Review Paper

Investigating Newborn Pain Identification by Health Professionals Versus Non-health Professionals: A Systematic Review

Sahar Gholami[1], Mojtaba Keikha[2], Zeinab Hemati[3*], Roya Kelishadi[3]

1. Student Research Committee, Isfahan University of Medical Sciences, Isfahan, Iran.
2. Department of Biostatistics and Epidemiology, Faculty of Public Health, Kerman University of Medical Sciences, Kerman, Iran.
3. Child Growth and Development Research Center, Research Institute for Primordial Prevention of Non-Communicable Disease, Isfahan University of Medical Sciences, Isfahan, Iran.

Use your device to scan and read the article online

Citation Gholami S, Keikha M, Hemati Z, Kelishadi R. Investigating Newborn Pain Identification by Health Professionals Versus Non-health Professionals: A Systematic Review. Journal of Pediatrics Review. 2024; 12(4):311-320. http://dx.doi.org/10.32598/jpr.12.4.1214.1

http://dx.doi.org/10.32598/jpr.12.4.1214.1

Article info:
Received: 01 Jun 2024
First Revision: 29 Jun 2024
Accepted: 17 Jul 2024
Published: 01 Oct 2024

Key Words:
Neonate, Newborn, Pain, Health professionals, Non-health professionals, Systematic review

ABSTRACT

Background: Eye-tracking methods are among the tools used to assess neonatal pain. This study systematically reviews newborn pain identification by health professionals versus non-professionals.

Objectives: This study aims to systematically review the newborn pain identification by health professionals versus non-professionals.

Methods: This was a systematic review conducted following the preferred reporting items for systematic reviews and meta-analysis guidelines. The research question was to compare newborn pain identification by health professionals versus non-professionals. A comprehensive search was conducted in the following databases: Medline via PubMed, Clarivate Web of Science, Scopus, and Google Scholar. The search was done until December 2022 using the following keywords: Pain identification, pain perception, infant, neonate and newborn. The data were extracted based on the inclusion criteria. Articles were assessed by two researchers and any discrepancies were resolved by a third author. After the selection process, 6 papers were included in this systematic review. The study protocol is registered in PROSPERO with identification number CRD42022347654.

Results: This systematic review revealed that the process of pain assessment in newborns is different according to the decision of a health professional and a non-health professional; therefore, equipping the newborn intensive care unit with verified instruments and their frequent use may help improve communication among caregivers and health professionals.

Conclusions: Additional efforts are required to improve the knowledge of both health professionals and non-health professionals in the process of pain assessment and management according to the age groups of neonates.

** Corresponding Author:*
Zeinab Hemati, Assistant Professor.
Address: *Child Growth and Development Research Center, Research Institute for Primordial Prevention of Non-Communicable Disease, Isfahan University of Medical Sciences, Isfahan, Iran.*
Tel: *+98 (913) 3838758*
E-mail: *z.hemate@gmail.com*

Introduction

Pain is a sensory and emotional phenomenon [1] and natural response that protects the body from potential damage to tissue [2, 3] that is present everywhere. However, it is complicated to understand the pain of other individuals [1]. Although there are some common characteristics among the fundamentals of the process involved in pain perception, pain is subjective. Transducing a harmful stimulus that initiates a pain experience depends on some factors including individual physiology, personal experiences and social environment [4, 5].

Varying pain experiences among individuals makes pain measurement and treatment more complicated. This is of special concern in newborns who cannot express their experiences in words and have an undeveloped central nervous system. This system includes pathways and networks responsible for somatosensory and emotional processing [5]. Since neonates cannot verbalize their pain, developing several scales will enable people to assess their pain. Although these scales assess the observable indicators of neonatal pain, many other factors contribute to the results. These factors include the characteristics of the patient and the evaluator, as well as the environment. In this regard, the evaluation of pain performed by those adults who are responsible for neonatal care is a way for the process of quality improvement. There are many techniques for enhancing the process of pain assessment [3, 6].

Several investigations have employed the visual tracking technique to determine the focal point of individuals' gaze in varying circumstances, like assessing the portrayal of discomfort in grown-ups. These studies revealed that people who have undergone pain in the past exhibit different eye fixation patterns when observing images depicting pain, compared to those without any previous pain experience. Eye tracking and pain evaluation research predominantly elucidate how adults direct their visual attention when observing the faces of adults exhibiting diverse emotional expressions [7, 8].

