para las mujeres embarazadas en situación de calle: una revisión de alcance

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Abstract

Introduction: Pregnant women experiencing homelessness face a global challenge with negative consequences for both mothers and children, including unplanned pregnancies, sexual exploitation, reproductive health complications and premature births. Lack of access to basic health services and stress resulting from homelessness adversely affect fetal development and can lead to chronic diseases. Given the complexity and heterogeneity of the literature on this topic, a scoping review is necessary to map existing evidence, identify gaps and synthesize the risks faced by this vulnerable population. **Objective:** To identify and map the risk factors associated with pregnant women experiencing homelessness and the main consequences for maternal and fetal health described in recent scientific literature. **Methods:** A scoping review was conducted using the PubMed and SciELO databases with the descriptors «Pregnancy», «Homelessness» and «Risk.» The search took place between February and March 2023, including articles published in the last 10 years (2013–2023) that addressed pre-pregnancy risks and post-pregnancy consequences. A thematic content analysis of the 30 selected articles was performed to identify and categorize the main risks and outcomes. **Results:** Thematic analysis of the 30 articles revealed three main axes: prenatal care, pregnant woman's health and childbirth/post-pregnancy. Findings indicated a high prevalence of unplanned pregnancy, exposure to sexual violence and substance use as pre-pregnancy risks. During pregnancy, mental health challenges, limited (though variable) access to prenatal care and comorbidities are prominent. Outcomes include higher risks of preterm birth, low birth weight and neonatal complications. Quantitative analysis of theme frequency showed a higher concentration of studies focusing on the pregnant woman's health. **Conclusions:** Pregnant women experiencing homelessness face multiple interconnected risks that negatively impact maternal-fetal health. This review highlights the need for public policies and interventions that address socio-structural determinants, improve access to sexual and reproductive health care and offer psychosocial support. The lack of official data in Brazil is a significant limitation. Future research should focus on the effectiveness of interventions and longitudinal data.

Keywords: Pregnant women; Homeless persons; Maternal and child health; Risk factors; Scoping review; Public policies.

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Resumo

Introdução: Gestantes em situação de rua enfrentam um desafio global com consequências negativas para mães e filhos, incluindo gravidezes não planejadas, exploração sexual, complicações na saúde reprodutiva e partos prematuros. A falta de acesso a serviços básicos de saúde e o estresse decorrente da falta de moradia afetam adversamente o desenvolvimento fetal e podem levar a doenças crônicas. Dada a complexidade e heterogeneidade da literatura sobre o tema, uma revisão de escopo é necessária para mapear as evidências existentes, identificar lacunas e sintetizar os riscos enfrentados por essa população vulnerável. **Objetivo:** Identificar e mapear os fatores de risco associados a gestantes em situação de rua e as principais consequências para a saúde materna e fetal descritas na literatura científica recente. **Métodos:** Realizou-se uma revisão de escopo nas bases de dados PubMed e Scientific Electronic Library Online (SciELO), utilizando os descritores “Pregnancy”, “Homelessness” e “Risk”. A busca ocorreu entre fevereiro e março de 2023, incluindo artigos publicados nos últimos 10 anos (2013–2023) que abordassem riscos pré-gestacionais e consequências pós-gestacionais. Foi realizada uma análise de conteúdo temática dos 30 artigos selecionados para identificar e categorizar os principais riscos e desfechos. **Resultados:** A análise temática dos 30 artigos revelou três eixos principais: cuidados pré-natais, saúde da gestante e parto/pós-gestação. Os achados indicam alta prevalência de gravidez não planejada, exposição à violência sexual e uso de substâncias como riscos pré-gestacionais. Durante a gestação, destacam-se desafios na saúde mental, acesso limitado ao pré-natal (embora variável) e comorbidades. Os desfechos incluem maior risco de parto prematuro, baixo peso ao nascer e complicações neonatais. A análise quantitativa da frequência dos temas mostrou maior concentração de estudos sobre a saúde da gestante. **Conclusões:** Gestantes em situação de rua enfrentam múltiplos riscos interconectados que impactam negativamente a saúde materno-fetal. A revisão evidencia a necessidade de políticas públicas e intervenções que abordem determinantes socioestruturais, melhorem o acesso a cuidados de saúde sexual e reprodutiva e ofereçam apoio psicossocial. A falta de dados oficiais no Brasil é uma limitação importante. Estudos futuros devem focar na eficácia de intervenções e em dados longitudinais.

