Catastrophizing pain in the perinatal period in postnatal maternal psychological outcomes: scoping review

Catastrofização da dor no período perinatal em desfechos psicológicos maternos pós-natais: revisão de escopo

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https://doi.org/10.5935/2595-0118.20240045-en

ABSTRACT

BACKGROUND AND OBJECTIVES: There are several conditions that can influence the experience of parturition and experiences related to labor pain. These aspects can result in important psychological outcomes in the postpartum period. Painful responses are mediated in different ways, and catastrophizing is one of the related variables. The objective of the present study was to map the evidence about the impact of pain catastrophizing in the perinatal period on postnatal maternal psychological outcomes, such as baby blues, anxiety disorders, postpartum depression and psychosis, up to three months after delivery.

CONTENTS: A literature scope review, was carried out with the following question: "What is the impact of pain catastrophizing in the perinatal period on postnatal maternal psychological outcomes"? The search for studies that made up the sample was carried out on July 31, 2023, using the Pubmed, Cochrane Library, Virtual Health Library and Science Direct databases. 113 documents were identified and based on the selection, four articles were included in the sample, all of them prospective/observational studies. The impact of catastrophizing on outcomes was evaluated: state-trait anxiety, postpartum depression, perceived stress, mother-infant interactions, maternal blues and social functioning.

CONCLUSION: It was shown that the catastrophizing of pain in the perinatal period is related to worse postnatal maternal psychological outcomes.

Keywords: Catastrophization, Depression postpartum, Labor pain, Parturition, Puerperal disorders.

RESUMO

JUSTIFICATIVA E OBJETIVOS: São diversas as condições que podem influenciar a experiência de parturição e vivências relacionadas à dor do parto. Esses aspectos podem resultar em desfechos psicológicos importantes no pós-parto. A mediação das respostas dolorosas ocorre de diferentes formas, e a catastrofização é uma das variáveis relacionadas. O objetivo deste estudo foi mapear as evidências acerca do impacto da catastrofização da dor no período perinatal em desfechos psicológicos maternos pós-natais, como *baby blues*, transtornos de ansiedade, depressão pós-parto e psicose, até três meses após o parto.

CONTEÚDO: Foi realizada revisão de escopo da literatura, com a seguinte pergunta: "Qual o impacto da catastrofização da dor no período perinatal em desfechos psicológicos maternos pós-natais"? A busca dos estudos que compuseram a amostra foi realizada em 31 de julho de 2023 utilizando as bases de dados Pubmed, Cochrane Library, Biblioteca Virtual da Saúde e Science Direct. Foram identificados 113 documentos e, a partir do processo de seleção, foram incluídos na amostra quatro artigos, todos eles estudos prospectivos/observacionais. Foi avaliado o impacto da catastrofização nos desfechos: ansiedade estado-traço, depressão pós-parto, estresse percebido, interações mãe-bebê, *maternal blues* e funcionamento social.

CONCLUSÃO: Evidenciou-se que a catastrofização da dor no período perinatal está relacionada a piores desfechos psicológicos maternos pós-natais.

Descritores: Catastrofização, Depressão pós-parto, Dor do parto, Trabalho de parto, Transtornos puerperais.

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Submitted on October 14, 2023.
Accepted for publication on June 21, 2024.
Conflict of interests: none - Sponsoring sources: none

HIGHLIGHTS

- The catastrophization of pain is related to worse postnatal maternal psychological outcomes.
- The outcomes found are maternal blues, social adjustment, depressive symptoms and less mother-baby reciprocity.
- Early identification of pregnant women with catastrophizing can help with risk classification and the necessary referrals in the prenatal and postnatal periods.