Facial expression in infants following stimuli used to harm tissues offers significant and unbiased evidence after tissue-damaging stimuli. It may provide important and objective evidence of pain in infants at a time when many people doubted the ability of infants to perceive pain [9, 10]. Hence, scrutinizing facial expressions in infants can be a reliable and responsive method for evaluating pain [11].

Eye-tracking methods are valuable tools for enhancing our understanding of certain behaviors [3, 6]. This technique has been applied to assess the actions of healthcare professionals in neonatal resuscitation settings, revealing that their primary focus was on the mannequin, followed by the monitors and the staff [12]. In a related experimental study, both healthcare and non-healthcare professionals were observed while assessing neonatal pain by tracking their gaze on facial images of newborns. The findings indicated that healthcare professionals spent more time focusing on the mouth and nasolabial folds, while non-professionals were more likely to fixate on the eyes and forehead [3]. Given the critical role of visual tracking in determining whether a neonate is in pain, the current study seeks to conduct a systematic review of existing research comparing the ability of healthcare professionals and non-healthcare professionals to identify neonatal pain.

Methods

This systematic review was carried out following the guidelines outlined by the preferred reporting items for systematic reviews and meta-analysis [13]. The study protocol has been registered in PROSPERO under the identification number CRD42022347654.

Review question

The review question was to investigate whether there is a difference in the ability to identify newborn pain between health professionals and non-health professionals. The participants, interventions, comparisons and outcomes of the study are as follows:

P: Newborn child, I: No intervention, C: Health professionals and non-health professionals and O: Pain identification.

Data sources

A systematic electronic search was conducted in the PubMed, Scopus and Clarivate-Web of Science databases. All databases were searched from inception to December 2022. The search terms that were used in databases are as follows: (Pain) AND (cognition OR assessment OR detection OR intensity OR measurement OR perception OR identification OR evaluation OR perceptions OR assess OR expression OR Indicators OR judgments OR predicting OR recognition OR rating OR expressing OR judging OR interpretation) AND (infant OR infancy OR neonate OR neonates OR neonatal OR newborn).

Additionally, we searched for human studies on Google Scholar to enhance the sensitivity of the search algorithm. Conference papers, editorials, letters, commentaries, short surveys and notes were excluded from the review. The search was carried out without any time restrictions.

Citation tracking

To enhance search sensitivity and maximize the number of relevant studies, the reference lists of each research article were also examined.

Data management

The EndNote software, version 7 was used to manage and organize the references retrieved from the databases. Duplicate papers were removed and stored in a separate duplicate library.

Inclusion and exclusion criteria

The dataset included all cross-sectional, case-control, and longitudinal studies that examined the pain perspective of parents and treatment teams in neonates and infants. There were no restrictions based on time or language in the search for relevant studies. As a result, conference papers, editorials, letters, commentaries, short surveys and notes were excluded.

Data extraction

The titles and abstracts of the articles in the literature were independently screened by two reviewers (Zeinab Hemati and Mojtaba Keikha) to assess their relevance and determine whether the full text should be evaluated for inclusion in the review. The data extracted from all research involved the location of research, type of study, ward, characteristics of participants, tools for assessment of pain, and main result (Sahar Gholami). Any reviewer's disagreement was resolved by consulting with an expert investigator (Roya Kelishadi).

Quality assessment

The quality of the articles was assessed using the Newcastle–Ottawa Scale and the PEDro scale for cross-sectional and experimental studies. The Newcastle–Ottawa Scale consists of three sections, with a maximum of 9 points possible: Patient selection (up to 4 points), comparability (up to 2 points) and outcome (up to 3 points) [14]. The PEDro scale includes 11 questions [15]. The quality scores for each study are listed in Table 1.

Results

Study inclusion

A total of 3441 studies were identified in the initial search, with 621 duplicates removed by EndNote and placed in the duplicate library. This left 2820 unique studies for screening. Of these, 2564 studies were excluded after reviewing the titles and abstracts due to irrelevance or failure to meet the inclusion criteria. After a full-text review, 6 studies were included in the systematic review (Figure 1). Table 1 provides an overview of the study characteristics and outcome measures.

Study characteristics

Facial expressions are considered the gold standard for assessing pain because they exhibit a remarkable degree of specificity and are frequently observed as reliable pain indicators [16]. Consequently, determining where adults direct their visual attention while assessing neonatal pain has proven to be advantageous in improving the precision of identifying the presence or absence of pain [17]. In the current systematic review, we studied newborn pain identification by health professionals versus non-health professionals.

Among all included studies, one study provides information about the comparative perspective of father and mother [18], three studies are related to parents, nurses, and physician [3, 11, 19], one study is related to professionals and individuals with professions not related to health [17], and one study is related to pediatricians [20]. The study design and characteristics for all included studies according to the outcome are shown in Table 1.