Palavras-chaves: Gestantes; Pessoas em situação de rua; Saúde materno-infantil; Fatores de risco; Revisão de escopo; Políticas públicas.

Resumen

Introducción: Las mujeres embarazadas en situación de calle enfrentan un desafío global con consecuencias negativas para madres e hijos, incluyendo embarazos no planificados, explotación sexual, complicaciones en la salud reproductiva y partos prematuros. La falta de acceso a servicios básicos de salud y el estrés derivado de la falta de vivienda afectan adversamente el desarrollo fetal y pueden conducir a enfermedades crónicas. Dada la complejidad y heterogeneidad de la literatura sobre el tema, es necesaria una revisión de alcance para mapear la evidencia existente, identificar lagunas y sintetizar los riesgos que enfrenta esta población vulnerable. **Objetivo:** Identificar y mapear los factores de riesgo asociados a las mujeres embarazadas en situación de calle y las principales consecuencias para la salud materna y fetal descritas en la literatura científica reciente. **Métodos:** Se realizó una revisión de alcance en las bases de datos PubMed y SciELO, utilizando los descriptores “Pregnancy”, “Homelessness” y “Risk”. La búsqueda se realizó entre febrero y marzo de 2023, incluyendo artículos publicados en los últimos 10 años (2013–2023) que abordaran riesgos pregestacionales y consecuencias postgestacionales. Se realizó un análisis de contenido temático de los 30 artículos seleccionados para identificar y categorizar los principales riesgos y resultados. **Resultados:** El análisis temático de los 30 artículos reveló tres ejes principales: atención prenatal, salud de la gestante y parto/postparto. Los hallazgos indican una alta prevalencia de embarazos no planificados, exposición a la violencia sexual y uso de sustancias como riesgos pregestacionales. Durante el embarazo, destacan los desafíos en salud mental, el acceso limitado (aunque variable) a la atención prenatal y las comorbilidades. Los resultados incluyen mayores riesgos de parto prematuro, bajo peso al nacer y complicaciones neonatales. El análisis cuantitativo de la frecuencia de los temas mostró una mayor concentración de estudios sobre la salud de la gestante. **Conclusiones:** Las mujeres embarazadas en situación de calle enfrentan múltiples riesgos interconectados que impactan negativamente la salud materno-fetal. La revisión evidencia la necesidad de políticas públicas e intervenciones que aborden los determinantes socio-estructurales, mejoren el acceso a la atención de salud sexual y reproductiva y ofrezcan apoyo psicossocial. La falta de datos oficiales en Brasil es una limitación importante. Estudios futuros deben centrarse en la eficacia de las intervenciones y en datos longitudinales.

Palabras clave: Mujeres embarazadas; Personas sin hogar; Salud materno-infantil; Factores de riesgo; Revisión de alcance; Políticas públicas.

INTRODUCTION

The problem of homeless people, including women and young people, is a global phenomenon. Within this group, women face particular adversities, such as greater exposure to violence, sexual exploitation and difficulties in accessing essential services.^{1,2} Pregnancy in this context adds layers of vulnerability, impacting maternal and fetal health. It is common for homeless women to have limited access to basic sexual and reproductive health services, facing difficulties in family planning, during pregnancy, childbirth and postpartum care.^{3,4}

The literature indicates that homeless people experience worse reproductive health outcomes, including high rates of unplanned or unwanted pregnancies, abortions (often unsafe), premature births, low birth weight babies and increased risk of sexually transmitted infections (STIs).^{1,3-5} Qualitative studies, such as one conducted in Ethiopia, detail challenges such as physical and sexual abuse, unprotected sex and lack of access to health services and adequate nutrition.¹ In addition, chronic stress associated with housing instability and homelessness during fetal development can negatively impact the brain architecture of the fetus and increase the risk of chronic diseases throughout life.⁶

