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Looking at neonatal facial features of pain: do health and non-health professionals differ?

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Abstract
Objective: To analyze the regions that trigger the attention of adults' gaze when assessing pain in newborn infants' pictures and to verify if there are differences between health and non-health professionals.
Method: Experimental study with 84 health professionals and 59 non-health professionals, who evaluated two images of 10 neonates, one at rest and the other during a painful procedure. Each image was shown for 7 seconds on a computer screen, while eye movements were tracked by the Tobii TX300 EyeTracker. After evaluating each image, participants gave a score from 0 (absent pain) to 10 (maximum pain), according to their perception of neonatal pain. For each image, the number and total time of gaze fixations in the forehead, eyes, nasolabial furrow, and mouth were studied. Comparisons between both groups of adults were made by an intraclass correlation coefficient, Student's t-test, and Bland Altman graphic.
Results: 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; p = 0.010), with 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, forehead, and for the total fixation time in the eyes and forehead.
Conclusions: Adults, irrespective of their profession, showed a homogeneous gaze pattern when evaluating pictures of neonates at rest or during a painful procedures.

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Introduction

Pain is a critical experience for human protection, as it signals a potential threat to the integrity of the body. This signal must be understood by the people with whom an individual relates.[1] Newborns, especially preterm infants, undergo painful procedures during the neonatal period,[2] and pain, if not treated, can result in short and long-term consequences.[3] Therefore, neonatal pain must be identified, and treatment should be considered.

Health professionals involved in newborn care should know how to interpret their expression of pain.[4] Since neonates are not capable of verbalizing their pain, several scales were developed for pain assessment. Although these scales have adequate psychometric properties to identify neonatal pain, they are subjective, and the results may vary according to the characteristics of the patient, evaluator, and environment.[5] For example, parents consider it easier to assess their children's pain than the health professionals who provide care to them.[6,7] The difficulty in recognizing and quantifying neonatal pain and the subjectivity of this assessment are important obstacles to offering adequate pain treatment to critically ill infants.

In this context, the understanding of how pain assessment is made by adults in charge of neonatal care may help to optimize the process, and eye-tracking techniques are one of the tools used to improve this understanding. Visual tracking was used to assess the behavior of health professionals in neonatal resuscitation settings, showing that they focused their gaze mainly on the mannequin, followed by the monitors and staff.[8] Regarding the use of eye-tracking techniques in the pain context, the few studies published in the literature focus mainly on the recognition of the different emotions expressed by adults, including pain.[9,10] With visual tracking, it is possible to identify which areas that adults fix their gaze in order to decide whether the neonate is expressing pain or not. There are few studies in the literature that analyze the gaze pattern of adults when they are evaluating neonatal facial expressions to identify pain.

Therefore, the objective of this study was to evaluate the fixation points of adults' gaze when evaluating pain in pictures of the face of neonates, comparing health professionals and non-health professionals. Our hypothesis is that these groups of adults focus their gaze on different regions of newborn infants' faces, when assessing their pain.

Method

This is an experimental study in which the gaze of health professionals and non-health professionals was tracked when observing facial images of newborns at rest and undergoing a painful procedure. The study was approved by the Research Ethics Committee of the institution (#3.116.146), and the participants signed a consent form. A convenience sample was studied, consisting of health professionals (nurses, nursing technicians, physical therapists, speech therapists, and pediatricians) and non-health professionals (parents of newborn infants and laypeople). Health professionals should be working in a Neonatal Unit. Individuals with severe visual impairment were excluded. After the experiment, those whose eye signal capture in the gaze tracking assessment was less than 70% of the total time of the experiment were also excluded. This threshold was defined during study design, prior to study start.

As reported in previous studies,[11,12] each participant evaluated two pictures of ten healthy full-term newborns, one taken at rest and the other during a painful procedure (capillary or venous puncture, or intramuscular injection) performed by medical request. The photos used were from the database of Heiderich and were used with the author's permission.[13] The neonates had the following characteristics: gestational age of 38.0 + 1.2 weeks, birth weight of 2990 + 508g; 40% male, 60% born by cesarean section, 1st and 5th minute Apgar scores of 8.5 $\pm$ 1.0 and 9.2 $\pm$ 0.6, respectively. The pictures of the neonates were taken at the age of 1.8 $\pm$ 0.8 days.