Visual tracking of health professionals and non-health professionals

The findings of this review indicate that when examining neonatal facial expressions, both health professionals and non-health professionals demonstrated a consistent pattern of visual attention across various areas of interest, with only slight differences. However, health professionals showed a stronger focus on the mouth and nasolabial furrow compared to non-health professionals. Additionally, the results revealed a positive correlation between the total duration of visual fixation by health professionals and a higher likelihood of accurately identifying both the presence and absence of pain in newborns. In a study involving 84 health professionals and 59 non-health professionals, who assessed two images of 10 neonates (one at rest and the other during a

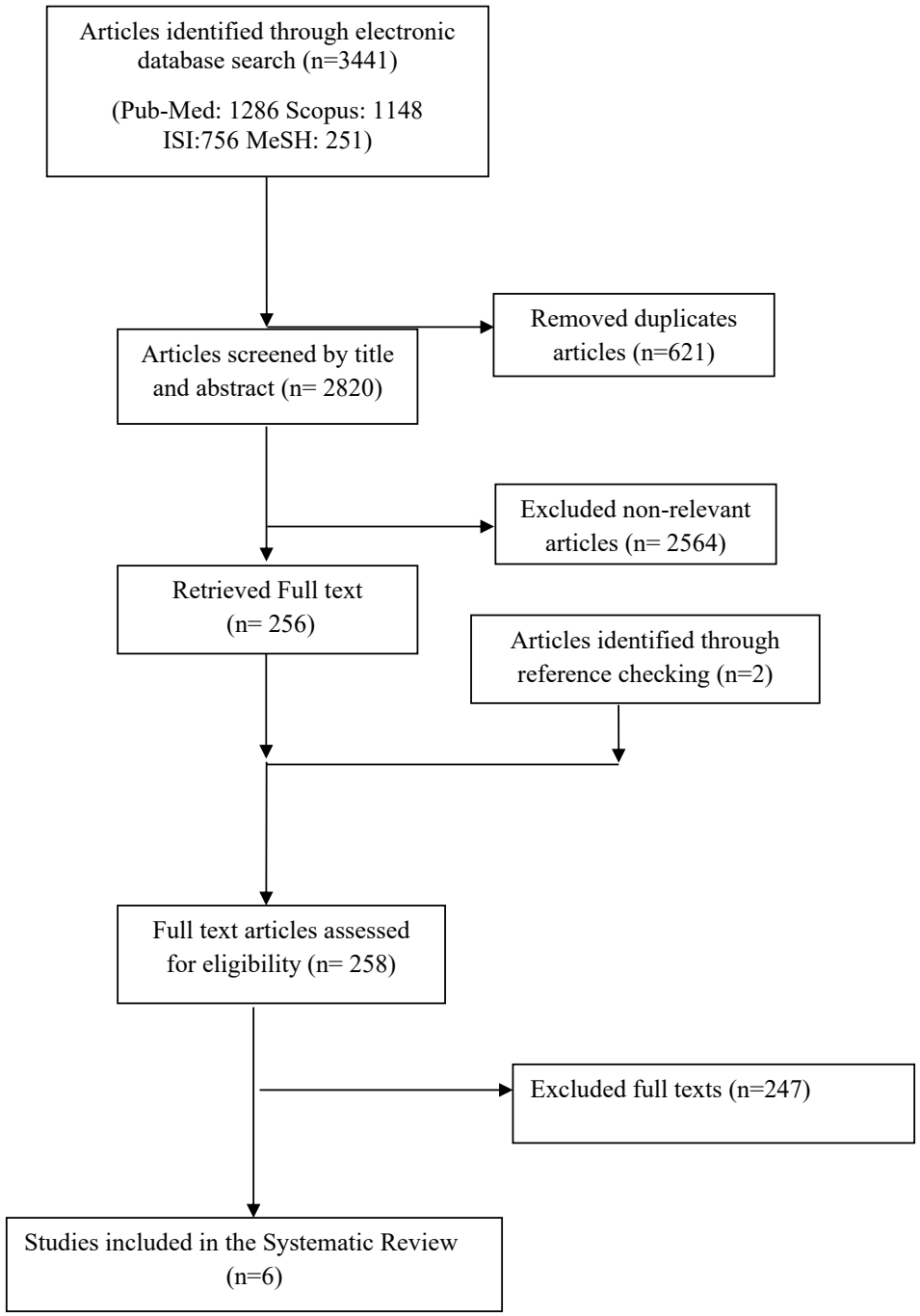

Figure 1. Papers search and review flowchart for selection of primary studies

Journal of Pediatrics Review

painful procedure), health professionals provided lower scores for the resting images (0.81±0.5 vs 1.59±0.76; P=0.010) but showed no difference in ratings for the images taken during the painful procedure (6.98±1.08 vs 6.73±0.82). The eye-tracking results revealed that health professionals, in contrast to non-health professionals, tended to focus more on the mouth and nasolabial furrow, while spending less time on the eyes and forehead when evaluating the facial images of the neonates [3]. The experimental study, involving 38 pediatricians (92% females, 22 neonatologists) who evaluated 20 pictures (two pictures of each newborn: One at rest and one during a painful procedure), aimed to analyze the gaze fixation of pediatricians during the decision process regarding the presence/absence of pain in pictures of newborn infants showed pediatricians fix their gaze preferably in the mouth [20].

According to a cross-sectional study, 74% of the health professionals and 86% of the non-health professionals

correctly identified pictures depicting facial expressions of pain in at least 2 of the 3 sets. When asked to choose the picture taken during a heel puncture, 94% of healthcare professionals and 92% of non-health professionals correctly selected the image from set 1 [11].

An experimental study revealed that individuals who accurately distinguished between images of newborns experiencing pain and those not experiencing pain, compared to those who were unable to make accurate distinctions in both situations, focused their attention on the nasolabial furrow in a greater number of pictures (P=0.003). These individuals also had a greater average number of fixations in this specific area of interest (P=0.005) [17]. In a cross-sectional study involving 52 infants and 52 adult observer sets, each consisting of a parent, a nurse technician, and a pediatrician, all observing the same newborns receiving mechanical ventilation, no significant correlation was found between the pain and distress scores provided by the adult observers. The correlation coefficients were 0.359 and confidence interval (CI) were (95% CI, 0.007%, 0.632%) for parents, 0.471 (95% CI, 0.227%, 0.659%) for nurse technicians and 0.461 (95% CI, 0.215%, 0.652%) for doctors [19].