The relevance and complexity of the topic, added to the heterogeneity of the existing literature on the risks of pregnancy in homeless situations (with studies focusing on different factors, outcomes and interventions), motivated the choice of a scoping review. This type of review is particularly suitable for mapping the breadth and nature of available evidence in a broad field and identifying concepts, sources and gaps in knowledge, without the aim of assessing the quality of studies or performing quantitative syntheses, as in systematic reviews.⁷ Thus, this approach provides the comprehensive overview necessary to understand the risks associated with this condition and support future research and policies.

The present study aims to identify and map, through a scoping review, the different risk factors associated with homeless pregnant women and the main consequences for maternal and fetal health described in the scientific literature of the last 10 years, aiming to contribute to the understanding of the problem and the planning of care for this vulnerable population.

METHODS

This is a scoping review conducted between February and March 2023, with the aim of mapping the risks associated with pregnancy in homeless women. The steps followed a predefined protocol, including: definition of search descriptors, selection of databases — PubMed and Scientific Electronic Library Online (SciELO) —, combination of descriptors using the Boolean operator “AND”, selection of articles, assessment of inclusion/exclusion criteria, extraction of information and data analysis.

The search strategy used the MeSH/DeCS descriptors: “*Pregnancy*” AND “*Homelessness*” AND “*Risk*”. The inclusion criteria were: articles published in the last 10 years (January 2013 to March 2023); English, Portuguese or Spanish; and articles that addressed risks intrinsic to the pre-gestational period (e.g., unprotected sexual intercourse, sexual abuse, drug use, housing insecurity) and/or post-pregnancy consequences associated with these risks — for example: premature birth, low birth weight, admission to a neonatal intensive care unit (ICU), child health. Articles that were not directly related to the topic, editorials, letters and conference abstracts were excluded.

The study selection process is detailed in Figure 1. Initially, 207 publications were identified in PubMed. After applying the time filter (last 10 years), 95 publications remained. Reading the titles and abstracts led to the exclusion of 55 articles. The remaining 40 articles were read in full, resulting in the exclusion of another 10 articles that did not fully meet the criteria. In the end, 30 publications were included in the review. No relevant articles were found in the SciELO database with the search strategy used.

Data from the 30 selected articles were extracted and compiled into an Excel spreadsheet containing information on authors, year, source, type of study, country, population studied, main risks identified and main outcomes/consequences reported.

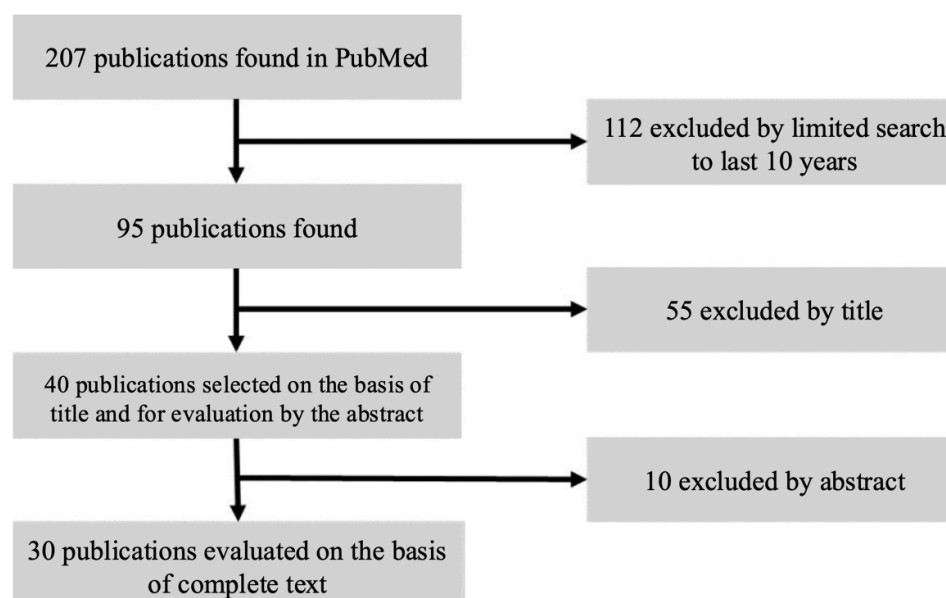


Figure 1. Study selection process.