The evaluation of the newborn infants' images was carried out in a closed room with artificially controlled light. For visual tracking, the Tobii EyeTracker, model TX300 (Tobii Technology AB, Danderyd, Sweden) was used. The characteristics of the equipment were described elsewhere.[11,12] A Precision M6800 BTX model notebook (Dell, Texas, USA) with Tobii Studio software (Tobii Technology AB, Danderyd, Sweden) was used to perform the equipment calibration and record and analyze the data captured by tracking the gaze of each participant.

After calibration and instructions, a screen with a cross (+) in the center was presented for two seconds, with the objective that all participants would start the experiment looking at the center of the screen. Next, the 20 images of the newborn infants' faces were shown in a random order for each participant for a period of seven seconds. After this period, a screen was presented for three seconds with the question, "How much pain do you think this baby is feeling?". The participant was instructed to answer with a score from 0-10, with zero being the absence of pain and ten the maximum pain. This procedure was repeated for the 20 images.

For each one of the 20 images, the following areas of interest were drawn: forehead, eyes, nasolabial furrow, and mouth, according to the Neonatal Facial Coding System (NFCS).[14] In each area of interest of each image, the outcomes of visual tracking for each participant evaluated were the number of gaze fixations and the total time of gaze fixations.

Demographic characteristics, scores attributed to the neonatal images at rest and during the painful procedure, and visual tracking outcomes in the four areas of interest were compared between both groups of adults by the Student t-test for independent samples or by the chi-square test. The correlation of visual tracking between health professionals and non-health professionals in the evaluation of the 20 neonatal images applied the intraclass correlation coefficient (ICC). Correlations were classified as weak (<0.00), mild (0.00-0.20), reasonable (0.20-0.40), moderate (0.40-0.60), strong (0.60-0.80) and almost perfect (0.80-1.00).[15] Homogeneity of visual tracking outcomes between health professionals and non-health professionals was verified using the Bland-Altman analysis. Homogeneity was considered when the differences between the outcomes of the two groups were between -2 and +2 standard deviations of the differences.[16] Logistic and linear regression analyses were applied for a number of fixations and time of gaze in each one of the four facial areas of interest in order to evaluate associations of the general characteristics of the adults, such as gender, age, socioeconomic class, having a child, and previous personal experience with hospitalized children, and the pain perception and the gaze pattern of the adults. Analyses were two-tailed and performed using the SPSS program for Win/v.20.0 (IBM SPSS Statistics, Somers, NY).

Results

In this study, 150 individuals were evaluated and 7 were excluded because the eye capture occurred in less than 70% of the time of the experiment. Therefore, 143 adults have included: 84 health professionals (44 pediatricians, 10 nurses, 17 nursing technicians, 5 physical therapists and 8 speech therapists) and 59 non-health professionals (29 parents and 30 laypeople). The characteristics of the studied adults were, respectively for health *vs.* non-health professional: age of 34 ± 9 *vs.*35 ± 11 years (p = 0.482); female gender in 93 *vs.* 64% ($p < 0.001$); >12 years of schooling in 82 *vs.* 42% ($p < 0.001$); married in 16 *vs.* 54% (p = 0.004); and presence of children at home in 26 *vs.* 85% ($p < 0.001$). For health professionals, the median time working in regular nurseries/rooming and in neonatal intensive care was, respectively, 1.5 years (interquartile range - IQR: 0-4) and 2.0 years (IQR: 0.7-8.5). Their median weekly workload in the intensive care unit was 36 hours (IQR: 24-60).

Health professionals, compared to non-health professionals, gave lower scores to newborn infants' images obtained at rest (0.81 ± 0.50 *vs.* 1.59 ± 0.76; p = 0.010), with no difference for the images taken during the painful procedure (6.98 ± 1.08 vs. 6.73 ± 0.82; p = 0.298). Each picture was presented for 7 seconds, and the gaze could be tracked during an average time of 6.49 ± 0.25 seconds (92.7 ± 3.6% of the allowed time), with no difference between health and non-health professionals (6.47 ± 0.27 vs. 6.51 ± 0.24 seconds; p = 0.355). Within the 7 seconds that each image was available to be observed by the adults, the duration of gaze fixation on the areas of interest was similar between health and non-health professionals (2.58 ± 0.73 vs. 2.50 ± 0.81 seconds; p = 0.582).

