WHOT, a Novel Tool to Assist Women Victims of Violence: A Case Study in the Brazilian Amazon

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ABSTRACT Violence against women is a problem faced in several ways, in various societies; however, the introduction of computational tools is something still little explored in this confrontation. Thus, it is necessary to invest in researches that bring technological development closer to the prevention, discovery, and combat of this form of violence. This paper presents the Women's Health Observer Tool (WHOT) that helps to build psychobehavioral profiles of women victims of violence, based on three features: i) recognition of facial expressions to infer emotions; ii) provision of digital questionnaires on intimate partner violence (IPV), adverse childhood experiences (ACE) and post-traumatic stress disorder (PTSD); and iii) generation of individual reports with cross-references of statistical analysis between the data obtained in each interview. To validate the tool, a case study was conducted with 50 women assisted in basic health units in a city of the Brazilian Amazon for prenatal care. The results are satisfactory for the use of the tool, which was able to infer emotions (joy, surprise, sadness, and anger), and the prevalence of sadness (25.24%) was verified among the interviewees. For ACE, the majority (21) of the women reported having suffered only physical abuse; as for IPV, the majority of the interviewees (27) reported no abuse; and 78% of the women (39) had no indicative signs of PTSD. The results further point out that there is 3.94 more chance that the group of women who reported any abuse, either in childhood or adulthood, compared to the reference group, would develop PTSD.

INDEX TERMS Face detection, emotion recognition, violence against women, multidisciplinary, health and safety.

I. INTRODUCTION

Violence against women (VAW) is a global public health problem; it does not distinguish social class, cultural, professional, religious or educational background, and generally leaves sequels for the rest of the victim's life. This violence, most often, happens within the domestic, family and/or professional environment, since the aggressor often lives

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with the woman, sharing the same space which generates a climate of tension and fear that can last for years; the problem is so alarming that, in a document released in 2019, the United Nations (UN) indicated that 17.8% of women and girls around the world reported physical and/or sexual violence committed by their partner in the last 12 months prior to the publication [1].

The World Health Organization (WHO) highlights that VAW worsens in situations of catastrophes and other humanitarian emergencies and warns of the need for services

for women victims of violence to remain vigilant and accessible during, including, the COVID-19 pandemic [2]. In Brazil, where the Federal Government has a service for reporting violence against women that can be made by phone, in the first four months of 2020 there was a 14.12% increase in calls compared to the same period in 2019. While January registered a drop of 6.4%, February, March and April registered a rise of 13.35%, 17.89% and 37.58% respectively, according to data published in May 2020 by the Ministry of Women, Family and Human Rights[1] (MMFDH). Note that this gradual increase intensifies exactly when the measures of social isolation begin to be effective in the national territory, which further highlights a fact already verified before: the residence is not always the safest place for women [3].

Characterized by physical violence, sexual violence, stalking, or psychological harm, Intimate Partner Violence (IPV) is the violence perpetrated by a current or former spouse or partner against another in the context of an intimate relationship. The MMFDH's 2019 Annual Review shows that among the biggest perpetrators of IPV are: partner, ex-partner, spouse, child, neighbor among others.[2]

In the Brazilian Amazon, data catalogued by the Brazilian Public Safety Yearbook [4], released in 2019, demonstrate the gravity of the situation afflicting women in this region: while the national rate of lethal violence (which are those that cause death) against women between 2017 and 2018 grew by 11.3% throughout Brazil, in the Amazon this increase was 15.1%. Regarding non-lethal violence (which are the cases in which the aggressions do not culminate in the death of the victim), while Brazil as a whole recorded a positive variation of 0.8% between 2017 and 2018, the Amazon had an increase of 9.9% of cases. In turn, the State of Pará recorded a positive variation of 27.1% for lethal violence and 17.2% for non-lethal violence in the same period.

According to studies that deal with this theme, VAW is almost always preceded by another form of violence, keeping a close relationship with it. These are Adverse Childhood Experiences (ACE), which refer to some of the most intense and frequent sources of stress that people can have early in life. These experiences include various types of abuse; neglect; violence between parents or caregivers; other types of serious domestic dysfunctions such as alcohol and other substance abuse [5]–[11].

They can be of an individual nature, that is, when the child suffers from abuse in his own body, or with dysfunctions that affect the entire household, such as the use of illegal substances by parents or guardians. There is no way to make a direct relationship between ACE and VAW as a cause and a consequence; however, studies always point to a significant

number of adult women victims of violence who have also suffered some kind of abuse in childhood [5]–[11].

This violent context that involves women in the most diverse societies has been the object of research with numerous objectives; almost always, however, this panorama is related to the development or increased chances of developing various traumas from the point of view of the victims' mental health, such as Post-Traumatic Stress Disorder (PTSD). This syndrome is the result of exposure to a traumatic event and can cause severe anxiety disorders, depression, suicidal ideas, alcohol abuse, among others [12]–[21].

VAW is even more serious in pregnant women, as it can have consequences not only for the health of the woman but also for the baby; there may be an increase in the frequency or severity of domestic violence during pregnancy; in addition, pregnant women, victims of sexual violence, tend not to perform prenatal care or postpone its onset; furthermore, the occurrence of abuse in childhood is associated with greater chances of developing PTSD during early pregnancy [6], [21]–[29].

However, despite the significant steps that society has taken in order to support these women, one of the difficulties faced is awakening the victim to the abusive situation she finds herself in, or, having already awakened, being able to talk openly about her situation [30], [31]. The health system could be a means by which the woman victim can be welcomed, listened to, and accompanied more closely; however, the traditional means available for this purpose in many cases no longer correspond satisfactorily to the attempt to help women realize how abusive their relationship is or, having already realized it, to speak more openly about it [32].

Thus, cases of women victims of violence can be investigated through responses to questionnaires, physical or digital, but also using facial expression recognition (FER) tools that, together, have the ability to infer emotions expressed in the face.

In this context, the article presents a tool developed by the authors entitled Women's Health Observer Tool (WHOT) able to a) detect facial expressions and infer emotions; b) provide digital questionnaires on IPV, ACE and PTSD; and c) generate reports from the collected data. This proposal innovates because its goal is to demonstrate the use of the tool to understand the IPV phenomenon, its relation with ACE and the development of PTSD, aiming to help in the construction of psychobehavioral patterns that denote VAW. For validation, a case study was conducted in public health units in the municipality of Ananindeua, located in the State of Pará - Amazon Brazilian, in which women at different times of pregnancy participated.

Once it has proved to be satisfactory for the purposes of this research, WHOT shows itself as a promising auxiliary tool for decision making in the prevention and protection of victims of VAW, whether by researchers, health teams, by the community, by public power, whether by anyone who is interested in investigating cases of violence and protection of

the human person in any geographical context, which makes it possible to apply it in other situations.

This article is divided as follows: Section II presents related works both from the point of view of IPV, ACE and PTSD as well as the recognition of facial expressions; Section III shows in detail the WHOT and its functionalities; in Section IV, the case study is reported; and Section V shows the results achieved that demonstrate the tool's effectiveness.