To analyze the data, a thematic content analysis was performed. The researchers repeatedly read the full articles to familiarize themselves with the content. They then identified and coded relevant excerpts related to the risks and consequences of homeless pregnancy.

These codes were grouped into emerging themes and subthemes, which were then organized into three main axes:

1. prenatal care;
2. pregnant women's health;
3. childbirth and post-pregnancy.

This thematic analysis allowed us to synthesize the qualitative findings of the literature and also to quantify the frequency with which each theme and subtheme was addressed in the selected articles, supporting the construction of the graphs presented in the results.

RESULTS

The review included 30 publications that addressed different aspects of pregnancy risks and outcomes in women experiencing homelessness or housing instability. The general characteristics of these publications are summarized in Table 1.^{1-3,5,6,8-32} Most studies were conducted in North America (United States and Canada), with some studies from Europe, Africa (Ethiopia) and systematic/qualitative reviews of global scope.

Thematic analysis

Thematic content analysis of the 30 articles allowed us to identify patterns and group the findings into the three axes mentioned (Prenatal, Pregnancy, Childbirth/Post-pregnancy), with several recurring subthemes. The frequency with which the articles addressed the main axes and specific subthemes is represented in Charts 1 and 2.

Table 1. Characteristics of references selected for scoping review.

Reference	Source	Main thematic axis (according to analysis)
St. Martin et al. ²³	Journal of Perinatology	Perinatal outcomes (preterm birth, LBW, neonatal ICU)
Cutts et al. ²¹	Maternal and Child Health Journal	Homelessness as a temporal risk factor for adverse birth outcomes (LBW)
Sandel et al. ⁶	Pediatrics	Impact of pre- and postnatal homelessness on child health (hospitalizations, development)
Assegid et al. ¹	BMC Womens' Health	Pre-pregnancy risks (sexual abuse, STIs, unwanted pregnancy, unsafe abortion) – Qualitative study
Paissi et al. ³	BMJ Sexual and Reproductive Health	Barriers to access to sexual and reproductive health – Systematic review
Begun ⁸	Social Work in Health Care	Causes and risk factors for pregnancy in homeless youth (including intentionality)
O'Brien et al. ²⁹	Progress in Community Health Partnerships	Health needs and training programs for pregnant/parenting youth in shelters
Leifheit et al. ²²	Int J Environ Res Public Health	Housing insecurity and adverse neonatal/child outcomes
Borghesi et al. ²⁷	PLoS One	Perceived impact of homelessness on health during pregnancy/postpartum (qualitative, France)
Rayment-Jones et al. ³²	PLoS One	Impact of community care and continuity on maternal/neonatal outcomes (social risk)
Orlando et al. ²⁸	American Journal of Obstetrics and Gynecology	Abortion and abortion outcomes in homeless pregnant women
Yamamoto et al. ²⁴	JAMA Network Open	Costs care and birth outcomes (preterm birth, higher costs)
DiTosto et al. ¹⁸	American Journal of Obstetrics and Gynecology MFM	Housing instability and adverse perinatal outcomes (prematurity, LBW, ICU, inadequate prenatal care)
Winetrobe et al. ⁹	Journal of Pediatric and Adolescent Gynecology	Contraceptive use and attitudes toward pregnancy in homeless youth
Goodman and Wolff ¹¹	Journal of Midwifery and Women's Health	Alcohol/drug use screening in women (increased risk of violence, STIs, unplanned pregnancy)
Kittirattanapalboon et al. ¹²	Current Opinion in Psychiatry	Methamphetamine use in vulnerable populations of women and impacts on health/pregnancy
Esen ²⁰	The Journal of Maternal-Fetal & Neonatal Medicine	High-risk profile, need for housing support, and collaboration between services
Kozlowski et al. ¹⁰	Journal of Health Care for the Poor and Underserved	Family planning needs and experiences in women with housing insecurity
Gordon et al. ¹⁷	British Journal of General Practice	Women's views on perinatal care, influence of trauma, and previous interactions (qualitative)
Wagman et al. ¹⁴	BMC Pregnancy and Childbirth	Barriers to congenital syphilis treatment (preferences, provider-patient relationship)
Goodsmith et al. ¹⁶	Psychiatric Services	Housing and mental health needs of vulnerable women (pregnant women, IPV) in the era of COVID-19
Kandasamy et al. ¹⁹	Journal of Obstetrics and Gynaecology Canada	Risks and outcomes in refugee women (exposure to homelessness, poor health, and nutrition)
Huang et al. ²⁶	American Journal of Obstetrics and Gynecology MFM	Risk of birth complications in housing-insecure pregnant women
Ginn et al. ³⁰	Canadian Journal of Nursing Research	Two-generation prenatal programs for vulnerable families (Canadian experience)
Santa Maria et al. ¹⁵	JMIR Research Protocols	Human immunodeficiency virus (HIV) prevention intervention for homeless youth (nurse-based case management)
Kurata et al. ³¹	Hawaii Journal of Health and Social Welfare	Report on provision of prenatal care for homeless pregnant women in Hawaii
Batra et al. ²⁵	Asian Journal of Psychiatry	Maternal psychosocial risk factors (including homelessness) for preterm birth (review)
Cheng et al. ⁵	BMC Public Health	Substance use and unprotected sex in homeless youth (prospective cohort)
Misganaw and Worku ²	BMC Public Health	Sexual violence in homeless women (prevalence and consequences, Ethiopia)
Stewart et al. ¹³	Sexually Transmitted Diseases	Clinic model for homeless women with SUD† and engagement in transactional sex

