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Research paper

Effects of maternal psychological distress and perception of COVID-19 on prenatal attachment in a large sample of Italian pregnant women

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ABSTRACT

Background: Evidence concerning the impact of COVID-19-related stress exposure on prenatal attachment in pregnant women is unknown. In this study we sought to assess the effect of psychological distress and risk perception of COVID-19 on prenatal attachment in a Italian sample of pregnant women.

Methods: 1179 pregnant women completed an anonymous online survey and self-report questionnaires measuring socio-demographic and obstetric characteristics, psychological distress (STAI Form Y-1-2 and BDI-II), prenatal attachment (PAI) and risk perception of COVID-19. Data were collected from March 2020 to April 2020 referring to the national lockdown period.

Results: After adjusting for the socio-demographic and obstetric factors in the multivariable analysis, we found out the state anxiety was shown to be a significant predictor ($p < 0001$) of prenatal attachment. Moreover, the COVID-19-risk perception positively moderate the relationship between trait anxiety and prenatal attachment (p=0008), indicating that when COVID-19-risk perception is high, the effects of trait anxiety on prenatal attachment is attenuated. The synergistic effect between STAI Form Y-1 and COVID-19-risk perception index on PAI is partially mediated by STAI Form Y-2 score.

Conclusions: Findings from this study showed that state anxiety related to COVID-19 outbreak in pregnant women may affect the prenatal attachment process of the expectant mother negatively. However, an adequate and functional perception of COVID-19 could enhance prenatal attachment. These results underline the importance of monitoring the prenatal attachment process and the mother's mental health during pandemics, to safeguard maternal and infant mental health.

1. Introduction

It is well-known that COVID-19 not only affects physical health, but also mental health and well-being throughout the population (Lai et al., 2020; Shereen et al., 2020). The vulnerability to psychological distress across populations could be attributable to various factors, including gender, social support, specific previous experiences with other infections, length of isolation, and amount of exposure to the media (Salari et al., 2020; Xiong et al., 2020). The potential impact of the current pandemic on mental health should not be neglected, especially in vulnerable populations like pregnant women. Despite, pregnant women do not appear to be at increased risk of contracting SARS-CoV-2 (Easterlin et al., 2020), however, pregnancy is a critical developmental period characterized by enhanced susceptibility to environmental

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exposures (Su et al., 2015; Zhu et al., 2014).

All mothers live pregnancy as a unique experience. The theory of prenatal attachment suggests that this unique relationship between parents and fetus is identified as "prenatal attachment" (Atashi et al., 2018; Brandon et al., 2009). The prenatal attachment was defined as an emotional relationship that parents develop toward the unborn baby during the gestation period (Salehi et al., 2019). Similarly, some researchers used the term "maternal–fetal attachment" (MFA) to refers to the emotional attachment between the mother and fetus as an indicator of their health and the mother's efficiency in the postnatal period (Alhusen, 2008). Attachment developes during pregnancy across different stages, such as planning for pregnancy, adapting to pregnancy, accepting pregnancy, feeling the fetal movements, recognizing the fetus as an individual, birth-giving, until to seeing and touching the baby (Robinson et al., 1999). The strength of the mother-fetus relationship has important implications in the postnatal period, influencing the postnatal maternal-child attachment and the quality of the care (Howland et al., 2020; McNamara et al., 2019). However, it is important to be aware of the factors that may have an impact on or interrupt a mother's healthy prenatal attachment process.

Psychological distress during pregnancy has been shown in some studies to compromise the process of attachment between mother and child (Røhder et al., 2020). Pregnant women are facing numerous life-changes that make them particularly vulnerable to psychological distress (Davis and Narayan, 2020). Pregnant women may suffer from mood swings due to the influence of hormone levels during pregnancy. The World Health Organization suggests that about 10% of pregnant women (and 13% of (recent) mothers) experience a mental disorder, especially anxiety and depression that generallylead to adverse outcomes for early mother-child bonding, postnatal mother-child interactions, and early child development (McNamara et al., 2019; Nath et al., 2019). Further, infants with emotional-behavioural difficulties belong to mothers who had no attachment to their babies during pregnancy (Akbarzadeh et al., 2016). Hence, it is important to study the association between prenatal attachment and psychological distress due to exposure to COVID-19-related stressors.