II. RELATED WORKS

This section presents a brief review of research on the health of women victims of violence through studies that look for the relationship between violence suffered and the development of mental illness/disorders, in particular PTSD related to IPV and ACE; a brief review on use of facial recognition tools and distinct techniques for emotion inference are also presented.

A. IPV, ACE AND PTSD: CONECTIONS

Several works address the discovery and assistance to women victims of violence, as well as the understanding of the phenomenon itself within its multiple variables. This was the case of [33], which sought to examine how the different characteristics of IPV interact with other traumatic experiences that trigger stress. The author found that among the possible causes for the development of PTSD is the intensity of IPV and that violent acts of abuse (physical and sexual) perpetrated against women, whether in childhood or adulthood, do not have equal impact on the development of the disorder.

The work described in [34] dealt with the relationship between experienced violence and development of mental illness and/or disorders; the researchers reported that the most common forms of VAW were domestic abuse and sexual violence which was associated with increased risk of mental disorder. The same authors pointed out the need for early help for the woman victim in order to alleviate the harmful effects on her psychological health.

In [6] a study was presented in which it was shown that women - especially those of childbearing age, pregnant or in the perinatal period - who had suffered abuse in childhood (sexual, physical or both) and/or suffering from IPV were higher prone to develop PTSD, considering the data that pointed out that women with a history of physical abuse associated with sexual abuse in childhood and related to IPV had a 16.6% rate of PTSD, while those with only IPV were 7.4%. However, as the researchers themselves pointed out, one cannot conclude that if a woman suffered abuse in childhood, she will also be a victim of IPV in adulthood and develop PTSD; however, it is necessary to observe a set of factors associated with abuse in order to act preventively.

Another important factor in the lives of women who are victims of violence is in the past of abuse suffered during childhood, whether sexual, physical, or both. Seeking to examine the joint and independent associations of childhood abuse and IPV with the existence of migraine among pregnant women, [11] conducted a cross-sectional cohort

study of 2,970 pregnant women in Lima, Peru. The authors found that 33.5% of them suffered with any type of migraine, 70% reported a history of child abuse, and 36.7% reported IPV. The group with a history of child abuse was 38% higher in the likelihood of suffering any type of migraine than those who reported no history of child abuse. Among women who suffered from IPV, the likelihood increased by 43% when compared to the group who did not report IPV.

The most significant finding, however, is that both IPV and ACE abuse, when present together, caused an 88% increase in the likelihood that the pregnant woman would suffer from any migraine. These data reveal how these two forms of violence, whether separate or together, take away from the quality of life of the pregnant woman at a crucial time for her well-being.

Further addressing the consequences of IPV and ACE in pregnant women, [10] examined the associations between childhood physical and sexual abuse with risk of a history of IPV and to what extent such abuse associates with general health status and antepartum depression symptoms in Peru. They found that any of the childhood abuse was associated with 2.2 times greater odds that the woman would also be a victim of IPV. Compared to women who reported no childhood abuse, those who reported both physical and sexual abuse had a 7.14 times higher lifetime risk of suffering physical and sexual IPV. When related to the general health of pregnant women, child abuse was associated with the highest odds of a poor health status during pregnancy (1.32) and with symptoms of antepartum depression (2.07) revealing the urgency in seeking support mechanisms for women victims of violence, even more so during the gestational period.

In a similar direction, [22] conducted an observational, descriptive and analytical study with 232 pregnant women in prenatal care; one of the objectives of the research was to identify the prevalence of IPV among pregnant women classifying it as to its type and frequency. A structured interview was used as a data collection tool, in addition to using their own medical records as sources. The authors found that 15.5% of the participants had suffered IPV during pregnancy; of these, 14.7% reported psychological violence, 5.2% reported physical violence, and 0.4% reported sexual violence. The authors found no statistically significant association of these violences with uncommon obstetric and neonatal repercussions, but point to a greater chance that a woman who did not desire pregnancy would be a victim of violence.

In this same sense, [23] conducted a cross-sectional, exploratory and analytical study of domestic violence with 385 women who were assisted in a public maternity hospital in the state of São Paulo (Brazil), aiming to characterize domestic violence in pregnant women. Of these women, 36.9% had already been victims at some moment in their lives and, during the current pregnancy, 34.6% reported suffering some type of violence. The prevalence of psychological violence (97.1%) was evidenced, followed by physical (48.7%) and sexual (4.9%) violence. In the same line of

official data on domestic violence, the partner was the main perpetrator followed by a family member.

[24] aimed to examine the association between domestic violence and health problems reported by pregnant women reaching the following data: 19.1% reported experiencing psychological violence; and 6.5% reported physical or sexual violence. Psychological violence was significantly associated with obstetric problems (OR 1.95), premature rupture of membranes (OR 1.64), urinary tract infection (OR 1.71), headache (OR 1.75), and risky sexual behaviors (OR 2.28). In contrast, physical or sexual violence was significantly associated with obstetric problems (OR 1.72), premature rupture of membranes (OR 2.11), urinary tract infection (OR 2.05), vaginal bleeding (OR 1.95), and lack of sexual desire (OR 3.67). These data confirm how violence against pregnant women requires health care services that are well organized and whose care team is prepared to receive, listen to, and help pregnant women.

Allied to the above, Computation has been intensely evidenced in the last decades through studies, creation of computational tools and other devices to assist in the discovery, monitoring and, in many cases, solution of problems that affect societies around the world [35]. As such, the use of computational tools can be an important ally to predict and/or assist in the diagnosis of VAW, such as the use of FER. Some relevant works using this technology are discussed in the following subsection.

B. FACIAL EXPRESSION RECOGNITION TOOLS

Several literatures address the use of facial expression recognition tools and distinct techniques including for emotion inference in various fields of knowledge. [36] proposed a fused bimodal model of emotion recognition based on two different modalities: facial expressions and upper body gestures and the fusion of both. The first approach led to emotion recognition from facial expressions and upper body gestures; in the second approach, a combination of the extracted data was performed in order to obtain emotion recognition. The authors concluded that the application of the second (bimodal) approach gave higher accuracy than the first (unimodal) approach for the recognition of the expressions of anger, joy, disgust, sadness, surprise, fear, and neutral.

In this sense, [37] used FER method for occluded face. They based the authors on the WGAN method which consists of a generator and two discriminators, and as distance metric they used Wasserstein. The experiment of the proposed method identified facial expressions up to a threshold of 40% of the occluded face which, according to the authors, was a much better result when compared to other state-of-the-art methods.

In recent work, [38] proposed a FER system based on Facial Electromyograms (fEMG); such system was based on Riemannian approach to reduce the number of training data sets needed and improve the performance of FER. Furthermore, they developed an online FER system in order

to perform face recognition of virtual social reality users in real time. Their findings showed that such a method is a promising substitute for current methods of face and expression detection of users since it was possible to perform face recognition even when they were wearing equipment over their face.

[39] explored the recognition of human facial expressions through a Deep Learning (DL) approach using a Convolutional Neural Network (CNN) algorithm. The authors used a bank of 32,298 images and obtained 79.8% accuracy for the expressions of anger, joy, disgust, sadness, surprise, fear, and neutral without applying optimized techniques. Face detection, feature extraction and the use of the neural classifier were the phases of this system that uses only one face each time.