LBW: low birth weight; ICU: intensive care unit; STIs: sexually transmitted infections; IPV: intimate partner violence; SUD: substance use disorders.

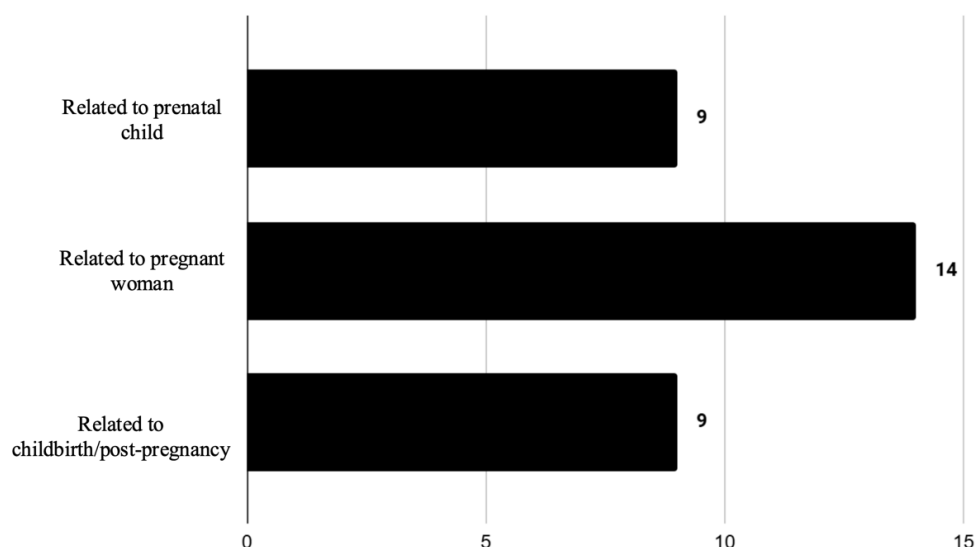


Chart 1. Frequency of the main thematic axes in the articles analyzed (n=30 articles; an article can address more than one axis).