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INTRODUCTION

The experience of childbirth is unique, and this event, to a greater or lesser degree, brings with it the phenomenon of pain. It is a complex, subjective and multidimensional response to the sensory stimuli generated during parturition, and is highly variable in its sensory, affective and cognitive dimensions[1]. For example, during childbirth, oxytocin levels can encode the memory of pain in such a way as to reinforce positive emotions related to the event[2]. Thus, in the future there may be "underestimation" of the painful experience of childbirth[2]. In addition, the context has an impact on emotions and the memory of the event, which can make the experience positive or negative. Conditions related to health, changes in a woman's social life, behavior and feelings can all have a negative impact on the childbirth experience[3]. Intense pain and the feeling of not being able to control the situation also increase the risk of an unfavorable experience[3].

The postpartum period is unique in terms of the degree of neuroendocrine changes and psychosocia" adaptations[4]. There are various types of possible psychological disorders and negative experiences during childbirth can result in unfavorable outcomes such as anxiety[5] and depression[6]. The intensity of intrapartum pain may be associated with the incidence of baby blues[7] or maternal blues[8]. This is a "transient psychological condition with possible temporary symptoms, such as brief bouts of crying or crying, irritability or emotional lability, sadness/crying, unstable mood, insomnia, anxiety, loss of appetite and lack of concentration"[9], with symptoms beginning around the fourth or fifth day after childbirth and lasting up to 2 weeks[8]. Postpartum depression (PPD), on the other hand, is another disorder that can start a few days to a few weeks after giving birth, usually in the first 2 to 3 months[10]. Postpartum psychosis is one of the less common disorders, with an abrupt onset, observed between 2 weeks and 3 months after giving birth[11]. As already described, anxiety can also be present. The woman may not necessarily be depressed, but anxiety can have an impact on psychological functioning[12].

Pain responses can be mediated in a number of ways. An event known as "catastrophizing", which can be described as "an exaggerated negative mental set exerted during the actual or anticipated painful experience"[13], has been explored in the field of pain research and there are consistent findings showing that catastrophizing is associated with increased perception of the painful experience[13].

Catastrophizing is a psychological variable that can be measured using scales. The best known and most widely used was developed and validated by a reference study[14,15]. The Pain Catastrophizing Scale (PCS) instrument, in its initial instructions, guides participants to reflect on past painful experiences and indicate the degree to which they experienced each of the 13 thoughts or feelings when feeling pain, on 5-point scales ranging from zero (0) 'not at all' to four (4) 'all the time'. PCS provides a total score and three subscale scores assessing rumination, magnification and helplessness. PCS is often used for situational and dispositional assessment[15]. However, in recent years, some researchers have made adaptations to use it as a daily measure[16] and momentary measure[17], improving its prognostic usefulness and the prediction of results related to this outcome.

There are conditions that can be predictors of pain catastrophizing, such as high levels of fear of childbirth[18]. In turn, catastrophizing can be a predictor of requesting pain relief during the first stage of parturition[19]. In addition, catastrophizing is related to parturient having a higher level of pain when requesting analgesia[20]. Women with high scores for catastrophizing are twice as likely to request pain relief during labor than women with lower scores[19]. It is important to mention that this study was carried out in the Netherlands[19], a country that has guidelines for pain relief in childbirth that include the active participation of women in choosing the type of analgesia they want[21]. Therefore, it is necessary to consider cultural aspects that can strongly influence the behavior of requesting analgesia.

In view of the above, it is clear that early recognition of parturients with catastrophic traits can be a care approach aimed at mitigating the incidence of postnatal psychological alterations. Thus, the aim of this study was to map the evidence on the impact of catastrophizing pain in the perinatal period on postnatal maternal psychological outcomes, such as maternal blues, anxiety disorders, postpartum depression and psychosis, up to three months after delivery.

CONTENTS

A Scoping Review of the literature was carried out following the guidelines in the Joanna Briggs Institute's (JBI) manual for evidence synthesis[22] and the PRISMA-SCR-10 protocol[23].

The inclusion criteria were original studies published in English, Spanish or Portuguese, available in full, without a time frame; primary, quantitative or qualitative studies and studies that correlated catastrophizing pain in the perinatal period (described by the World Health Organization as starting at 22 completed weeks of gestation and ending at seven completed days of life)[24] with maternal psychological outcomes up to three months after childbirth. The exclusion criteria were: studies that did not address the research question, literature reviews, theses, dissertations, conference abstracts and clinical protocols.