Thus, in contrast to non-health professionals, healthcare professionals displayed a greater frequency of focusing their gaze on the nasolabial furrow and mouth. Furthermore, being a healthcare professional was linked to an elevated likelihood of having the capability to accurately differentiate between the presence and absence of pain.

Total time of visual fixations

Health professionals displayed prolonged periods of visual fixation on the infant's mouth in contrast to their non-health professional counterparts. This extended focus on the mouth was positively associated with an increased likelihood of accurately detecting pain. In a study conducted by Barros et al.'s study, it was found that the nasolabial furrow received less attention compared to other areas. However, adults who correctly identified the presence or absence of the pain in the pictures spent more time looking at this area; moreover, they had a greater number of fixations on it [17]. In an experimental study with 84 health professionals and 59 non-health professionals, it was found that individuals with health professional backgrounds spent more time visually fixed on the baby's mouth compared to individuals with non-health professionals. In contrast, health professionals had shorter visual fixation duration on the infant's eyes when compared to their non-health professional counterparts. No differences were found between the two groups in terms of visual fixation times in other areas [3].

In another study, the average duration of eye fixation was found to be longer on the mouth and forehead than on the nasolabial furrow. After controlling for the gaze fixation time in the areas of interest in each image, each additional second spent focusing on the mouth (odds ratio [OR]: 1.26; 95% CI, 1.08%, 1.46%) and forehead (OR: 1.16; 95% CI, 1.02%, 1.33%) was linked to an increased likelihood of detecting moderate to severe pain in the neonatal facial image [20].

Discussion

To the best of our knowledge, this is the first systematic review comparing newborn pain identification by health professionals and non-health professionals. The results of this review indicated that both groups exhibited a similar pattern of visual attention when evaluating neonatal facial expressions, with only minor differences. Health professionals, compared to non-health professionals, tended to focus more on the mouth and nasolabial furrow. Furthermore, the findings revealed that the total duration of visual fixation by health professionals was associated with an increased likelihood of accurately identifying both the presence and absence of pain in newborns. Being a health professional is linked to a higher probability of possessing the skills necessary to accurately assess neonatal pain. It is necessary to assess neonatal pain over time, and some factors should be considered in this assessment such as neonates' response to interventions, environment, and their general state of well-being. Health professionals come up with the solution by developing scales for pain assessment which leads to better decision-making in managing neonates in critical situations [21, 22].