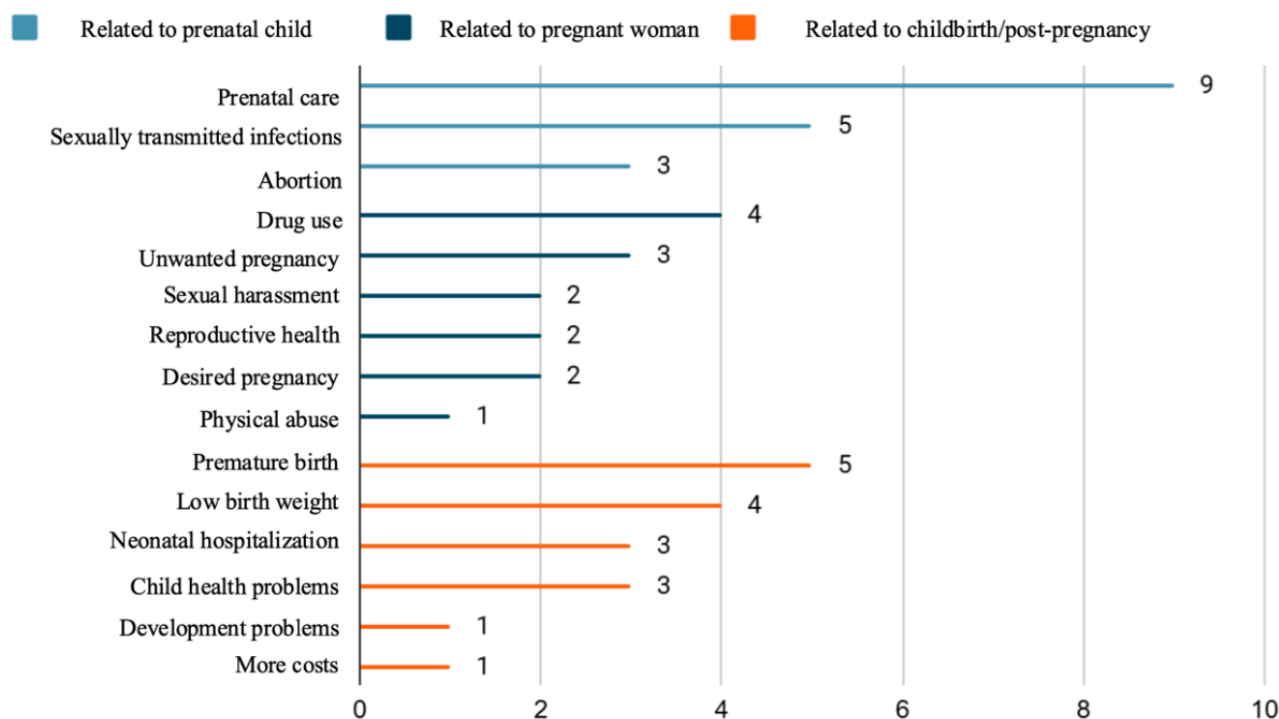


Chart 2. Frequency of specific subtopics addressed in the analyzed articles.

The construction of the graphs was based on the identification of the main and secondary focus of each article during the thematic analysis. Chart 1 shows the count of articles that addressed each of the three major axes. Chart 2 details the frequency with which specific subthemes were the focus or an important component of the discussion in the articles, categorized within the three axes. For example, nine articles had “Prenatal care” as their main or secondary focus, while five articles focused specifically on “Preterm birth” as an outcome.

In addition to frequency, the thematic analysis revealed the following main qualitative findings within each of the axes shown below.

Risks and pre-pregnancy factors

- Unplanned/unwanted pregnancy: High pregnancy rates have been consistently reported, especially among homeless youth.^{3,8} Some studies indicate that a proportion of these pregnancies may be intentional.^{8,9} Difficulties in accessing and using effective contraceptive methods have been highlighted.^{9,10}
- Sexual violence and exploitation: Homeless women are highly vulnerable to sexual violence, rape and exploitation, increasing the risk of pregnancy and STIs.^{1,2,11}
- Substance use: alcohol and drug use (including methamphetamines) is prevalent and associated with unprotected sex and other risks.^{5,11-13}
- STIs: increased risk of STIs, including HIV and syphilis, with specific barriers to screening and treatment during pregnancy.^{3,14,15}