In this sense, [40] proposed a system subject to the evaluation of two data sets: the Facial Emotion Recognition Challenge (FERC-2013) and the Japanese Female Facial Emotion (JAFFE). The accuracy rates achieved by the proposed system in FERC-2013 were 70.14% and in JAFFE it was 98.65%, considering the emotions anger, joy, disgust, sadness, surprise, fear, and neutral. This demonstrates, according to the authors, an evolution in relation to other systems presented in the literature.

The research presented in [41] addressed the question regarding ethnic and cultural differences that interfere with the expression of emotions. The authors developed computational algorithms in order to manage these variations to achieve a high accuracy of expression recognition. The authors developed computational algorithms to handle these variations in order to achieve a high accuracy of expression recognition. They proposed a joint classifier based on artificial neural network for multicultural facial expression analysis and found as preliminary result that facial expressions are innate and universal across all cultures which is in agreement with [42].

Thus, it is evident that studies on facial expression recognition have been developed and applied to the most diverse areas. Based on this statement, this paper presents a tool that uses facial expression recognition algorithm, based on Paul Ekman's studies on Facial Action Coding System (FACS), and the use of the Kinect motion sensor Face Tracking (SDK) for real-time FER.

The present study used the conventional FER approach, for detection of four basic facial expressions (surprise, anger, sadness and joy). Having as main steps: (1) face and face component detection, (2) feature extraction, and (3) expression classification.

Although more recent studies on FER use DL techniques, with more accurate results compared to the conventional FER approach, these systems have limitations regarding the need for large-scale datasets, higher processing power and memory.

Despite the long history related to FER, there are no comprehensive literature reviews on this topic applied to the topic of women victims of violence. During this study, use
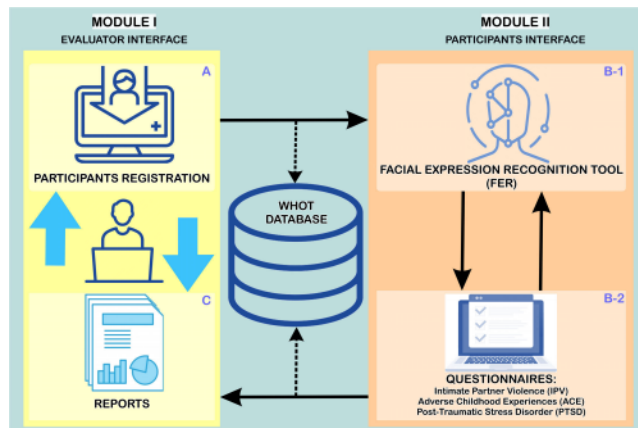
of FER, conventional or by DL, was found for areas such as gaming, security, psychology, and neuroscience.

Therefore, this work aims to contribute to FER studies focused on the health area, in particular on the care of women victims of violence.

C. SUMMARIZATION

The innovative contribution of this work is to expand the limits of relationship and analysis between the circumstances of violence that affect women (ACE, IPV and PTSD) and the use and application of the FER through a computational tool.

Thus, by investigating VAW repercussions and creating a FER tool, this work presents a direct interconnection between the search for a better method for early detection of violent situations in which women are victims and the possibility of indicating probable mental disorders in them, notably PTSD; the efficiency of this tool, as we will see later, is shown mainly in what concerns facial recognition and emotion inference.

III. PROPOSED METHOD

In order to carry out this research, it was necessary to follow a set of steps that are highlighted in this section.

As shown in Figure 1, WHOT is composed of two modules. Module I is the interface of the Evaluator.[3] It is in this module that the registration of the research participant[4] is made, which is stored in the tool database (Phase A). This registration is carried out face-to-face and the questions refer to social, economic, ethnic and educational conditions, in addition to collecting the personal data of each Participant.

Module II is the Participant/Volunteer interface. After her registration is completed, the FER tool (Phase B-1) and the ACE, IPV, and PTSD questionnaires (Phase B-2) are activated and released to her so that simultaneously and in real time WHOT both records her responses and tracks her facial expressions to infer the prevalence of emotions in each questionnaire. The information is sent to the database

from where the reports for each Participant (Phase C) can be generated and subsequently queried. The database acts as an intersection between Modules I and II.

From the point of view of its construction, WHOT has interfaces that combine the programming languages C#[5] and PHP,[6] in addition to Python scripts[7] for operation and connection of the application's functionalities. The following technologies implemented by the Bootstrap[8] framework were used: Hypertext Markup Language, Cascading Style Sheets - CSS3 and JavaScript.[9]

Phases B-1, B-2 and C are detailed in the subsections below.

A. FACIAL EXPRESSION RECOGNITION (MODULE II - PHASE B-1)

With the Participant's access to Module II authorized by the Evaluator, WHOT starts to perform facial expression recognition (Phase B-1 - Figure 1) whose details can be seen in Figure 2.

The system used images captured by the Kinect camera (Step A) [43] as input to the face feature tracking module (Step B); the face tracking used the Viola-Jones [44] techniques, which performs the face detection of the individual, and CANDIDE-3 [45], which performs the facial features detection by finding the characteristic face points of certain locations of interest (mouth, eyes, eyebrows, and nose).

The Viola-Jones technique is one of the most widely used for image detection due to its low computational complexity and its good performance (low false positive rate) in locating faces in 320 x 240 dimension images in real time. The algorithm is composed of three parts: (a) representation of the image in a feature space based on Haar filters (Integral Image); (b) assembly of a Boosting learning classifier called

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[3]Who performs the Participant's registration, activates Module II and can consult registrations and reports.

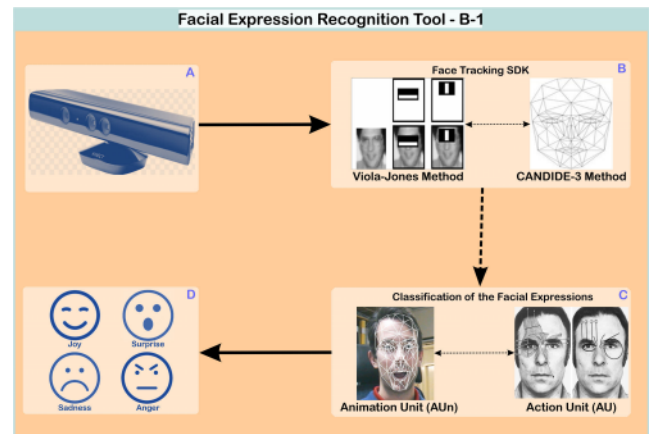[4]Volunteer who has agreed to participate in the research will answer the questionnaires.

[5]https://docs.microsoft.com/pt-br/dotnet/csharp/getting-started/

[6]https://www.php.net/manual/pt_BR/intro-whatis.php

[7]https://www.python.org/

[8]https://getbootstrap.com/

[9]https://www.javascript.com/

AdaBoost, capable of selecting the relevant features and (c) creation of a tree structure called cascade of classifiers.