In this regard, Elias et al. evaluated the agreement between physicians, nursing professionals, and parents regarding the existence of pain in sick newborns. The results showed that physicians, nursing professionals, and parents are in line; however, the heterogeneity was observed between the three studied groups when the pain was present [23]. Furthermore, Barros et al. illustrated that although adults typically exhibit uniform visual attention when observing neonatal faces, individuals who can accurately distinguish between images of neonates with and without pain tend to focus their gaze more frequently and for longer durations on the nasolabial furrow compared to those who cannot. Moreover, being a health professional was associated with a 2.15-fold increase in the likelihood of correctly identifying both the

Table 1. Characteristics of included studies in the current systematic review

ID	Authors (y)/ Location	Study Type	Ward	Characteristics of Newborn	Tools for Assessing the Pain	Comparator	Main Results	Q Score
1	Craig et al. 1988/Columbia [18]	Cross-sectional	Newborn unit	Babies on the second day after birth-undergoing routine heel lance to provide blood samples for phenylketonuria screening-healthy infants	Observation	Father-mother	Fathers rated sensory intensity as more severe than mothers, $F_{(l, 43)}$=5.29, P<0.05. The mean ratings for mothers and fathers were 13.4 and 15.9, respectively. Both cry pitch, $F_{(l, 43)}$=56.1, P<0.001 and facial activity, $F_{(l, 43)}$=85.7, P<0.001, affected ratings of the sensory dimension, as expected. Analyses of judgments of affective discomfort again yielded significant effects for cry pitch, $F_{(l, 43)}$=50.9, P<0.001, and facial activity, $F_{(l, 43)}$=92.0, P<0.001, but the mothers and fathers did not differ in their ratings of the amount of discomfort experienced (P>0.05). The interaction between cry pitch and amount of facial activity was also significant, $F_{(l, 43)}$=12.2, P<0.001.	6
2	Elias et al. 2014/ Brazil [19]	Cross-sectional	Neonatal intensive care	Postnatal age of 24 to 96 h old; placement in an incubator, presence of gastric tube, peripheral and/ or central venous access, and conventional mechanical ventilation by a tracheal tube, independent of the ventilator settings. Infants with congenital malformations or chromosomal syndromes were excluded from the study.	Observation and using two vertical visual analog scales	Parents-nurse technicians-pediatricians	The assessments of pain and distress were heterogeneous in all three investigated groups of adults as determined by the results of a Bland-Altman plot. The pain and distress scores in each adult group were not correlated as shown by the intraclass correlation coefficient (parents: 0.36 [95% CI, 0.01%, 0.63%]; nurses 0.47 [95% CI, 0.23%, 0.66%]; pediatricians: 0.46 [95% CI, 0.22%, 0.65%]). Adults systematically underscore pain in comparison to distress in mechanically ventilated newborns, without recognizing the association between them.	7
3	Xavier Balda et al. 2000/ Brazil [11]	Cross-sectional	Neonatal intensive care unit, nursery, and outpatient clinic of one university hospital and one private hospital	Healthy full-term newborns who needed glucose screening were photographed at rest and during light exposure, heel rubbing, and heel puncture.	Observation	Parents-health professionals: Physicians, nurses	A total of 74% of the health professionals and 86% of the non-health professionals indicated correctly the picture with facial expressions of pain in at least 2 of the 3 sets. Regarding which picture was picked out by the interviewee, 94% of the health professionals and 92% of the non-health professionals indicated the picture was taken during the heel puncture in set 1. The same observation was made by 53% and 54% of the health professionals and by 68% and 66% of the non-health professional interviewees for sets 2 and 3, respectively. The facial expression of pain represents an effective neonatal communication tool. The health professional group achieved a lower level of recognition of neonatal facial expressions of pain.	5