Pregnant women's health and access to care

- Mental health: Mental health issues such as depression, anxiety and post-traumatic stress disorder (associated with previous violence) are common and can impact pregnancy.^{11,16,17}
- Access to and adherence to prenatal care: Access to and use of prenatal care are often described as inadequate or delayed.^{3,18} However, a qualitative study suggests that adherence can be good if there is support and a trusting relationship with professionals.¹⁷ Barriers include lack of transportation, documentation, fear of judgment and previous negative experiences with health services.
- Health and nutrition conditions: Higher prevalence of medical and nutritional comorbidities.^{19,20} Chronic stress from homelessness is also a risk factor.⁶
- Impact of housing instability: housing instability itself is an independent risk factor for worse outcomes.^{18,21,22}

Outcomes of childbirth and post-pregnancy (maternal and neonatal)

- Preterm birth and low birth weight (LBW): consistently associated with maternal homelessness or housing instability during pregnancy.^{18,21,23-25}
- Neonatal complications: increased risk of neonatal intensive care unit (ICU) admission and other birth complications.^{18,22,23}
- Child health: negative impacts on child health in the medium term, including increased risk of post-neonatal hospitalizations and developmental delays.⁶
- Maternal outcomes: increased risk of birth complications,²⁶ higher care costs²⁴ and challenges in the postpartum period.²⁷
- Abortion: the issue of abortion was also addressed, including associated outcomes in women in this situation.^{1,28}

Interventions and facilitators

- Some studies have described or evaluated interventions such as shelter-based health training programs,²⁹ co-located clinic models for specific populations,¹³ two-generation prenatal programs^{30,31} and nurse-led case management for HIV prevention.¹⁵ The importance of continuity of care and social support has been highlighted as a protective factor.^{27,32}

DISCUSSION

This scoping review mapped the recent literature on the risks associated with pregnancy in homeless women, revealing a complex and worrying panorama. The findings corroborate the perception that this population faces a confluence of social, economic and health vulnerabilities that negatively impact maternal and child outcomes.

Epidemiology

The difficulty in quantifying the homeless population in Brazil, as noted by the Institute of Applied Economic Research (IPEA),³³ reflects an invisibility that extends to public services and policies. Although the Demographic Census does not include this population, estimates indicate a significant increase in recent years, especially in the North region.³³ The specific census carried out in the city of Rio de Janeiro³⁴ provides important local data, but the lack of systematic national data on pregnant women in this context makes it difficult to understand the magnitude of the problem and to plan large-scale actions (Table 2).

Table 2. Homeless people: comparison between Rio de Janeiro and Brazil, 2022.^{33,34}

Location	Source	Homeless people	Homeless people/100,000 inhabitants
Brazil	Ipea; 2022	281,472	131.9
Rio de Janeiro	IPP; 2022	7,865	116.1

This invisibility contributes to barriers in accessing basic rights, such as documentation and health services,³⁵ despite legal advances such as inclusion in the Single Registry and the right to access the Unified Health System (SUS) without proof of residence.³⁶ The literature reviewed, mostly international, highlights problems that certainly have parallels in Brazil, such as violence and difficulty in accessing services.⁴

Pre-pregnancy risks and sexual and reproductive health

The articles analyzed reinforce the high vulnerability of homeless women to pre-pregnancy risks. The high prevalence of unplanned pregnancy^{3,8} is intrinsically linked to barriers in access to contraceptive methods and family planning services,^{9,10} but also to complex factors such as the desire for pregnancy in contexts of exclusion.⁸ Exposure to sexual violence^{1,2} and substance use^{5,11} emerge as critical risk factors, interconnected with worse sexual and reproductive health outcomes, including STIs.^{3,14} Addressing these risks requires not only the provision of services, but also consideration of social and structural determinants, such as poverty, gender-based violence and lack of safe housing.^{16,17}