CANDIDE-3 is a parameterized face model, specifically developed for model-based encoding of human faces. This face model is defined by approximately 100 polygons capable of capturing the most relevant points of the human face, allowing its fast reconstruction at low computational cost. The model is controlled by Global and Local Animation Units. The global units correspond to rotations around the X, Y and Z axes (coordinates used by Face Tracking from Kinect's SDK to map the position and rotation of the head), while the local units control the face so that different expressions can be obtained. Thus, the Face Tracking SDK can model the face in a quick and easy way.

These techniques were implemented using the resources of the Kinect Library - SDK. After capturing the image and tracking facial features using the techniques presented above, the expressions were classified, allowing the inference of the emotions of each Participant (Step C).

For the development of this phase, the studies about the Facial Action Coding System (FACS) [46] were the main reference; in this system, Ekman states that facial expressions are unique and universal and defines 44 Action Units (AU) that are the parts used to illustrate the human face; the movements described in the AU are caused by muscle actions (contraction and relaxation). In principle, this approach enables a facial expression to be understood as a combination of relevant facial action units.

Through the CANDIDE-3 method we can artificially configure the psychological model proposed by Ekman using the Face Tracking SDK. For the detection of the expressions, the Kinect SDK in version 1.8 provides 6 (six) animation units (AUn), which use the AU of [46] to easily model any facial expression. Each AUn is expressed as a numerical value between -1 and 1 [43].

In the process of building the WHOT, the authors observed the complete set of AU from FACS and all the AUn from Face Tracking SDK. Upon finding equivalence between some of them, they identified the presence of four basic emotions: joy, surprise, sadness and anger, which is the reason why the present research works only with these emotions. The combined AU and AUn, as well as the identified emotions can be seen in Table 1.

Considering that the values of each AUn vary between -1 and 1, according to the movement of the facial muscles, it was necessary to calibrate the tool to determine the limits that, once exceeded, would lead to the inference of the occurrence of a specific emotion.

For this step, 10 volunteers were chosen at random to reproduce faces that were shown to them and that indicated the emotions of joy, sadness, surprise and anger. Each volunteer expressed each emotion 5 times, performing 200 calibration tests. Thus, within the limit of -1 and 1, limits were assigned to each expression and, whenever the conditions defined for each one were satisfied, the tool inferred its occurrence; such limits are described in Table 2.

TABLE 1. Equivalence table.

FACS		FACE TRACKING SDK		Expression
AU	DESCRIPTION	AUn	DESCRIPTION	
6	Cheek Raiser	0	Upper Lip Raiser	JOY
12	Lip Corner Puller	4	Lip Corner Depressor	
1	Inner Brow Raiser			SURPRISE
2	Outer Brow Raiser	5	Outer Brow Raiser	
5B	(Soft) Upper Lid Raiser			
26	Jaw Drop	1	Jaw Lowerer	
1	Inner Brow Raiser			SADNESS
4	Brow Lowerer	3	Brow Lowerer	
15	Lip Corner Depressor	0	Upper Lip Raiser	
17	Chin Raiser			
2	Outer Brow Raiser			ANGER
4	Brow Lowerer	3	Brow Lowerer	
7	Lid Tightener			
23	Lip Tightener	2	Lip Stretcher	
24	Lip Pressor			

TABLE 2. AUn expression validation values.

Expression	Conditions To Detect Expression
Joy	AUn [0] >0.2 and AUn [4] <-0.2
Surprise	AUn [1] >0.4 and AUn [5] >0.1
Sadness	AUn [0] >-0.1 and AUn [3] >0.1
Anger	AUn [3] >0.2 and AUn [2] <-0.2

At the end of these processes, we obtained an FER tool capable of detecting four types of expressions (joy, surprise, sadness and anger) according to the muscle movements associated with the local regions of interest (Step D). For the realization of the tests/experiments referring to the tool, the following scenario was created: selection of 20 volunteers with distinct age, gender and skin color considering that according to [42] the basic facial expressions are universal; use of a Kinect sensor to capture the faces and selection of images that represented the desired facial emotions to show the volunteer which simulation of the expression was desired to be analyzed.

In real time, each volunteer simulated 20 emotions (5 of joy, 5 of anger, 5 of sadness, 5 of surprise) totaling 400 expressions. The facial analysis was performed under light variations, and some subjects had beards, mustaches, or wore glasses. The subjects were of both genders with ages ranging from 7 to 55. As a total performance of this initial tool, we obtained a result of 67.9% in tracking all 400 expressions analyzed in the test, given the following hit rates: joy, 81.37%; surprise, 60.54%; sadness, 60.24%; and anger, 69.52%.

Despite the existence of other forms and techniques for recognizing facial expressions that use several automated approaches such as, for example, Convolutional Neural Network (CNN) and Principal Component Analysis (PCA), the method presented here proved to be satisfactory for a first version of this study and responded to its objectives. However, the authors are already working with the possibility of improving WHOT, an opportunity in which machine learning algorithms will be used.

B. IPV, ACE AND PTSD QUESTIONNAIRES (MODULE II - PHASE B-2)

Phase B-2 of WHOT Module II contains the questionnaires to be answered by the Participant at the same time Phase B-1 is performed by the tool. These questionnaires are about IPV, ACE, and PTSD, and all have been validated in previous research. It should be noted that no study was found in which the application of these questionnaires was done unmediated by a human interviewer. In this study, the participant reads the questions on a computer screen by herself and can stop the interview at any time.

IPV was investigated using questions adapted from the Demographic Health Survey Questionnaires, specifically the Domestic Violence Module.[10] Of the studies in which this protocol has been applied, the one with the largest global reach is described in [47]. The WHO team aimed to estimate the extent of intimate partner physical and sexual violence in women from 10 countries, including Brazil. The findings demonstrate the effectiveness of using the questionnaire even with the linguistic adaptations that were made by the researchers. Another study in which this questionnaire was successfully used was [6] which used only 2 blocks of questions totaling 13 questions about sexual and physical violence committed by an intimate partner. Such adaptation, as it responded better to the objective of the present research, was also performed here.

Thus, the occurrence or not of IPV was verified when the Participant answered ''yes'' to at least one of the questions regarding violence committed by the current or last intimate partner (first block); or ''yes'' to questions regarding violence committed by any previous intimate partner (second block), according to Table 3.

As for ACE, its occurrence or non-occurrence was investigated using the ACE study protocol [5]. The authors aimed to describe the relationship between risk behavior for health and disease in adulthood and the extent of exposure to emotional, physical or sexual abuse in childhood and domestic dysfunction in childhood. Thus, this questionnaire contains two groups of adverse situations about this period: the first refers to categories of abuse and the second refers to categories of household dysfunctions. For the present research, only the categories of physical abuse and sexual abuse were used, according to the cut-off made in the IPV

[10]https://dhsprogram.com/publications/publication-DHSQM-DHS-Questionnaires-and-Manuals.cfm

TABLE 3. IPV questionnaire.