ID	Authors (y)/ Location	Study Type	Ward	Characteristics of Newborn	Tools for Assessing the Pain	Comparator	Main Results	Q Score
4	Soares et al. 2021/Brazil (Sao Paulo) [3]	Experimental	Neonatal units	Newborns at rest and undergoing a painful procedure (capillary or venous puncture, or intramuscular injection); gestational age of 38.0+1.2 weeks-birth weight of 2990+508 g; 40% male; 60% born by cesarean section; first and fifth min Apgar scores of 8.5±1.0 and 9.2±0.6, respectively; the pictures of the neonates were taken at the age of 1.8±0.8 days.	Observation	Health professionals (nurses-nursing technicians-physical therapists-speech therapists- pediatricians), non-health professionals (parents, lay people)	Health professionals (93% female; 34±9 years old), compared to non-health professionals (64% female; 35±11 years old), gave lower scores for images at rest (0.81±0.50 vs 1.59±0.76). No difference for those obtained during the painful procedure (6.98±1.08 vs. 6.73±0.82). There was a strong or almost perfect correlation for the number of fixations in the mouth, eyes, and forehead and for the total fixation time in the eyes and forehead.	7
5	Barros et al. 2021/São Paulo [17]	Experimental study	Neonatal intensive care unit	Eye movements of adults were tracked during the evaluation of facial images of newborns admitted to the NICU at rest and during a painful procedure.	Observation and Tobii-TX300 tracked the participants' eye movement	A total of 84 health professionals and 59 individuals with professions not related to health	To identify neonatal pain, adults look at the mouth, eyes and forehead in facial pictures. The latent class analysis identified four classes of adults: Identifying painful/painless neonates (YY-Class; n=80); only painful neonates (n=28); only painless neonates (n=34) and none (n=1). Being a health professional (OR: 2.29; 95% CI, 1.16%, 4.51%) and each look at the nasolabial furrow (OR: 2.07; 95% CI, 1.19%, 3.62%) increased the chance of belonging to the YY-Class.	8
6	Silva et al. 2023/São Paulo [20]	Experimental study	Neonatal unit of a tertiary level	20 pictures of 10 full-term and healthy newborn infants: one obtained at rest and the other during a painful procedure.	Observation and Tobii-TX300 equipment tracked eye movement	A total of 38 pediatricians were included, 16 were fellows in neonatology, and 22 neonatologists	In the 20 newborn pictures, the mean number of gaze fixations was greater in the mouth, eyes, and forehead than in the nasolabial furrow. Also, the average total time of gaze fixations was greater in the mouth and forehead than in the nasolabial furrow. Controlling for the time of gaze fixation in the areas of interest, each additional second in the time of gaze fixation in the mouth (OR: 1.26; 95% CI, 1.08%, 1.46%) and forehead (OR: 1.16; 95% CI, 1.02%, 1.33%) was associated with an increase in the chance of moderate/severe pain presence in the neonatal facial picture.	10

presence and absence of pain in images of newborns [17]. Stevens et al. suggested that paying attention to the nasolabial furrow can be used to evaluate the pain in neonates exposed to the heel puncture [24].

In another study, although both groups exhibited similar gaze patterns, health professionals, in contrast to non-health professionals, placed greater focus on the mouth and nasolabial furrow while paying less attention to the eyes and forehead when assessing neonatal facial expressions. Additionally, health professionals spent more time fixating on the infant's mouth compared to non-health professionals, while their fixation duration on the infant's eyes was shorter. No significant differences were observed in the attention given to other areas [3].

In an experimental study involving 38 pediatricians, which included 16 neonatology fellows and 22 neonatologists, pediatricians predominantly directed their gaze toward the mouth. Furthermore, the total duration of visual fixation on the mouth was notably longer when the pediatricians assessed cases with a perception of moderate to severe pain compared to cases where they perceived the absence of pain [3]. Grunau and Craig [25] also identified the mouth as the most sensitive indicator for pain recognition in their study, which analyzed videos of newborn infants undergoing heel punc-

tures. Consequently, the increased focus on the mouth, compared to other facial areas, may be due to the more noticeable changes between a neutral mouth expression and one displaying signs of pain, in contrast to the movements observed in other regions [26].

Although there was an overall similarity in gaze patterns between the two groups regarding the presence or absence of pain, some differences were still apparent. In general, when assessing neonatal facial expressions to determine pain, adults tend to adopt a holistic approach [3]. The ability to recognize and understand pain has its roots early in life. Zahn-Waxler [27], suggests that even one-year-old children can identify pain in family members through facial expressions and respond to it. This indicates that the capacity for empathy in recognizing others' pain develops at a young age. Therefore, when adults assess pain in others, they draw on this inherent empathy. This shared empathetic response suggests that the experiences of health professionals in recognizing pain do not significantly differ from those of non-health professionals [3].

Therefore, given that the mouth is the primary visual fixation for health professionals, including nurses and doctors, when assessing the presence or absence of pain, and there exists a direct correlation between the duration of eye fixation with this region and the pain intensity, educating parents about the facial features that can signify pain in their neonate's expression can greatly enhance their ability to diagnose pain accurately and provide higher-quality care.

The findings of this study offer a novel perspective on neonatal pain assessment, highlighting the specific facial movements that health professionals and non-health professionals focus on when determining the presence or absence of pain. The results from this study have the potential to improve our understanding of how health professionals make decisions regarding pain identification in neonates. Moreover, these findings aid in the improvement of pain assessment training within neonatal units by highlighting the significance of fixing gaze on previously overlooked areas. Additionally, identification of facial points that health professionals examine in the process of pain evaluation in neonates, could play a crucial role in the refinement of the assessment tool.