Pregnancy and access to prenatal care

During pregnancy, risks accumulate. Housing instability and associated chronic stress are independent risk factors for negative outcomes.^{6,19,20} Poor mental health, often resulting from trauma and homelessness itself, poses an additional challenge.^{11,16,17} Although access to prenatal care is

often inadequate,¹⁸ the review also suggests that models of care based on trust, support and continuity can improve adherence.^{17,32} This suggests that the way services are organized and delivered is crucial. Interventions that integrate health, social and housing support appear promising.^{13,20,29}

Post-pregnancy outcomes and child health

Adverse perinatal outcomes, such as preterm birth and low birth weight, are consistently more frequent in pregnant women who are homeless or have housing instability.^{18,21,23-25} These outcomes have immediate implications, such as increased need for neonatal intensive care,^{18,22,23} as well as long-term consequences for child health and development.⁶ The costs associated with these outcomes are also higher,²⁴ reinforcing the argument that investing in prevention and appropriate care during pregnancy can yield social and economic returns. A recent study by Clark et al.³⁷ demonstrated increased risks of hypertension during pregnancy and hemorrhage among homeless women in Massachusetts.

Implications for policies and practices

The findings of this review reinforce the need for public policies and intersectoral interventions that address the social determinants of health in this population. This includes not only ensuring access to quality sexual and reproductive health and prenatal services tailored to the specific needs of these women (with active search, flexible hours, trauma-sensitive approaches), but also providing safe housing solutions, psychosocial support and harm reduction programs for substance use. The articulation between social assistance, health and housing is essential.²⁰ Care models such as Consultórios na Rua in Brazil are important strategies, but they need to be strengthened and integrated with other policies.^{35,36}

Strengths and limitations

This study used the scoping review methodology to comprehensively map recent literature on a complex topic relevant to public health and primary care.⁷ The thematic analysis allowed us to synthesize the main risks and outcomes identified. However, the review has limitations. The search was conducted in only two databases and may not have captured all relevant literature. Most of the included studies are from North America, limiting direct generalization to the Brazilian context, although many of the problems are universal. The main contextual limitation is the lack of robust epidemiological data on homeless pregnant women in Brazil, which makes it difficult to assess the size of the problem nationally.³³ Furthermore, as is characteristic of scoping reviews, the methodological quality of the included studies was not critically evaluated.⁷

CONCLUSION

This scoping review demonstrates that homeless pregnant women constitute a highly vulnerable group, exposed to multiple interconnected risks that result in significant adverse consequences for maternal and fetal health. Factors such as housing instability, violence, substance use, barriers to accessing sexual and reproductive health and prenatal services and mental health problems contribute to outcomes such as preterm birth, low birth weight and neonatal complications.

The findings reinforce the urgency of comprehensive and intersectoral approaches. It is essential to develop and implement public policies that ensure safe housing, easy access to quality health care (including mental health and substance use treatment) and social protection for this population. Health services need to be adapted to accommodate and meet the specific needs of these women, with active search and continuum of care strategies.

Future research should focus on evaluating the effectiveness of different intervention models and collecting longitudinal data to better understand the health trajectories of these women and their children. In the Brazilian context, it is crucial to overcome statistical invisibility through the systematic collection of data on the homeless population, including pregnant women, to support evidence-based policies. By addressing knowledge and intervention gaps, it is possible to offer more effective support to these women and children, promoting healthier futures.

CONFLICT OF INTERESTS

Nothing to declare.

AUTHORS' CONTRIBUTIONS

DMAS: Project administration, Formal analysis, Conceptualization, Data curation, Writing—original draft, Writing—review & editing, Methodology, Validation. FS: Conceptualization, Data curation, Writing—original draft, Writing—review & editing, Validation. GR: Conceptualization, Data curation, Writing—first draft, Writing—review & editing, Validation. GG: Conceptualization, Data curation, Writing—original draft, Writing—review & editing, Validation. GC: Conceptualization, Data curation, Writing—original draft, Writing—review & editing, Validation. RCCC: Conceptualization, Data curation, Writing—original draft, Writing—review & editing, Validation. MMBF: Project administration, Formal analysis, Conceptualization, Data curation, Writing—original draft, Writing—review & editing, Methodology, Validation.

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