Table 1 shows the intra-class correlation coefficients of the visual tracking parameters in the four areas of interest between health and non-health professionals. The correlation was strong or almost perfect for the number of gaze fixations in the mouth, eyes, and forehead, and not significant for the nasolabial furrow. For the total time of visual fixation, the correlation was moderate for the mouth, strong for the forehead and nasolabial furrow, and almost perfect for the eyes.

Despite the almost perfect correlation between health and non-health professionals observed for most visual tracking outcomes in the studied areas of interest, some subtle differences were noted. Table 2 shows the comparisons of visual tracking outcomes for the areas of interest between health and non-health professionals. Health professionals had a greater number of visual fixations in the mouth and in the nasolabial furrow and fewer visual fixations on the eyes compared to non-health professionals. The total time of visual fixation of health professionals in the infant's mouth was also greater than that of non-health professionals, and the total time of visual fixation of health professionals in the infants eyes was lower than that of non-health professionals, with no difference for the other areas.

Table 1 Intraclass Correlation Coefficients of the mean values of number of gaze fixations and total time of gaze fixations in the mouth, eyes, forehead, and nasolabial furrow, among health and non-health professionals.

	ICC	95%CI	*p*-value
Number of visual fixations			
- Mouth	0.851	0.483; 0.948	< 0.001
- Eyes	0.966	0.915; 0.986	< 0.001
- Forehead	0.782	0.250; 0.924	< 0.001
- Nasolabial furrow	0.371	-0.327; 0.730	0.117
Total time of visual fixations (seconds)			
- Mouth	0.457	-0.184; 0.772	0.036
- Eyes	0.827	0.557; 0.932	< 0.001
- Forehead	0.737	0.332; 0.896	0.003
- Nasolabial furrow	0.791	0.481; 0.917	0.001

ICC, Intraclass Correlation Coefficient.

Figs. 1 and 2 show the Bland-Altman graphics for the eye-tracking outcomes, the number of fixations and the total time of visual fixations in the areas of interest. For both visual tracking outcomes and for all studied areas, most differences between health professionals and non-health professionals are located between -2 and +2 standard deviations of the differences, showing the presence of a homogeneous gaze at the neonatal face of both groups. However, for the mouth and nasolabial furrow, most points are above zero, indicating that the number of fixations and the total time of visual fixations in these areas by health professionals were greater than that of non-health professionals. On the other hand, for the eyes, most points are below zero, indicating that health professionals, compared to non-health professionals, fixed their gaze on eyes less often and for a shorter time. Finally, health professionals, compared to non-health professionals, fixed their gaze a smaller number of times in the forehead, but for the total time of visual fixations in this area, half of the points are above zero and half of them below zero, indicating homogeneity of the gaze in the forehead between groups.

We analyzed the association between general characteristics of the study group, such as gender, age, socioeconomic class, having a child, and previous personal experience with hospitalized children, and the gaze pattern by logistic regression. Two regression analyzes were performed for each one of the four areas of interest: mouth, eyes, forehead, and nasolabial furrow. As dependent variables, we considered: 1) having or not a greater number of visual fixations than the median number of the average number of fixations of each adult when evaluating the 20 images, and 2) having or not fixed the gaze for a time greater than the median time of the average fixation times of the gaze of each adult when evaluating the 20 photos. Therefore, we made eight logistic regression analyses, two for each area of interest, being one

Table 2 Visual tracking outcomes of health and non-health professionals when evaluating the 20 images of newborns.

		Mouth	Eyes	Forehead	Nasolabial furrow
Number of visual fixations					
Health professional	Yes	1.55 ± 0.74	1.54 ± 0.96	1.75 ± 0.52	0.77 ± 0.19
	No	1.21 ± 0.80	1.64 ± 1.04	2.23 ± 0.78	0.63 ± 0.15
p-value[a]		< **0.001**	**0.024**	< **0.001**	**0.001**
Total time of visual fixations (seconds)					
Health professional	Yes	0.72 ± 0.29	0.67 ± 0.36	0.84 ± 0.31	0.35 ± 0.09
	No	0.54 ± 0.35	0.74 ± 0.42	0.92 ± 0.43	0.31 ± 0.12
p-value[a]		< **0.001**	**0.047**	0.152	0.163

[a] Student t-test.

related to the number of fixations and the other related to the time of fixation. None of the variables were associated with any one of the eight outcomes, with the exception of the adults' age. Each additional year was associated with a 3-4% reduction in the chance of looking for 0.45seconds or more in the mouth. Although significant, this result was considered as having little practical meaning. We also analyzed the association between the general characteristics of the adults, such as gender, age, socioeconomic class, having a child, and a previous personal experience with hospitalized children, with the average score attributed by each participant to the 10 images taken at rest and the 10 images obtained during a painful procedure by linear regression. None of the adults' characteristics was associated with the mean scores attributed to the images of the newborn infants obtained during a painful procedure or at rest.