Conclusion

This systematic review revealed considerable differences among the health and non-health professionals regarding the presence of pain in neonates. The findings of our review offer a deeper insight into how health professionals ascertain the presence of pain in newborns. Additionally, these results can serve as valuable inputs for devising strategies to enhance the education and training of healthcare professionals in neonatal units. Moreover, it is difficult for adults to understand the experienced pain in newborns and attributing perceived distress to pain. There is a need to investigate novel strategies and to conduct longitudinal studies to overcome this problem.

Study limitations

The limitation of this review is the limited number of studies that might be considered. Despite this limitation, this review provides comprehensive information on newborn pain identification by health professionals versus non-health professionals. The strengths of this systematic review relate to the inclusion of articles in moderation with high methodological quality, studies with appropriate sample sizes, and the inclusion of studies with different perspectives between health professionals and non-health professionals in the process of pain identification in neonates and infants, have not been investigated in previous systematic reviews, to the best of our knowledge.

Ethical Considerations

Compliance with ethical guidelines

This study received approval from the Ethics Committee of Isfahan University of Medical Sciences, Isfahan, Iran (Code: IR.ARI.MUI.REC.1401.238).

Funding

This research was financially supported by Isfahan University of Medical Sciences, Isfahan, Iran (Grant No.: 2401166).

Authors contributions

Conceptualization: Zeinab Hemati and Sahar Gholami; Visualization: Mojtaba Keikha; Writing the original draft: Zeinab Hemati; Methodology, review and editing: Zeinab Hemati, Sahar Gholami and Roya Kelishadi; Final approval: All authors.

Conflicts of interest

The authors declared no conflict of interest.

Acknowledgements

The authors wish to thank the deputy of Research of Isfahan University of Medical Sciences, Isfahan, Iran for their support.

References

1. Riddell RP, Fitzgerald M, Slater R, Stevens B, Johnston C, Campbell-Yeo M. Using only behaviours to assess infant pain: A painful compromise? Pain. 2016; 157(8):1579-80. [DOI:10.1097/j.pain.0000000000000598] [PMID]

2. Brewer CL, Baccei ML. The development of pain circuits and unique effects of neonatal injury. J Neural Transm (Vienna). 2020; 127(4):467-79. [DOI:10.1007/s00702-019-02059-z] [PMID]

3. Soares JDCA, Barros MCM, da Silva GVT, Carlini LP, Heiderich TM, Orsi RN, et al. Looking at neonatal facial features of pain: Do health and non-health professionals differ? J Pediatr (Rio J). 2022; 98(4):406-12. [DOI:10.1016/j.jped.2021.10.006] [PMID]

4. Riddell RP, Flora DB, Stevens SA, Stevens B, Cohen LL, Greenberg S, et al. Variability in infant acute pain responding meaningfully obscured by averaging pain responses. Pain. 2013; 154(5):714-21. [DOI:10.1016/j.pain.2013.01.015] [PMID]

5. Fitzgerald M. What do we really know about newborn infant pain? Exp Physiol. 2015; 100(12):1451-7. [DOI:10.1113/EP085134] [PMID]

6. Maxwell LG, Fraga MV, Malavolta CP. Assessment of pain in the Newborn: An update. Clin Perinatol. 2019; 46(4):693-707. [DOI:10.1016/j.clp.2019.08.005] [PMID]

7. Priebe JA, Messingschlager M, Lautenbacher S. Gaze behavior when monitoring pain faces: An eye-tracking study. Eur J Pain. 2015; 19(6):817-25. [DOI:10.1002/ejp.608] [PMID]

8. Vervoort T, Trost Z, Prkachin KM, Mueller SC. Attentional processing of other's facial display of pain: An eye tracking study. Pain. 2013; 154(6):836-44. [DOI:10.1016/j.pain.2013.02.017] [PMID]

9. Ahola Kohut S, Pillai Riddell R. Does the neonatal facial coding system differentiate between infants experiencing pain-related and non-pain-related distress? J Pain. 2009; 10(2):214-20. [DOI:10.1016/j.jpain.2008.08.010] [PMID]

10. Grunau RE, Oberlander T, Holsti L, Whitfield MF. Bedside application of the neonatal facial coding system in pain assessment of premature neonates. Pain. 1998; 76(3):277-86. [DOI:10.1016/S0304-3959(98)00046-3] [PMID]