Up to now, considerable literature has grown up around the theme of the impact of the COVID-19 pandemic on maternal mental health (Saccone et al., 2020; Thapa et al., 2020). The main factors that increase perinatal distress are: the uniqueness of the disease, the unexpected global impact, the uncertainty about physical consequences (for both mothers and babies), the risk of transmission, and the restrictions of social contacts (Dubey et al., 2020; Chivers et al., 2020). A recent cohort study carried out during COVID-19 pandemic, showed that 68% of pregnant women, met the cut-off point for anxiety, particularly in the first trimester of pregnancy (Saccone et al., 2020). Similarly, in a Spanish study, Chaveset and Coworkers (2021) found that during pandemic, 58% and 51% of pregnant women reported depressive and anxiety symptoms, respectively. A recent cross-sectional study by Wu and collaborators (2020) compared the rate of anxiety and depressive symptoms among pregnant women before and after the national declaration of a pandemic in China. A significant increase in the prevalence of depressive symptoms was found among pregnant women raising from 26 to 34.2%. Another longitudinal study reported that pregnant women showed a more pronounced increase in depression and anxiety than non-pregnant women, in a time range of approximately 50 days during the pandemic (López-Morales et al., 2021). Moreover, perceived risk of the COVID-19 was related to greater mental health problems and a greater propensity to practice preventive behaviors against virus (Yıldırım et al., 2020). Similar findings have been detected from other infectious conditions; such as Ebola or SARS (Cheng et al., 2006; Yang and Chu, 2018). Despite this large amount of evidence, it remains to be evaluated if the risk perception of COVID-19 and psychological distress may affect the level of prenatal attachment

In this pandemic scenario, the high levels of psychological distress continuously experienced by mothers during pregnancy can emerge through increased production of cortisol due to altered activity of the hypothalamic-pituitary-adrenal axis (HPA) in the fetus, which, in turn, may directly affect infant temperament and social-stress regulation mechanisms (Van Bodegom et al., 2017). In addition, prenatal anxiety, depression, and stress can result in pregnancy complications, as well as difficulties in the establishment of mother-infant bond, which adversely affects the pregnant women's attachment process, which is essential to the baby's psychological development (Field, 2017; Liu et al., 2016; Tenuta et al., 2020). To date, no research has directly addressed the impact of psychological distress on prenatal attachment during the COVID -19 pandemic. As pregnancy is a critical period delineated by enhanced susceptibility to environmental exposures, analyzing the prenatal attachment consequences of psychological distress and COVID-19 risk perception in pregnant women is a rare condition with relevant clinical implications. Nevertheless, almost all studies on COVID-19 are limited to epidemiological and clinical data, and research on prenatal attachment is lacking.

Therefore, the main purpose of this study was to investigate the effects of psychological distress and COVID-19 risk perception on prenatal attachment in a sample of Italian pregnant women. The hypothesized model is shown in Fig. 1. Specifically, we hypothesized that (a) anxiety and depression symptoms would be related to COVID-19-risk perception and prenatal attachment; (b) psychological distress and COVID-19-risk perception would influence prenatal attachment, while adjusting for the other confounders; and (c) COVID-19-risk perception would moderate the relationship between psychological distress and prenatal attachment.

2. Methods

2.1. Participants

A cross-sectional, web-based survey was carried out among Italian pregnant women between 14 March and 25 April 2020, relying on an anonymous online survey using Google Forms platform. The study was sponsored by two local non-governmental associations, the "Associazione di Volontariato Mammachemamme" and the "Movimento di Psicologia Perinatale". Pregnant women received the survey's URL through social media, emails, and advertisements in many prenatal and neonatal clinics of the three geographical zones of the country – the North, South, or Centre zones. The sample consisted of women who were expecting a baby (antenatal period) during the first COVID-19 lockdown imposed by the Italian government on 9 March 2020. Inclusion criteria were being 18 years old and having reading skills and language comprehension to complete self-report questionnaire. All pregnant women were informed about the purpose of the study and gave their informed consent to participate in the study. Participants did not receive any reward. The study was conducted in accordance with the Declaration of Helsinki. The study was approved by the University of Calabria Ethics Committee (Protocol number: 0013005).