To meet the objective, the research question was developed using the acronym PCC, where P = *population*, C = *concept* and C = *context*. These were: parturients (P), catastrophizing (C) and psychological outcomes during childbirth and the postpartum period (C), and the following question was formulated to guide the summarization of the evidence: "What is the impact of catastrophizing pain during the perinatal period on maternal postnatal psychological outcomes"?

The search for the studies that made up the review was carried out on July 31, 2023, using the Pubmed, Cochrane Library, VHL and Science Direct databases. The terms selected for the search strategy are part of the controlled descriptors of the Health Sciences Descriptors (DeCS) and the Medical Subject Headings Section (MESH): P (population) = labor OR obstetric OR parturition OR childbirth OR postpartum; C (concept) = catastrophizing OR catastrophization and C (context) = depression OR anxiety OR psychology OR baby blues OR stress disorders.

The articles included in the search were assessed and selected by two independent reviewers (A.C.N. and M.I.F.), who read the titles and abstracts and applied the eligibility criteria. Disparities were resolved through discussion and consensus. EndNote Web[25] was used to manage the references of the articles selected from the databases, as well as the Rayyan[26] platform, a tool for archiving, organizing and selecting articles. Based on the JBI[22] guidelines, the data extraction tool was adapted to meet the objectives of this review.

The level of evidence of the studies that made up the final sample was analyzed using the levels of evidence proposed by the Oxford Centre for Evidence-Based Medicine[27]. Methodological quality/risk of bias was assessed using the JBI checklists corresponding to the designs of the included studies (identification, comparable groups, clear inclusion criteria, exposure measures, outcomes assessed, clarity of results and statistical methods)[28]. The answers to the questions on the checklists were classified as: "yes", "no", "not applicable" or "uncertain"[29]. The score obtained by the studies was classified as follows: high methodological quality for studies with 70% or more "yes" answers; moderate methodological quality for studies with 50-69% "yes" answers; low methodological quality for studies with 49% or less "yes" answers. The assessment was carried out independently by two reviewers (P.M.M. and M.I.F.) and any discrepancies were resolved through discussion and consensus between the researchers.

Of the 113 references identified in the databases (Virtual Health Library, n=62; Cochrane, n=27; Pubmed, n=18; Science direct, n=6), 25 duplicates were removed, leaving 88 studies for screening. After reading the titles and abstracts, 54 records were excluded because they did not meet the eligibility criteria, leaving 34 to be assessed and read in full. Thirty studies were removed, 24 because they did not aim to assess the impact of catastrophizing on postnatal psychological outcomes and 6 because they presented a clinical protocol or conference abstract, with no full text found. Four articles were included in the final sample. They were prospective observational studies[30,31] and cohort studies[32,33], classified as level 3 evidence, all with high methodological quality or low risk of bias. The countries in which the research took place were Israel, the United States of America and Singapore.

The flowchart describing the process of screening, exclusion and inclusion of articles in the sample, as well as the reasons, was adapted from PRISMA[34] and is described in figure 1. The characteristics of each study and a detailed summary of the results are shown in table 1.

Sample characteristics

The total sample of the studies ranged from 72 to 518 participants, with an average of 188 individuals per study. The average age of the women was around 29 to 30 years. The gestational age required in the inclusion criteria differed in each study. Study A1[30] evaluated women between 37 and 42 weeks' gestation who were in active labor. Study A2[31] included women between 38 and 42 weeks who were in stage 1 vaginal delivery. Study A3[32] included women without comorbidities who were in the third trimester, above 28 weeks of gestation. The A4[33] study included women at 36 gestational weeks or more, with a single fetus, in early labor. As for parity, studies A1[30] and A2[31] included primiparous and multiparous women in the sample, while A3[32] and A4[33] only included nulliparous women.