11. Xavier Balda Rd, Guinsburg R, de Almeida MF, Peres Cd, Miyoshi MH, Kopelman BI. The recognition of facial expression of pain in full-term newborns by parents and health professionals. Arch Pediatr Adolesc Med. 2000; 154(10):1009-16. [DOI:10.1001/archpedi.154.10.1009] [PMID]

12. Weinberg DD, Newman H, Fishman CE, Katz TA, Nadkarni V, Herrick HM, et al. Visual attention patterns of team leaders during delivery room resuscitation Resuscitation. 2020; 147:21-5. [DOI:10.1016/j.resuscitation.2019.12.008] [PMID]

13. Moher D, Liberati A, Tetzlaff J, Altman DG; PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. Ann Intern Med. 2009; 151(4):264-9, W64. [DOI:10.7326/0003-4819-151-4-200908180-00135] [PMID]

14. Wells GA, Shea B, O'Connell D, Peterson J, Welch V, Losos M, Tugwell P. The Newcastle-Ottawa scale (NOS) for assessing the quality if nonrandomized studies in meta-analyses. Ottawa: Ottawa Hospital Research Institute. 2011. [Link]

15. de Morton NA. The PEDro scale is a valid measure of the methodological quality of clinical trials: A demographic study. Aust J Physiother. 2009; 55(2):129-33. [DOI:10.1016/S0004-9514(09)70043-1] [PMID]

16. Brahnam S, Chuang CF, Sexton RS, Shih FY. Machine assessment of neonatal facial expressions of acute pain. Decis Support Syst. 2007; 43(4):1242-54. [DOI:10.1016/j.dss.2006.02.004]

17. Barros MCM, Thomaz CE, da Silva GVT, do Carmo Azevedo Soares J, Carlini LP, Heiderich TM, et al. Identification of pain in neonates: the adults' visual perception of neonatal facial features. J Perinatol. 2021; 41(9):2304-8. [DOI:10.1038/s41372-021-01143-1] [PMID]

18. Craig KD, Grunau, RV, Aquan-Assee J. Judgment of pain in newborns: Facial activity and cry as determinants. Can J Behav Sci. 1988; 20(4):442-51. [DOI:10.1037/h0079934]

19. Tannous Elias LS, Dos Santos AM, Guinsburg R. Perception of pain and distress in intubated and mechanically ventilated newborn infants by parents and health professionals. BMC Pediatr. 2014; 14:44. [DOI:10.1186/1471-2431-14-44] [PMID]

20. Silva GVTD, Barros MCM, Soares JDCA, Carlini LP, Heiderich TM, Orsi RN, et al. What facial features does the pediatrician look to decide that a newborn is feeling pain? Am J Perinatol. 2023; 40(8):851-7. [DOI:10.1055/s-0041-1731453] [PMID]

21. Bland JM, Altman DG. Measuring agreement in method comparison studies. Stat Methods Med Res. 1999; 8(2):135-60. [PMID]

22. Llerena A, Tran K, Choudhary D, Hausmann J, Goldgof D, Sun Y, et al. Neonatal pain assessment: Do we have the right tools? Front Pediatr. 2023; 10:1022751. [DOI:10.3389/fped.2022.1022751] [PMID]

23. Elias LS, Guinsburg R, Peres CA, Balda RCX, Santos AM. Disagreement between parents and health professionals regarding pain intensity in critically ill neonates. J Pediatr (Rio J). 2008; 48(1):35-40. [DOI:10.1590/S0021-75572008000100007]

24. Stevens B, McGrath P, Dupuis A, Gibbins S, Beyene J, Breau L, et al. Indicators of pain in neonates at risk for neurological impairment. J Adv Nurs. 2009; 65(2):285-96. [DOI:10.1111/j.1365-2648.2008.04854.x] [PMID]

25. Grunau RVE, Craig KD. Pain expression in neonates: Facial action and cry. Pain. 1987; 28(3):395-410. [DOI:10.1016/0304-3959(87)90073-X] [PMID]

26. Schiavenato M, Byers JF, Scovanner P, McMahon JM, Xia Y, Lu N, et al. Neonatal pain facial expression: Evaluating the primal face of pain. Pain. 2008; 138(2):460-71. [DOI:10.1016/j.pain.2008.07.009] [PMID]

27. Zahn-Waxler C, Hollenbeck B, Radke-Yarrow M. Advances in Animal Welfare Science. In: Fox MW, Mickley LD, editors. The origins of empathy and altruism. Houten: Springer; 1984. [Link]