2.2. Measures

Participants completed ad hoc questionnaires about sociodemographic (mother's age, civil status, educational levels, and a number of children) and obstetric (gestational age, having a history of abortion, and having a pregnancy complication) characteristics. A questionnaire was specifically developed to assess mothers' risk perception of COVID-19 during the pandemic lockdown. Risk perception is defined as the probability of negative outcomes and plays a crucial role in shaping individuals' health-related behaviors (Yue et al., 2020). Then, the questionnaire was developed to cover different domains that could have been subject to variations due to the COVID-19 pandemic lockdown, and, therefore, that may be potentially perceived as sources of concern during pregnancy (i.e., the health of the child, risk of contagion, worries about the future and jobs, social isolation,

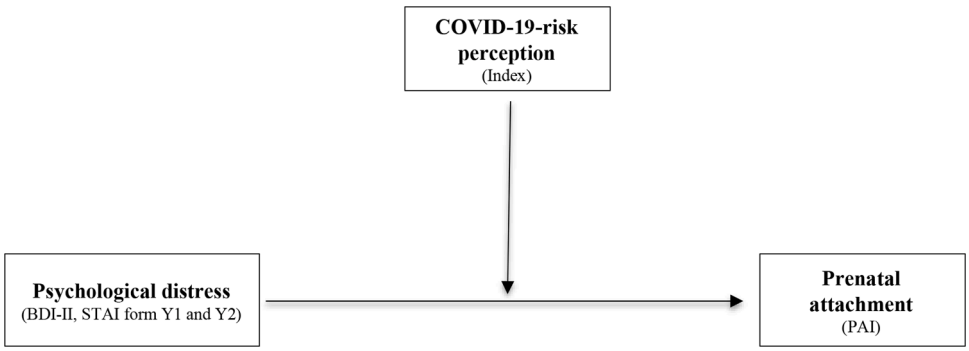

Fig. 1. The research issue: the conjectured relationships between Psychological distress (as represented by the observed variables BDI, STAI form Y1 and STAI form Y2), Covid19 stress index and prenatal attachment (PAI).

relationship with relatives). The development of the questionnaire was based on the paradigm widely used in human health risk perception (Slovic, 1992). It consists of six questions (e.g. *How worried are you about the potential effects of the Covid-19 pandemic on the health of your child?*) with a Likert-type scale ranging from "not at all" (1) to "severe" (5) and asked women to rate their concern about COVID-19 pandemic (supplementary file), with higher scores indicating higher levels of COVID-19-risk perception.

Prenatal Attachment Inventory (PAI) (Muller, 1993) was used measuring prenatal attachment, as well as emotions, thoughts, and conditions of pregnant women during pregnancy. It is a self-report scale consisting of Likert-type items ranging from 1 ('almost never') to 4 ('almost always'), with higher scores indicating higher levels of prenatal attachment, measured in one dimension. The total score ranges from 21 to 84, with higher scores indicating higher levels of prenatal attachment. The reported internal consistency reliability ranges between $\alpha = .81$ and $\alpha = .93$ (van den Bergh and Simons, 2009).

Beck Depression Inventory (BDI-II) (Beck et al., 1996) is a self-report questionnaire consisting of 21 items. This is one of the most used tool for detection of depression symptoms in the general population, allowing an estimation of the severity of the symptoms. The items receive a rating of zero to three and are summed to obtain a global score range 0–63, with higher scores indicating more severe symptoms. Scores of 0–13 indicate minimal depression, 14–19 mild depression, 20–28 moderate depression and 29–63 severe depression. The internal consistency was described as around 0.92 and the test-retest reliability is 0.93.