Assessment tools for psychological variables

Pain catastrophizing was assessed by PCS in all the studies. The articles that assessed the outcome PPD and Maternal Blues used the Edinburgh Postpartum Depression Scale (EPDS), a self-administered scale developed and validated by a reference study[35]. The woman is asked to think about the last 7 days and answer 10 questions, marking the intensity of each question. The intensity ranges from zero to three and the sum of all the points is a maximum of 30. A score higher than 14 indicates a depressed mood with a risk of serious long-term depressive symptoms[30].

State-trait anxiety was assessed using the State-Trait Anxiety Inventory, a 40-item psychological test on feelings of immediate anxiety that an individual has at the moment (state anxiety) and the dispositional anxiety (trait anxiety)[36]. Perceived stress was measured using the Perceived Stress Scale, an instrument for assessing the degree to which situations in a person's life are perceived as stressful, using questions that refer to feelings and thoughts during the last month and the frequency with which they were experienced[37].

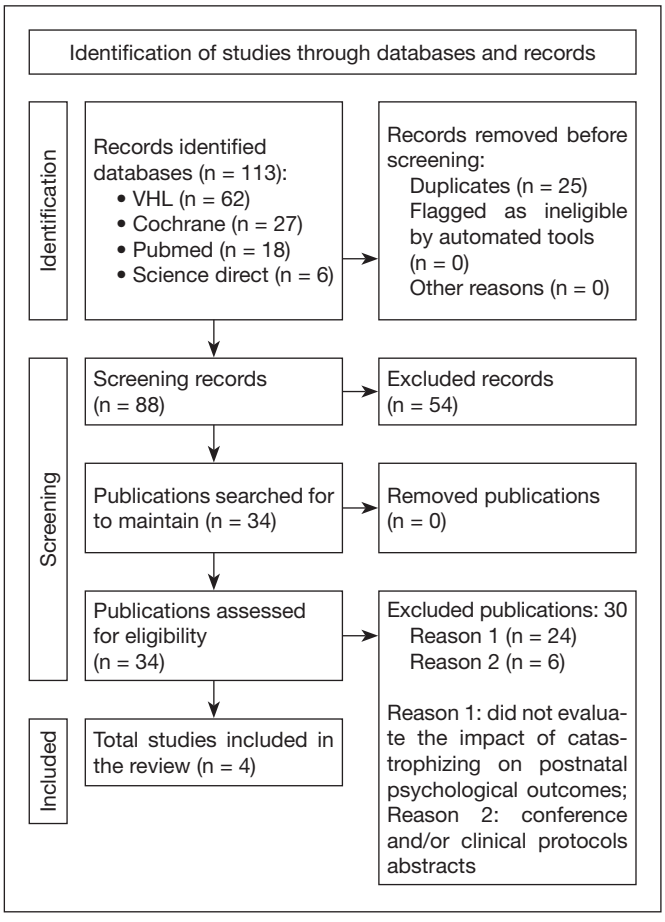

Figure 1. Article selection flowchart adapted from PRISMA

Table 1. Study characteristics and detailed results

Identification	Year/ country	Author(s)	Type of study and level of evidence and methodological quality	Sample size	Objective	Instruments/evaluation time*	Association of catastrophizing with psychological outcomes
A1	2005 Israel	Ferber, Granot and Zimmer[30]	Observational/ prospective Level: 3 High quality	n=82	To determine whether the catastrophizing of childbirth pain is associated with the level of maternal blues and social functioning in the short-term postpartum period.	Active phase of labor: - VAS 1 - PCS 1 Two weeks postpartum: - VAS 2 - PCS 2 - EPDS Six weeks postpartum: - Social functioning - SF36 Survey.	Maternal blues on the 2nd postpartum day and social functioning 6 weeks after delivery were predicted by scores above 9 on the catastrophizing scale (p<0.0001). Looking specifically at the three components of the PCS 1, it was found that rumination (p=0.003), helplessness (p=0.005) and enlargement (p=0.012) were significant predictors of maternal blues, while helplessness was significant in predicting social functioning at 6 weeks.
A2	2005 Israel	Ferber and Feldman[31]	Prospective observational Level: 3 High quality	n=81	To examine whether the experience of pain during labor has a long-term effect on the development of the mother-baby relationship.	On admission to the delivery room: - PCS - VAS - STAI - EPDS Six weeks postpartum: - PCS - VAS - CIB	Greater catastrophizing of pain was associated with older age, less schooling, less use of analgesia, greater pain intensity and greater depression. The three aspects of pain catastrophizing - rumination (p<0.0001), feelings of helplessness (p<0.0001) and the tendency to amplify pain (p<0.0001) - are each independently related to lower levels of mother-baby reciprocity.