Discussion

In this study, we evaluated the visual tracking of health professionals and non-health professionals when evaluating neonatal pain in facial images of newborn infants. The eye-tracking of both groups, when evaluating the facial pictures of neonates, showed a homogeneous look at the different areas of interest, with only subtle differences. Health professionals, compared to non-health professionals, fixed their gaze more on the mouth and nasolabial furrow and less on the eyes and forehead. This study may help to evaluate if the understanding of neonatal pain expression by adults is an intrinsic skill carried by human beings throughout evolution to favor the survival of their offspring or if the recognition of facial expression of pain by adults may be improved by experience training, and education. If the last one is true, it should

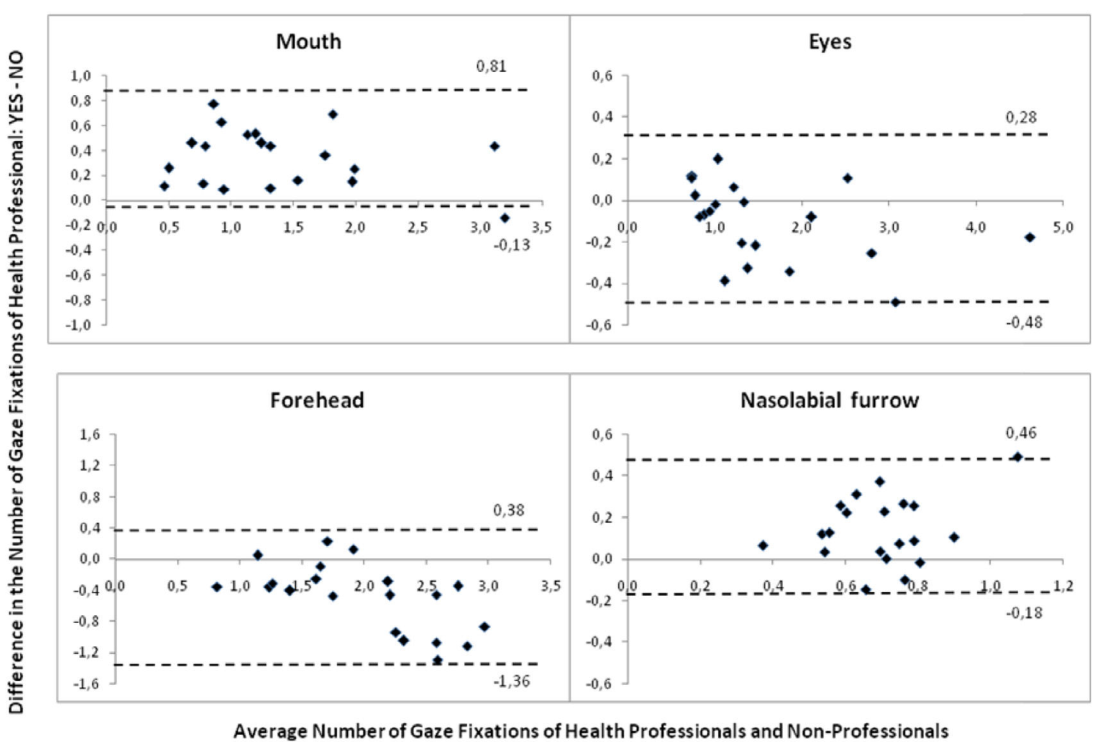

Fig. 1 Bland-Altman graphic - Difference in the number of gaze fixations in the areas of interest between health professionals and non-health professionals (ordinate), according to the average number of gaze fixations in the areas of interest of the two groups (abscissa). Dotted lines represent the mean ± 2 standard deviations of the differences.