Questions	Answers
Did your (last) (husband/partner) ever do any of the following things to you:	
a) Push you, shake you, or throw something at you?? b) Slap you? c) Twist your arm or pull your hair? d) Kick you, drag you, or beat you up? e) Punch you with his fist or with something that could hurt you?? f) Try to choke you or burn you on purpose? g) Threaten or attack you with a knife, gun, or other weapon? h) Physically force you to have sexual intercourse with him when you did not want to? i) Physically force you to perform any other sexual acts you did not want to? j) Force you with threats or in any other way to perform sexual acts you did not want to?	( ) YES ( ) NO
Now I want to ask you about the behavior of any previous (husband/partner):	
a) Did any previous (husband/partner) ever hit, slap, kick, or do anything else to hurt you physically? b) Did any previous (husband/partner) physically force you to have intercourse or perform any other sexual acts against your will? c) Did any previous (husband/partner) humiliate you in front of others, threaten to hurt you or someone you care about, or insult you or make you feel bad about yourself?	( ) YES ( ) NO

TABLE 4. ACE questionnaire.

Questions	Answers
"Did a parent or other adult in the household often push you, grab you, hit you or throw something at you? Or Have you ever hit so hard that you had marks or hurt yourself?"	( ) YES ( ) NO
"Did an adult or person at least 5 years older than you, often touch or caress you or did you touch your body sexually? Or tried or did you have oral, anal or vaginal sex with you?"	( ) YES ( ) NO

questionnaire. Thus, when the Participant answered ''yes'' at least once to one of the questions in Table 4, the occurrence of the researched question was understood.

Research on PTSD was done from [12]. The researchers developed this instrument in two versions: the PCL-M, specifically developed for assessing the consequences of military experiences, and the PCL-C, developed for the civilian population, which assesses the consequences of various types of traumatic experiences. Both versions are based on the diagnostic criteria of the American Psychiatric Association's Diagnostic and Statistical Manual of Mental Disorders-III-R (DSM-III-R), 1980, revised in 1987 [48], for PTSD. The adaptation used for this research (PCL-C) has been used in other works and has shown satisfactory reliability and validity [14]–[16] e [13].

It is possible to answer each of the 17 questions shown in Table 5 ''not at all'', ''a little'', ''moderate'', ''a lot'' and ''extremely'' which are equivalent to scores 1, 2, 3, 4 and 5, respectively. The total score of the questionnaire varies between 17 and 85 points, and the higher the score, the greater the severity of the disorder, knowing that above 44 points there is already evidence of PTSD [14]–[16] e [13].

WHOT shows the Participant a table with the checklist of questions in rows and the answers in columns. As she reads

TABLE 5. PTSD questionnaire.

Questions	Answers
a) Repeated, disturbing memories, thoughts, or images of a stressful experience from the past? b) Repeated, disturbing dreams of a stressful experience from the past? c) Suddenly acting or feeling as if a stressful experience were happening again (as if you were reliving it)? d) Feeling very upset when something reminded you of a stressful experience from the past? e) Having physical reactions (e.g., heart pounding, trouble breathing, or sweating) when something reminded you of a stressful experience from the past? f) Avoid thinking about or talking about a stressful experience from the past or avoid having feelings related to it? g) Avoid activities or situations because they remind you of a stressful experience from the past? h) Trouble remembering important parts of a stressful experience from the past? i) Loss of interest in things that you used to enjoy? j) Feeling distant or cut off from other people? k) Feeling emotionally numb or being unable to have loving feelings for those close to you? l) Feeling as if your future will somehow be cut short? m) Trouble falling or staying asleep? n) Feeling irritable or having angry outbursts? o) Having difficulty concentrating? p) Being "super alert" or watchful on guard? q)Feeling jumpy or easily startled?	Not at all (1); A little bit (2); Moderately (3); Quite a bit (4); Extremely (5).

the question, she marks the item that best fits her profile considering the adverse experiences she has had. At the end, WHOT makes the necessary calculations in order to indicate "Positive" or "Negative" for the presence of possible PTSD indicators in that particular respondent.

C. REPORTS (MODULE I - PHASE C)

Once the interview and facial expression recognition phases are completed, WHOT begins the statistical analysis by establishing crossings between the data obtained during the interview, starting with the participant's registration, when her social, economic, marital, ethnic and educational information was collected, going through her answers to the questionnaires presented and the expressions manifested throughout this period. For this task, the language R[11] was used.

As an example, these reports show the existence or not of ACE in the surveyed population, and, when existing, the numerical distribution of these experiences by groups of age, education, and ethnicity of the Participants. Thus, still as an example, in the "no abuse" category, 40% were white women, 15% were black, and 45% declared themselves to be brown. The reports present the association between ACE and PTSD, indicating that in the "Positive" group for PTSD, 54.5% had suffered physical and sexual abuse in childhood.

It is also possible to access multivariate comparison showing the joint and independent effects of ACE and IPV on the risk of developing PTSD; such comparison shows that the research Participants who reported experiencing both ACE and IPV have more than 20 times the odds of developing the disorder.

[11] https://www.r-project.org/

The data and analyses provided by WHOT also contemplate the inference of emotions throughout the response to the questionnaires. In this sense, as the tool collects responses for ACE, IPV, and PTSD, it also categorizes them according to the groups described in the previous subsection. Simultaneously, the percentages of emotions are extracted for each questionnaire. Thus, for example, in IPV, 54% of the Participants stated that they did not experience any intimate partner abuse, and for this questionnaire specifically WHOT inferred 28% occurrences of the emotion "joy". Furthermore, regardless of a specific questionnaire, the tool provides a report that shows the average number of emotions inferred during the entire interview.

At the end of the interviews, WHOT allows the Evaluator to access each participant's Individual Report, which contains a summary, in percentages, of the inferred emotions, as well as an indication of the existence or not of ACE, IPV and/or PTSD, which facilitates access to the profile of any person who undergoes the tool's evaluation. It should be noted that only the Evaluator has access to this Individual Report, which safeguards the confidentiality of the data stored there.

This is only a brief demonstration of how Phase C - Reports - works in WHOT. The Results and Discussion Section provides the details and context for each of these data.

IV. CASE STUDY

The chosen location was the city of Ananindeua, Metropolitan Region of Belém do Pará (RMB), capital of the State of Pará, Eastern Amazon, Brazil. With an estimated population of 530,598, according to the Brazilian Institute of Geography and Statistics (IBGE), in 2019, it is the second largest municipality in the State in population and the third in the Amazon Region having the largest share of inhabitants between 10 and 39 years old, both among women and men, considering the data from the 2010 Census, and there is a small female majority in the Ananindeuense population [49].

Another important factor for the choice of the municipality of Ananindeua is the fact that it is considered the Brazilian city with the most violent deaths of women. This can be observed in the data on lethal violence from the [50] in the period from 2005 to 2015, as shown in Figure 3. This category of violence includes deaths caused by various means, such as: suffocation, firearms or sharp objects. These data ratify the need for preventive measures and to combat violence against women.

The research was authorized by the Secretary of Health of the Municipality of Ananindeua (SESAU/PMA) through Authorization No. 07/2018, dated September 25, 2018. In addition, there is authorization from the Research Ethics Committee of the Institute of Health Sciences of the Federal University of Pará, through Consubstantiated Opinion 3.180.179 of March 1, 2019.