A3	2020 USA	Lim et al.[32]	Prospective cohort Level:3 High quality	n=72	To evaluate psychological, psychosocial and perinatal pain factors predictive of depression symptoms. In exploratory analyses, to investigate the moderator-mediator effects between these factors.	Third quarter: - EPDS - PCS - BPI - STAI - Resilience During labor: - VAS - PTSS 1st and 2nd day postpartum: - BPI (short form) - PSS 6 weeks and 3 months postpartum: - EPDS - BPI (short form)	The scores for levels of prenatal catastrophizing in the cohort did not meet the criteria for selecting variables for multivariate modeling.
A4	2020 Singapore	Zeng et al.[33]	Prospective cohort Level: 3 High quality	n=518	To investigate whether high prepartum pain catastrophizing is associated with the binary variable of postpartum Edinburgh Postnatal Depression Scale (EPDS) scores (a cut-off point ≥10) as the primary outcome. To identify whether prepartum factors were associated with increased changes in postpartum EPDS scores as a secondary outcome, and to determine prepartum factors that were associated with high prepartum pain catastrophizing status.	During labor: - PCS - EPDS - PSS - STAI 5 to 9 weeks postpartum: - EPDS - STAI	Compared to the low pain catastrophizing group, high pain catastrophizing was associated with increased pre-block pain scores on a 0-10 numerical rating scale (p =0.0094), more anesthesiologists needed for epidural analgesia (p =0.0082) and the presence of irruptive pain (p = 0.0075). In the high pain catastrophizing group, all the subcomponents of prepartum PCS (rumination, amplification, helplessness) were significantly higher than in the low catastrophizing group (p<0.0001). Similarly, during the prepartum survey, the high catastrophizing group showed greater perceived stress, (p<0.0001), state-trait anxiety (p<0.0001) and postpartum depression (p<0.0001), compared to the low catastrophizing group. Specifically, the high pain catastrophizing group was associated with an increased level of postpartum depression (p=0.0033).

VAS = Visual Analogue Scale; PCS = Pain Catastrophizing Scale; EPDS = Edinburgh Postpartum Depression Scale; STAI = State-Trait Anxiety Inventory; CIB = Coding of Interactive Behavior; BPI = Brief Pain Inventory; PTSS = Pain Treatment Satisfaction Scale; PSS = Perceived Stress Scale.

Mother-baby interactions were assessed by Coding Interactive Behavior, a global system used to analyze the interaction of the caregiver-infant dyad[38]. In addition, social functioning is one of the domains of the Quality of Life Questionnaire SF36 Survey[39,40], which covers eight health concepts; "this domain was chosen as the preferred measure for this study because social adjustment is one of the main difficulties for women after childbirth"[31].

Findings related to the catastrophization outcome

The selected studies focused on assessing the impact of pain-related variables, including catastrophizing, on different postnatal maternal psychological outcomes, such as state-trait anxiety[30-32], postpartum depression[30-33,] perceived stress[32,33], mother-baby interactions[31], maternal blues[30] and social functioning[30].

Study A1[30] showed that parturient with higher levels of catastrophizing of labor pain had lower maternal adjustment after childbirth, and PCS, applied during the active phase of labor, was a significant predictor of maternal blues and social functioning at 6 weeks after the birth of the baby. In addition, the study showed that the mothers' younger age and lower educational level indicated a greater risk of not adapting to the postpartum period changes.