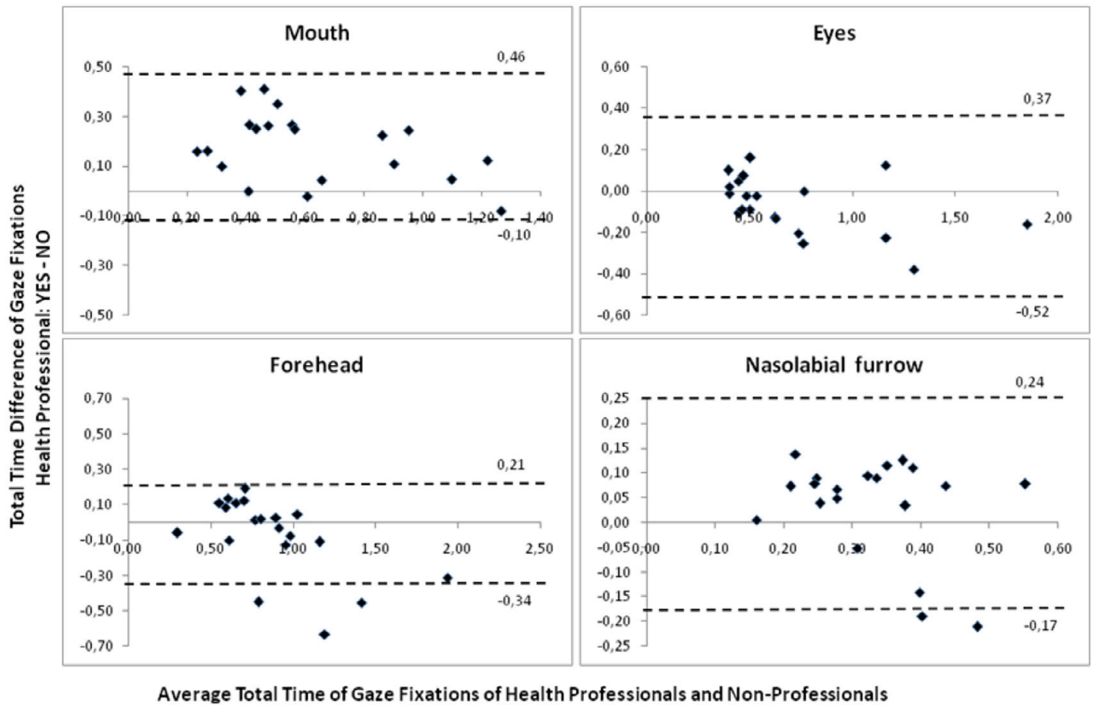

Fig. 2 Bland-Altman graphic - Difference in the total time of gaze fixations in areas of interest between health professionals and non-health professionals (ordinate), according to the average of the total time of gaze fixations in areas of interest by the two groups (abscissa). Dotted lines represent the mean ± 2 standard deviations of the differences.

be expected that the attention of health professionals, when looking at a newborn infant in pain, would be different than the gaze of adults less exposed to neonatal pain.

The pain perception of health and non-health professionals when looking at the neonatal facial images was evaluated using a verbal analog scale. Although there is no consensus on the score on an analog scale that indicates the absence or the presence of pain,[17] the scores given by both groups for images taken at rest are between zero and two, which are indicative of pain absence or presence of very mild pain.[18,19] According to van Dick, cutoff values to differentiate pain and non-pain on an analog scale depend on the experience and intuition of the observer.[17] Therefore, despite the statistical significance found in the scores given at rest, it seems that, overall, the perception of pain presence and absence was very similar among the studied adults. These findings are different from two other studies in which health professionals and non-health professionals assessed neonatal pain.[6,20] In 2009, Xavier Balda et al.[6] showed a lower perception of pain by health professionals, compared to non-health professionals, in the assessment of neonatal pain in pictures of newborn infants.[6] In 2008, Elias et al. evaluated the agreement between physicians, nursing professionals, and parents when evaluating sick newborns regarding the absence and presence of pain, and they found an agreement between the groups when the pain was absent; however, when the pain was present, there was heterogeneity in the assessment between the three groups of studied adults.[20] Among several factors, the diverse methodologic approaches, the different characteristics of the evaluated neonates, and a wider discussion on pain consequences in neonatology in the last decade may explain the differences found among studies.

The correlation of visual tracking between health and non-health professionals when observing newborn face images taken at rest and during a painful procedure was strong or almost perfect for both visual tracking outcomes, the number, and the total time of visual fixations, for most areas of interest, except for the number of visual fixations in the nasolabial furrow. This finding shows that health professionals and non-health professionals have a holistic sight when assessing the face of newborn infants in the decision process regarding the presence or absence of pain. Pain assessment and perception go back to early life. According to Zahn-Waxler,[21] one-year-old children are able to identify the presence of pain in family members who express their pain through facial mimicry, and they react to this perception, showing how empathy in evaluating the pain of others is already present since early childhood. Thus, when the adult evaluates a person in pain, they make use of this empathy in such a way that the experiences with pain among health professionals do not differentiate their look from non-health professionals.