State-Trait Anxiety Inventory (STAI-Y) (Spielberger and Sydeman, 1994) was used to identify both state and trait anxiety. The state anxiety scale consists of 20 items (STAI Form Y-1) evaluating current feeling of tension, anxiety and nervousness. The trait anxiety scale consists of 20 (STAI Form Y-2) items assessing anxiety levels, on the basis of the four-point Likert scale. Scores for both the State Anxiety Scale and Trait Anxiety Scale ranged from a minimum of 20 to a maximum of 80. A cutoff score of 40–50 indicates mild anxiety, 50–60 moderate anxiety, and over 60 severe anxiety. Internal consistency coefficients for the scale have ranged from .86 to .95; test-retest reliability coefficients have ranged from .65 to .75 over a 2-month interval (Spielberger et al., 1983). Test-retest coefficients for this measure in the present study ranged from .69 to .89.

2.3. Statistical methods

All demographic and clinical characteristics were entered into the statistical analysis. Descriptive analysis was conducted for the socio-demographic and obstetric characteristics, risk perception of COVID-19, prenatal attachment, depression symptoms, state, and trait anxiety. Spearman coefficients were used to investigate the correlations between risk perception of COVID-19, prenatal attachment, depression symptoms, state, and trait anxiety in pregnant women [hypothesis (a)].

The effects of psychological distress, COVID-19 risk perception and the other socio-demographic and obstetric variables on the response variable PAI were estimated via regression analyses relying upon beta regression models [hypothesis (b)]. The beta regression, rather than the usual Gaussian/OLS regression, is motivated by the bounded support of the response variable PAI taking values in the range (21, 84) (easily scaled in (0, 1)). The regression equation modelling the covariate effect on PAI reads as

$$log(\mu / (1-\mu)) = \beta 0 + \beta 1\ X1 + \ldots + \beta pXp \quad (1)$$

where μ is the expected value of the PAI score properly scaled in (0, 1) and assumed to be distributed according to a Beta random variable, and the X1, ..Xp are the continuous and categorical explanatory variables including, COVID-19-Perceptions Risk Index, STAI form Y1, STAI form Y2, BDI and the other confounders understood to affect, to some extent, the PAI, namely: gestational age, maternal age, high education (yes/no), previous sons (yes/no), previous abortion (yes/no), diagnosed high-risk pregnancy (yes/no).

The right-hand side of Eq. (1) is then extended to include the product between STAI form Y1 and COVID-19 risk perception in order to account for the moderated relationship via their interaction effect on the PAI [hypothesis (c)].

In addition to specified hypotheses, conditional mediation analysis (Baron and Kenny, 1986), sometimes referred as mediated moderation, was performed to assess the mediation rule of state Anxiety (STAI form Y2) on the joint effect of COVID -19-Perceptions Risk and STAI form Y1 on the PAI. At this aim another regression model having the potential mediator STAI form Y2 as response variable was exploited. Overall, our statistical framework allowed to estimate the average direct effect (ADE) and the average conditional mediated effect (ACME), i.e. the COVID19 by STAI form Y1 synergic effect on PAI explained via the mediator STAI form Y2. The statistically significant P value was set at 0.001. All statistical analyses were done using the software R (version 4.0.5) and packages mediation (Imai et al., 2010) and betareg (Cribari-Neto and Zeileis, 2010).

3. Results

A total of 1179 pregnant women were included in the study. The overall sociodemographic and clinical characteristics of the participants are summarized in Table 1. The mean age was 32.83 ± 8.9 years, ranging from 18 to 56 years. The mean gestational age was 26.28 ± 8.9 weeks, ranging from 5 to 41 weeks: 8.7% were in the first, 42.6% in the second and 48.7% in the third trimesters, respectively. None of the enrolled pregnant women had confirmed COVID-19, history of hospital admissions, and treatment for COVID-19. Most of the participants had college degrees (46.6%). Furthermore, it was found that 57.3% of pregnant women were having their first pregnancy. 26.6% of pregnant women are characterized by early termination of her pregnancy while

Table 1
Clinical, sociodemographic and obstetric characteristics of the pregnant women.