A. VOLUNTEERS

Once the location was defined, municipal health clinics were selected where women during pregnancy are monitored.
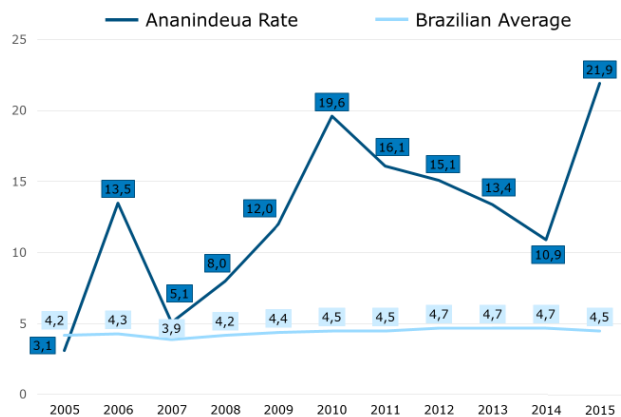
FIGURE 3. Deaths of women by VAW-deaths per 100 thousand women inhabitants.

TABLE 6. Exclusion criteria for volunteers.

Exclusion Criteria	Detailing
Children under 14 years of age	According to the current legislation in Brazil, pregnancy before the age of 14 is necessarily the result of sexual abuse; in addition, it avoids the child's re-victimization (Law 13.431/17).
Illiterate woman	Since only literate pregnant women were selected because they themselves had to read the questions on the computer screen.
Risk pregnancy	Because those who were in this situation could not be participants so that there would be no impact on their pregnancy, especially of an emotional nature.
Health status at the time of the test	Being healthy and willing at the time of testing, that is, the volunteers could not be tired and/or indisposed to not influence their responses or facial expressions.

Between April and August 2019, these women were invited to participate in this research. When they expressed interest in participating, they were taken to a reserved room for the application of the questionnaires, being informed about the purpose, confidentiality of the data, and the operation of the FER tool, leaving them free to request any clarification and/or withdrawal at any time. After an initial screening, 73 volunteers with different gestation times were obtained. The selection was based on exclusion parameters, according to Table 6.

After applying the exclusion criteria, 50 volunteers were able and agreed to participate in the tests until the end, proceeding to the signing of the Termo de Consentimento Livre e Esclarecido (TCLE).

B. DATA ANALYSIS

The responses to the ACE questionnaire were divided into 4 prevalence groups: "no abuse", "physical abuse only", "sexual abuse only", and "physical and sexual abuse". For IPV there are also 4 prevalence groups labeled as: "no abuse", "with physical abuse", "with sexual abuse" and "with sexual and physical abuse". The percentage of

TABLE 7. Correlations between the reference group and the others for ACE and IPV cases.

Num	Group	Activity
1	Positive for IPV and ACE	Group to be compared
2	Positive for IPV only	Group to be compared
3	Negative for IPV and ACE	Reference group
4	Positive for ACE only	Group to be compared

participants positive for PTSD and negative for PTSD was rated.

Odds Ratio (OR) association measures were used [51]–[54], with confidence intervals (CI) of 95% for PTSD in relation to child abuse history. This measure is widely used in studies using case-control groups, where the frequency of exposures to a particular factor is compared between a group of participants who have the disorder (cases) and one who does not (control).

Thus, OR is defined as the probability that an event will occur divided by the probability that it will not occur.

$$OR = \frac{\frac{P_1}{Q_1}}{\frac{P_0}{Q_0}} = \frac{P_1 Q_0}{P_0 Q_1} \tag{1}$$

where:

P_1 = Proportion of individuals who developed the disease among the exposed;

P_0 = Proportion of individuals who developed the disease among the unexposed;

Q_1 = Proportion of individuals who did not develop the disease among the exposed;

Q_0 = Proportion of individuals who did not develop the disease among the unexposed.

Participants "Negative for ACE and IPV" made up the reference group, to which participants in the other three categories were compared. Volunteers were categorized into four groups, based on combinations of ACE and IPV. Table 7 presents the summarization.

Frequency distributions of sociodemographic characteristics were examined according to types of child abuse. The odds of occurring PTSD according to types of child abuse ("physical abuse only," "sexual abuse only," and "physical and sexual abuse") were estimated with women who had no history of child abuse (physical or sexual) serving as the reference group. The joint and independent effect of child abuse and IPV experiences on PTSD risk was examined.

C. FACIAL EXPRESSION ANALYSIS

As described previously, at the moment of answering each questionnaire (ACE, IPV and PTSD), the facial expressions of the volunteers were analyzed, stored and processed by WHOT in order to infer the 4 already defined emotions: happiness, sadness, surprise and anger. When the face was static, it was classified as neutral. Therefore, the mean (frequency)

Features	All the participants N = 50		No abuse N = 20		Physical abuse (only) N = 21		Sexual Abuse (only) N = 2		Physical and sexual abuse N = 7	
	n	%	n	%	n	%	n	%	n	%
Age (years) *	24.32 ± 4.8		23.45 ± 4.47		25.19 ± 4.59		24 ± 8		24.29 ± 4.65	
Married / Living with a partner	17	34	3	15	11	52.38	0	0	3	42.86
Employment (working)	43	86	18	90	17	80.95	2	100	6	85.71
Age										
14-17	2	4.0	0	0.0	0	0.0	1	50.0	1	14.3
18-20	12	24.0	6	30.0	5	23.8	0	0.0	1	14.3
21-29	30	60.0	13	65.0	13	61.9	0	0.0	4	57.1
30-34	3	6.0	0	0.0	1	4.8	1	50.0	1	14.3
>= 35	3	6.0	1	5.0	2	9.5	0	0.0	0	0.0
Education										
Illiterate	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Elementary School (Incomplete)	1	2.0	0	0.0	1	4.8	0	0.0	0	0.0
Elementary School (Complete)	3	6.0	1	5.0	1	4.8	1	50.0	0	0.0
High School (Incomplete)	12	24.0	6	30.0	4	19.0	0	0.0	2	28.6
High School (Complete)	25	50.0	8	40.0	11	52.4	1	50.0	5	71.4
Higher Education (Incomplete)	7	14.0	3	15.0	4	19.0	0	0.0	0	0.0
Higher Education (Complete)	2	4.0	2	10.0	0	0.0	0	0.0	0	0.0
Postgraduate	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Race / Color / Ethnicity										
White	13	26.0	8	40.0	5	23.8	0	0.0	0	0.0
Black	16	32.0	3	15.0	11	52.4	1	50.0	1	14.3
Brown	21	42.0	9	45.0	5	23.8	1	50.0	6	85.7
Yellow	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Indigenous	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0

* Average + - Standard deviation.

FIGURE 4. Population characteristics according to the types of adverse childhood experiences (N = 50).

was extracted only for the facial data collected at the time of application of the ACE, IPV and PTSD questionnaires, and at the end, WHOT calculated an average of the facial data collected from all the interviewed participants. The results will be displayed in the following section.

V. RESULTS AND DISCUSSION

This section presents the results obtained and relates them to the current related literature, highlighting the contribution aspects of this article.

It should be noted that the graphs and tables are shown as pictures because they are print screens from the tool itself, since WHOT provides the data already in these presentation formats.