Study A2[31] indicated that pain catastrophizing was associated with older age, less schooling, less use of analgesia, greater pain intensity and higher levels of depression, and all three aspects of pain catastrophizing were independently related to lower levels of mother-baby reciprocity.

Study A3[32] did not present results related to the pain catastrophization outcome. The authors report that PCS scores during the prenatal period did not meet the variable selection criteria for the multivariate modeling described in the study's methodology. In an exploratory analysis in which the variable was included in the multivariate modeling, it was observed that pain catastrophizing did not significantly alter the findings.

Study A4[33] showed that high pain catastrophizing was not directly associated with probable PPD five to nine weeks after delivery. However, high prepartum pain catastrophizing, lower BMI and the presence of breakthrough pain during epidural analgesia were associated with increased EPDS scores five to nine weeks after delivery, indicating a higher level of depressive symptoms.

DISCUSSION

This review sought to summarize the evidence on the impact of pain catastrophizing in the perinatal period on maternal psychological outcomes up to three months after childbirth. Four articles made up the sample of this study, demonstrating that the field of research on the subject could be further explored. Most of the studies[30,31,33] listed pain catastrophizing among the main outcomes analyzed, while one study[32] aimed to evaluate variables related to the pain outcome, with catastrophizing not being considered one of the main variables.

It was found that high levels of pain catastrophizing in the perinatal period are related to negative impacts on psychological outcomes such as maternal blues[30], lower social adjustment[30], depressive symptoms[31,33] and lower mother-baby reciprocity[31]. In fact, during labour, women can present mental states ranging from focus and acceptance of the pain experience to states of distraction and negative perception of pain, mediated by psychological processes such as catastrophizing[41]. Thus, the data found in this study indicate the possibility of prevention and/or early treatment of negative outcomes in the puerperium by identifying women with pain catastrophizing during the perinatal period.

In this sense, the use of PCS as a screening tool for pain catastrophizing in parturient deserves to be considered. In Brazil, the scale has been validated for Portuguese and the results of the validation study confirmed the adequacy of its psychometric properties[42]. PCS use can predict catastrophizing some time before painful procedures[15], which makes its use in this population feasible. However, there are still no studies aimed at standardizing the best time to apply the scale to parturient, which is evident in the sample studied.

Thus, the evaluation period for the catastrophizing outcome differed between the studies, demonstrating a lack of homogeneity or consensus. Although it is not possible to establish a direct relationship, it can be speculated that this aspect has the potential to influence the findings about parturients who have catastrophized pain.

In article A1[30], the assessment was carried out at the beginning of the active phase of labor, before the women received analgesia, and two days after delivery. In article A2[31], the assessment took place two days after delivery. In article A3[32], the participants were assessed in the third trimester of pregnancy, a fact that could be explored to justify the absence of a relationship between the catastrophizing of pain and negative outcomes found in the study. Finally, in article A4[33], PCS was applied after epidural analgesia, during labor.

After the onset of labor and in the subsequent phases, neurohormonal and physiological changes begin in the parturient woman, which impact the self-perception of the experience, as well as the woman's perception of pain, in addition to fluctuations in the level of consciousness[43]. Knowing that catastrophizing refers to the experience of pain, it is necessary to investigate the ideal moment for evaluation, since catastrophizing can present itself in different ways at different times during the perinatal period.

Another aspect to consider is the cut-off point for the PCS score. In the adult community, a score above 30 represents a clinically relevant level of catastrophizing[15]. In the sample studied[30-33] the cut-off point described for PCS was 20 points to establish which patients had catastrophizing. One approach that can generate relevant data by allowing patients to be stratified according to the severity of the condition is grouping. Study A4[33] separated the participants' data into a high catastrophizing group for those who scored 25 or more, and a low catastrophizing group for those who scored below 25. Establishing this cut-off point is an important factor, since the scale has very wide scoring possibilities.

It is known that women with catastrophizing anticipate and experience more p'in during childbirth and their physical recovery[44] and this should be a concern for the team assisting them, observing the adequate provision of analgesia. All the studies[30-33]

in the sample of this research reported that parturients were offered epidural analgesia and chose to accept it. However, agreement to receive analgesia was not related to the levels of pain catastrophizing among parturients.