	N (1179)	%
BDI		
mild	223	18,9%
moderate	167	14,2%
severe	41	3,5%
STAI Form Y-1		
mild	273	23,2%
moderate	367	31,1%
severe	330	28%
STAI Form Y-2		
mild	429	36,4%
moderate	241	20,4%
severe	82	7%
Trimester		
First	103	8,7%
Second	502	42,6%
Third	574	48,7%
Educational level		
Secondary school	55	4,7%
High school	374	31,7%
University	550	46,6%
Post University	199	16,9%
Civil status		
married	745	63,2%
single	50	4,2%
divorced	10	0,8%
separated	10	0,8%
cohabiters	367	31,1%
Regions of Italy		
North	319	27%
Center	297	25%
South	563	48%
Previous children	503	42,7%
History of abortion	314	26,6%
Pregnancy complication	156	13,2%
Preparation class	426	36,1%
	Mean	**SD**
Maternal age (range 18 – 56 years)	33,06	8,91
Weeks of gestation (range 5 – 41 weeks)	26,28	8,92
PAI (23 – 82)	57,31	9,96
Covid-19-Perceptions Risk Index (range 4 – 24)	17.9	3.7
BDI-total score (range 0-54)	12,41	7,39
STAI Form Y-1 (range 20 – 80)	52,29	12,07
STAI Form Y-2 (range 21 – 79)	43,92	9,9

Note. Prenatal Attachment Inventory (PAI), Beck Depression Inventory (BDI-II), State-Trait Anxiety Inventory (STAI-Y).

13.2% had a pregnancy at risk. Regarding the distress psychological variables along with the PAI, we revealed a gaussian distribution of values without evidence of severe pathological levels (Table 1). Indeed, he mean PAI score in pregnant women was found to be 57.31 ± 9.96. The average score of COVID -19-Perceptions Risk Index was 17.9 ± 3.7. 63.4% of women had no depressive symptoms, 18.9% had mild depressive symptoms, 14.2% had moderate symptoms and only 3.5% severe symptoms. On the Trait-Anxiety scores, 23.2% had mild trait anxiety levels, 31.1% had moderate levels and 28% had severe levels. Among the anxiety levels, out of 1179 women 36.6% had mild state anxiety levels, 20.4% had moderate levels and 7% had severe levels. As shown in Table 2, the results of correlation analysis showed that PAI scores was negatively correlated with BDI- scores ($p = .0007$), STAI Form Y-2 ($p < 0001$), while it were positively correlated with COVID-19-Perceptions Risk Index ($p < 0001$). COVID-19-Perceptions Risk Index scores was negatively correlated with BDI scores ($p < 0001$), while it was positively correlated with trait ($p < 0001$) and state anxiety ($p < 0001$).

3.1. Statistical modelling: direct effects and conditional mediation

We fit a regression model including the PAI score as the outcome variable and the socio-demographic/obstetric characteristics, the risk perception of COVID-19, the depression symptoms, the state, and trait-anxiety were entered simultaneously as explanatory variables. Results indicated that maternal age ($p = .003$), previous childbirth ($p = .0005$), high education ($p = .0041$), and gestational age ($p < .0001$), state ($p < .0001$) and trait ($p = .0008$) anxiety were significantly related to PAI score. However, to corroborate our hypothesis depicted in Fig. 1, we next added the interaction terms between the COVID -19-Perceptions Risk Index and the three variables referring to the psychological distress (state/trait anxiety and depression). By testing for the sustainability of all the terms in model, we found that only state anxiety by COVID -19 resulted in a very significant effect (p=.0008), suggesting that the effect of the actual feeling of anxiety on PAI is moderated by the COVID-19 perception risk.

In addition to estimating the direct effects expressed in Table 3, we also tested the mediating role of the state anxiety by fitting a new regression model having the STAI form Y2 as response and all variables in the linear predictor. Results are reported in Table 4, and Fig. 2 summarizes the p-values coming from the two regression models for the variables of main interest.

We performed conditional mediation analysis to assess and quantify the ACME, i.e the COVID-19 by state anxiety effect on PAI mediated by

Table 2
The correlation between the mean scores of PAI, Covid-19-Perceptions Risk Index, BDI-total score, STAI (Y- and Y-2) score of the pregnant women.