The holistic view of an adult when assessing pain is pointed out by some studies. Female university students, when evaluating images of adult faces with expressions of joy, sadness, anger, surprise, fear, and annoyance, at different levels of intensity, fixed their gaze on all the main facial features to extract clues to identify the expression presented.[22] The similarity of gaze, was also observed among participants when images of lower intensity of these expressions were presented, characterized by a decrease in the number and time of gaze fixations in relation to the gaze when images with greater intensity were presented.[22]

Despite the homogeneity of gaze between health and non-health professionals when evaluating images of newborn infants in the decision process regarding the presence or absence of pain, some differences could be observed. In general, health professionals, compared to non-health professionals, fixed their gaze more on the mouth and nasolabial furrow and less on the eyes and forehead. Some studies have analyzed which areas are most indicative of pain presence when neonates undergoing painful procedures are evaluated by adults. In the study by Schiavenato et al.,[23] images from films of newborns undergoing two types of procedure, circumcision without analgesia and capillary heel puncture, were evaluated for pain before and during the procedure. The authors observed that, in relation to the image obtained at rest, the movement of the neonates' mouths (in the vertical axis during circumcision procedure and in the horizontal axis during the heel puncture) presented greater amplitude than the movement of the eyes, reinforcing that the mouth is an important indicator of neonatal pain. Grunau and Craig [24] also pointed the mouth as the most sensitive indicator for pain identification in a study in which videos of newborn infants submitted to heel puncture were evaluated. Regarding the nasolabial furrow, in a study in which different health professionals who provide care in a neonatal unit evaluated pain in videos of infants with different degrees of neurological impairment during a heel puncture, the authors showed that looking at the nasolabial furrow also helped to identify neonatal pain.[25] The nasolabial furrow is part of some scales that are used in clinical practice for neonatal pain assessment [14,26,27] and, therefore, is routinely evaluated by health professionals. It should be noted that our study was done in a university hospital with periodic training in neonatal pain assessment and, probably, health professionals were trained to look at the nasolabial furrow.

There are only two studies on neonatal pain assessment by adults using the visual tracking technique, but none of them verified the differences in the facial areas that health and non-health professionals fix their gaze when evaluating neonatal pain. One of these studies analyzed only pediatricians and showed that they fixed their gaze mainly on the mouth and that greater perception of pain was associated with a longer time of gaze fixation in the mouth when they evaluated the same set of images used in the present research.[11] In the other study with the same group of pictures, the authors showed that adults who correctly identified the images of neonates with and without pain, compared to those who do not, looked more often and longer at the nasolabial furrow.[12] Thus, the present investigation is a pioneer in evaluating, by visual tracking, the facial areas of newborn infants in which health and non-health professionals fix their gaze when evaluating neonatal pain. The visual tracking technique proved to be robust, capturing the look 93% of the time of the experiment. The same was observed in the study by Katz [28] that analyzed the gaze of neonatologists in a scenario of neonatal resuscitation.

Our study has some limitations. This is a single-center study carried out at a university hospital, where health professionals receive periodic training in pain management. The assessment of neonatal pain was performed using images of newborns on a computer screen in a closed room, an environment different from the NICU environment. The definition of the areas of interest, done before assessing the variables of interest, did not allow us to evaluate the visual tracking of other areas such as the chin and the tongue. Finally, adults have assessed pain in images of healthy full-term neonates, and it is not possible to generalize our results to preterm or critically ill patients.

In conclusion, visual tracking of health and non-health professionals is similar when evaluating images of the face of newborn infants at rest and undergoing a painful procedure to decide whether the pain is present or not. However, some subtle differences were observed. Health professionals, compared to non-health professionals, fixed their gaze more at the mouth and at the nasolabial furrow and less on the eyes and forehead. The results obtained by the study may help to understand the decision-making process of health professionals regarding the presence or absence of pain when assessing neonates. Also, these results may contribute to improving pain assessment training in neonatal units, emphasizing the importance of gaze fixation on areas that have been less looked at. In addition, knowing the facial points on which health professionals look when assessing neonatal pain may contribute to the refinement of the assessment tools.

Conflicts of interest

The authors declare no conflicts of interest.

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