Study A4[33] identified that in cases of patients with pain catastrophizing, there was a greater recommendation to use analgesia by the professionals accompanying them. The study indicated that these parturients became more sensitive to the recommendations of the professionals as they experienced the process of catastrophizing[45]. On the other hand, these data show that the professionals who took part in the study were aware of the impacts of catastrophizing on parturients and sought to include care measures to avoid them by offering analgesia.

As for parity, the studies in this study's sample included both groups of exclusively nulliparous women[32,33] and groups of nulliparous and multiparous women[30,31]. In studies that sought to compare whether fear of childbirth, pain intensity and analgesic consumption are related to parity, it was observed that multiparity does not represent a protective factor in terms of pain aspects[46]. In addition, cognitive descriptors of labor pain are not affected by parity or stage of labor[47]. As for the postpartum period, it has been shown that primiparous women, when compared to multiparous women, have a higher risk of developing depression, anxiety and sadness[48]. Despite this, the results relating to parity are still incongruous, indicating the need for further research.

Since catastrophizing is directly related to the experience of pain[49] and to the increase in intermittent and neuropathic sensory perception of childbirth pain[50], pain relief and management strategies can be useful tools in this scenario, since both the context and the way pain is perceived influence its experience[49]. A study that analyzed a childbirth education program based on mindfulness found that pregnant women in the intervention group had greater body awareness, fewer symptoms of postpartum depression and greater self-efficacy in childbirth[51].

Another prenatal education program for pregnant women showed that there was a significant improvement in maternal self-efficacy in the intervention group[52]. Therefore, in addition to providing adequate analgesia during childbirth, non-pharmacological strategies that include education for pregnant women, favoring psychological and cognitive aspects, have the potential to be useful in preventing and controlling the impacts of pain catastrophization in this population.

In view of the above, it is clear that studies addressing the issue of pain catastrophizing in the perinatal period, related outcomes and effective interventions for its prevention and control are important. The gaps that could be identified in this study are the lack of consensus on the cut-off point for PCS, the lack of homogeneity in the studies regarding the perinatal moment when levels of catastrophizing were assessed, as well as the period when the other psychological outcomes were assessed – which varied in relation to the moment when they could be identified in the puerperal women.

CONCLUSION

The limitations of this study include the fact that labor is a time when women are vulnerable, and evaluations at this stage may be biased depending on the context in which the parturient woman is inserted. Caution is advised when interpreting the data in this review, given the small number of studies in the sample, as well as the lack of a cut-off point for assessing the PCS score which would allow levels of catastrophizing to be established in the parturient population.

In summary, the analysis of the articles in the sample showed that catastrophizing pain in the perinatal period is related to worse maternal psychological outcomes in the postnatal period, namely: maternal blues, social adjustment, depressive symptoms and less mother-baby reciprocity. The data suggest that early identification of pregnant women with catastrophizing can help with risk classification and the necessary referrals in the pre- and post-partum period, thus enabling a lower incidence of psychological problems in the puerperium, better interaction in the mother-baby dyad and the mother's physical and emotional recovery.

In addition to these findings, which demonstrate the importance of the topic in terms of women's care during the perinatal period, mapping the sources of evidence allowed this research to identify gaps to be filled in future studies on the subject. These are the standardization of the cut-off point for the Pain Catastrophizing Scale score, the times when this outcome is measured, as well as the times when the instruments are applied to assess the other outcomes related to psychological variables.

AUTHORS' CONTRIBUTIONS

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Data Collection, Conceptualization, Research, Methodology, Writing - Preparation of the original, Writing - Review and Editing, Visualization

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Research, Methodology, Writing - Preparation of the original, Writing - Review and Editing, Visualization

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Data Collection, Conceptualization, Project Management, Research, Methodology, Writing - Preparation of the original, Writing - Review and Editing, Supervision, Visualization

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