A. SOCIODEMOGRAPHIC ANALYSIS

For the sociodemographic analyses, the mean age of the research participants was 24.32 years; among them, 17 are married or living with a partner (34%) and 43 have a job or work (86%). For age, they were divided into groups of 14 to 17 years (4%), 18 to 20 years (24%), 21 to 29 years (60%), 30 to 34 years (6%), and >= 35 years (6%). Half of the participants had completed high school (50%) and the predominant color was brown (42%) followed by black (32%). The age range for the ACE groups was between 23 and

Child Abuse	PTSD negative N = 39		Positive for PTSD N = 11		OR (95% CI)
	n	%	n	%	
Abuse (Negative)	15	38.5	1	9.1	Reference
Abuse (Positive)	24	61.5	10	90.9	6.25 (0.72, 53.9)
Types of Abuse					
No Abuse	18	46.2	2	18.2	Reference
Sexual Abuse (only)	1	2.6	1	9.1	9.00 (0.39, 206.54)
Physical Abuse (Only)	19	48.7	2	18.2	0.95 (0.12, 7.48)
Sexual and Physical Abuse	1	2.6	6	54.5	54.00 (4.12, 707.09)

FIGURE 5. Associations between adverse childhood experience (ACE) with post-traumatic disorder (PTSD) (N = 50).

25 years of age, not varying much between groups (23.35 for no abuse, 25.19 for physical abuse, 24 for sexual abuse, and 24.29 for both types of abuse). All the characteristics of the research participants and according to the types of childhood abuse are shown from Figure 4.

As shown in Figure 5 a history of physical and sexual abuse in childhood was associated with a 6.25 times greater likelihood of developing PTSD. For the study population, the odds of developing PTSD regarding the type of abuse is much higher for those experiencing both types of abuse (54.5%), followed by sexual abuse only (18.2%).

Figure 6 shows a multivariate comparison between the odds of women who have not experienced any type of abuse,

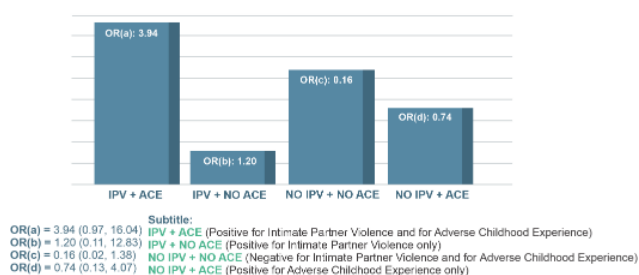**REGISTRATION OF POST-TRAUMATIC STRESS DISORDER**

Subtitle:
OR(a) = 3.94 (0.97, 16.04)   IPV + ACE (Positive for Intimate Partner Violence and for Adverse Childhood Experience)
OR(b) = 1.20 (0.11, 12.83)   IPV + NO ACE (Positive for Intimate Partner Violence only)
OR(c) = 0.16 (0.02, 1.38)   NO IPV + NO ACE (Negative for Intimate Partner Violence and for Adverse Childhood Experience)
OR(d) = 0.74 (0.13, 4.07)   NO IPV + ACE (Positive for Adverse Childhood Experience only)

FIGURE 6. Multivariate comparison showing the joint and independent effect of ACE and IPV experiences on the risk of PTSD.

FIGURE 7. Individual report.

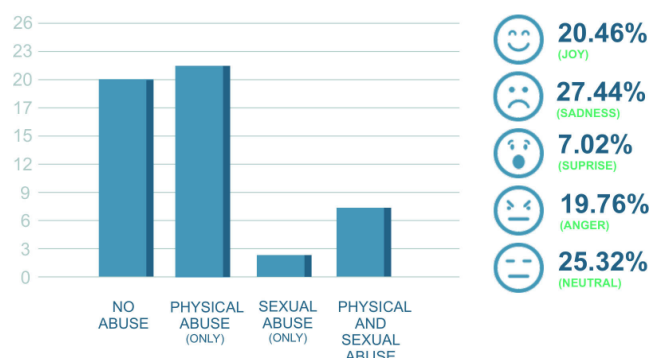**REGISTRATION OF ADVERSE CHILDHOOD EXPERIENCES**

FIGURE 8. ACE result with the percentage of emotions inferred during the answers to the respective questionnaire.
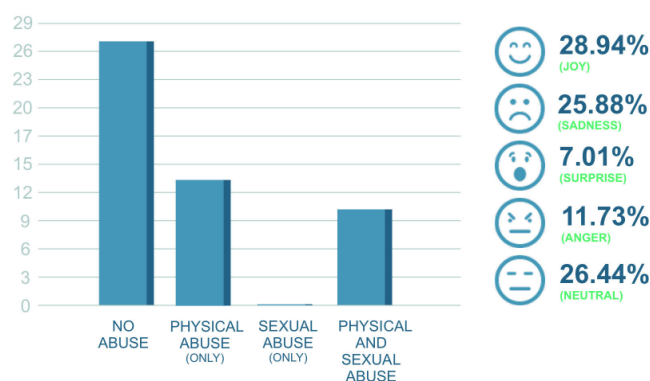
REGISTRATION OF INTIMATE PARTNER VIOLENCE

FIGURE 9. IPV result with the percentage of emotions inferred during the answers to the respective questionnaire.
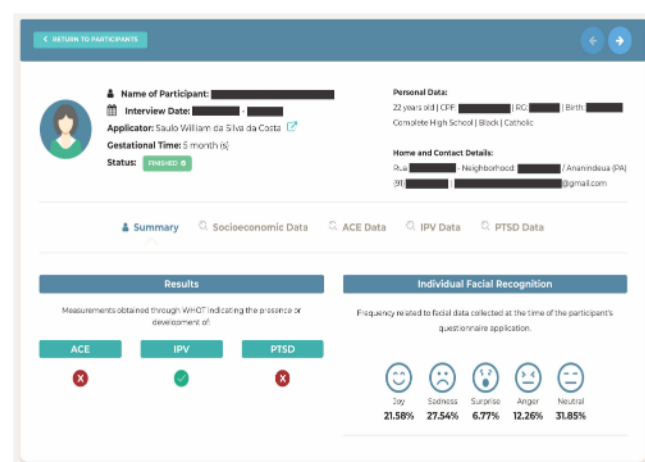
either in childhood or by an intimate partner (reference group) and those who have experienced abuse of developing PTSD. Women who have suffered both types of abuse, either from a partner or from a history of childhood abuse, are 3.94 times higher in the likelihood of developing PTSD.

At the end, WHOT allowed a diagnosis of the interviewee; Figure 7 shows the Individual Report screen, with personal data and a summary. There are five tabs, the first of which (Summary) is described here; the others are a mirror of the answers given to the questionnaires including the socioeconomic data.

The lower left part of the screen shows a result indicating the occurrence or not of ACE, of past or current situations of IPV and the possibility of developing or not PTSD. It can be seen, in this case, the presence of indicators of the occurrence of IPV for the participant. On the right are the emotions inferred throughout the interview. This screen shows the versatility and good usability of the tool for the researcher who has quick access to the desired information almost instantly.

B. ANALYSIS OF ACE, IPV AND PTSD QUESTIONNAIRES

Among the 50 research participants and considering the answers about ACE, 20 women declared they had not suffered any abuse in childhood, 21 reported physical abuse only, 2 sexual abuse, and 7 for both types of abuse. The analyzed emotion most present at the time of the questionnaire application about ACE was sadness (27.44%), followed by neutral (25.32%), joy (20.46%), anger (19.76%), and surprise (7.02%). Figure 8 graphically presents the quantitative values of responses to the ACE questionnaire, as well as the percentage of emotions prevalent at the time.

For IPV records, 27 women responded negatively to any intimate partner abuse, 13 reported suffering/having suffered physical abuse only, none reported only sexual abuse, and 10 said they had been victims of both physical and sexual abuse. Considering the emotions expressed by the interviewees during the questionnaire on IPV, the following data were collected: 28.94% prevalence of the expression joy, configuring it as the most frequent for this subject; 26.44% for neutral and 25.88% for sadness. Anger and surprise were the least frequent during this analysis: 11.73% and 7.01% respectively. Figure 9 presents the graph showing the quantity according to each classification group and the emotions divided by their prevalence percentages in WHOT.
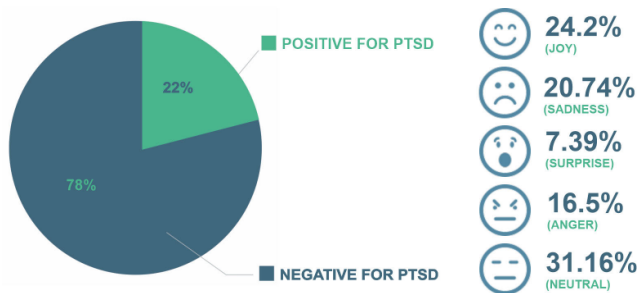
POST-TRAUMATIC STRESS
DISORDER (PTSD)

FIGURE 10. PTSD result with the percentage of emotions inferred during the answers to the respective questionnaire.

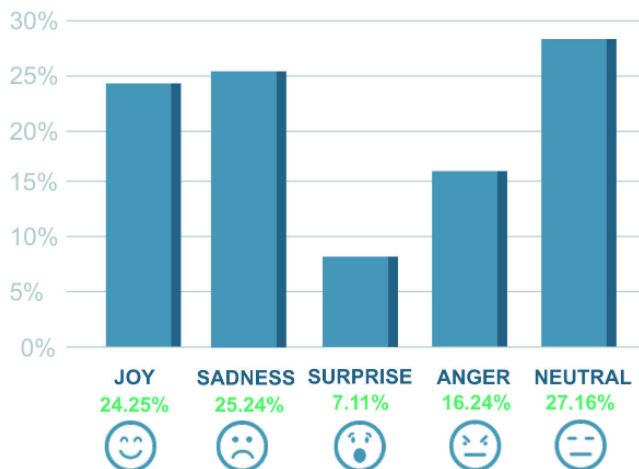AVERAGE OF THE FREQUENCY OF
FACIAL EXPRESSIONS/EMOTION

FIGURE 11. General percentages of emotions inferred during the entire period of all interviews.

For the score of women analyzed regarding the PTSD questionnaire, 78% were negative (39 women of the total) and 22% attested positive (11 women of the total). The predominant emotion at the time of analysis for the questionnaire was neutral (31.16%), followed by joy (24.2%), sadness (20.74%), anger (16.5%), and surprise (7.39%). The graphical representation and emotions are presented by WHOT, as Figure 10 shows.

An average of the emotions throughout the interview period is demonstrated in Figure 11. It can be noted a prevalence of the expressions neutral with 27.16%, sadness with 25.24%, and joy with 24.25%; the expression anger was the fourth most occurring among the analyzed emotions, with 16.24%, and finally, the expression surprise with 7.11%.

C. GLOBAL ANALYSIS OF EMOTIONS DETECTED BY WHOT

Considering the studies and documents discussed in this article as well as their findings ([3], [6], [21], [33], [34], [55]–[57]), the data described above have similarities with them only in terms of the feelings and emotions expressed by the

interviewees given the reality of abuse in which many women find themselves. Thus, it is reasonable that women who have suffered some abuse during childhood, when remembering it, emit a sad face (30 said they did and in this group of questions sadness was the most perceived emotion); similarly, when asked about IPV and 27 said they did not suffer situations understood as such, it is understandable that joy (28.94%) and a probable indifference manifested by the neutrality of the face was in 26.44% of the cases. Similarly, it is understandable that 39 women who did not demonstrate PTSD traits indicated this by face neutrality (31.16%) and/or joy (24.2%).

The fact is that the results of WHOT, contained in the Individual Report of each interviewee, both when based on the answers of the digital questionnaires, and when analyzing them together with the emotions expressed by the face, demonstrate that the tool is capable of being used within the objective intended here of which, unfortunately, no analogies or comparisons can be made due to the fact that there is, to date, no other tool that generates the same data from the same approach as WHOT.

VI. CONCLUSION

The pandemic crisis that the world has been experiencing since 2020 has highlighted numerous social problems; violence against women and children is one of these situations that, despite the warning from the United Nations and the World Health Organization, societies have not prepared effectively to face. The data and studies presented in this article demonstrate the emergence of human rights violations perpetrated against women and, at the same time, corroborate the urgency to take seriously intervention methods that are at the service of protecting the victims.

Thus, this study aimed to demonstrate a tool that would allow the construction of profiles of women victims of violence through, basically, three activities: i) detection of facial expressions and inference of emotions; ii) provision of digital questionnaires on IPV, ACE and PTSD; and iii) generation of reports from the collected data.

The face of each interviewee was tracked using the Viola-Jones and CANDIDE-3 techniques and, combining FACS with Face Tracking (SDK), the tool was able to diagnose joy, sadness, anger, and surprise. Throughout the interview, the tool inferred sadness (25.24%), joy (24.24%), anger (16.24%) and surprise (7.11%) in addition to a percentage of neutrality (27.16%). The techniques used, therefore, proved to be efficient for the study that the authors proposed.

As for the questionnaires, it should be noted that all of them had already been applied by other researchers in previous studies with different objectives. The differential in the present study was the fact that there was no human mediator, that is, there was no interference such as intonation or the interviewer's way of reading, which can influence the answers when the interview is face-to-face. Each Participant, as explained, was placed in front of a computer and on

the screen answered the questions posed. This way of interviewing makes it possible, besides the already mentioned non-interference, for the woman to be more comfortable answering the questionnaires in a confidential, reserved, and discreet way, which can increase the reliability of the data that the Participant reports.

The reports were generated by crossing from the socioeconomic data to the emotions that were inferred. In this way, the tool itself provides graphs and percentages that facilitate the necessary analyses that the authors must do, as described throughout the article.

The data obtained at the end of this research indicates to the authors, however, the need to make improvements to the tool. Such improvements will tend to perform future facial expression tracking and emotion inference using more refined techniques, such as DL, for example. On the other hand, further research may reveal differences that other populations and/or situations may present, and thus further adaptations may be necessary in order to give WHOT a greater margin of accuracy.

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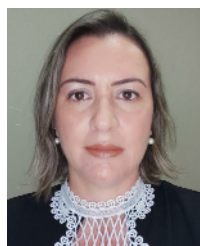
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