	Type	PAI	Covid-19-Perceptions Risk Index
PAI	Pearson	-	0.19**
		-	.000
Covid-19-Perceptions Risk Index	Pearson	0.19**	-
	Sig. (2-tailed)	.000	-
BDI-II-total score	Pearson Correlation	-.097**	-.031**
	Sig. (2-tailed)	.0007	.000
STAI Form Y-1	Pearson Correlation	-.053	0.049**
	Sig. (2-tailed)	.069	.000
STAI Form Y-2	Pearson Correlation	-.15**	0.033**
	Sig. (2-tailed)	.000	.000

Note. Prenatal Attachment Inventory (PAI), Beck Depression Inventory (BDI-II), State-Trait Anxiety Inventory (STAI-Y);
*p-value < 0.01.
** p-value < 0.001.

Table 3
Summary of Beta regression model of variables related to PAI score.

Variable	Estimate	St. Error	p-value
(Intercept)	0.4007	0.7996	.61
age	-0.0125	0.0042	.003*
early abortion (Yes vs No)	0.0060	0.0399	0.88
high-risk pregnancy (Yes vs No)	0.0501	0.0507	.32
early chilbirth (Yes vs No)	-0.1310	0.0374	.0005**
married (Yes vs No)	0.0505	0.0361	.16
high education level (Yes vs No)	-0.1069	0.0373	.004*
gestational age†	0.5359	0.0409	<.0001**
BDI-II-total score	-0.0035	0.0035	.32
STAI form Y2	-0.0137	0.0029	<.0001**
STAI form Y1	-0.0552	0.0165	.0008**
Covid-19-Perceptions Risk Index †	-0.2216	0.2755	.42
STAI form Y1: Covid-19-Perceptions Risk Index †	0.0189	0.0056	.0008**

Note. Parameter estimates are log odds ratios: positive values suggest high probability to increase PAI. The term with ":" in the last row indicates the interaction term between the two variables;
† values on the log scale;
* p-value < 0.01.
** p-value < 0.001.

Table 4
Summary of regression analysis of variables related to STAI form Y2 score.

Variable	Estimate	St. Error	p-value
(Intercept)	-5.228	0.7089	<.0001**
age	-0.002	0.0033	.54
early abortion (Yes vs No)	0.0508	0.0309	010
high-risk pregnancy (Yes vs No)	-0.001	0.0389	.97
early chilbirth (Yes vs No)	-0.006	0.029	.83
married (Yes vs No)	-0.0408	0.028	.14
high education level (Yes vs No)	-0.0765	0.0286	.007**
gestational age†	-0.0714	0.0315	.02*
BDI-II-total score	0.0433	0.0024	<00001**
STAI form Y1	0.1002	0.014	<.0001**
Covid-19-Perceptions Risk Index†	11.098	0.243	<.0001**
STAI form Y1: Covid-19-Perceptions Risk Index†	-0.0252	0.0048	<.0001**

Note.
† values on the log scale;
* p-value < 0.01.
** p-value < 0.001.

trait anxiety. Relevant point estimates and confidence intervals based on 2,000 bootstrap replicates are reported in Fig. 3 and indicate that trait anxiety only partially mediates the synergic effect of COVID-19 by state anxiety on the PAI. Most of the effect appears to be purely direct. In fact, the ACME overall about 5% only of the total effect, turns out to be relatively smaller than the direct effects and non-significant at low values of state anxiety.

Finally, Fig. 4 portrays the state anxiety by COVID -19 interaction effect on the PAI. More specifically the effect of each variable is displayed at the quartile values of the other

4. Discussion

To the best of our knowledge, this is the first study attempting to determine the consequences of psychological distress and risk perception of COVID-19 on prenatal attachment in pregnant women, after controlling for relevant demographic and obstetric variables. It was found that prenatal attachment negatively correlates with state anxiety and depression, while it positively correlates with COVID-19-risk perception, although the effect depends on the actual condition of anxiety. Thus, as state anxiety and depression increase prenatal attachment decreases, indicating that these variables are interrelated. These results are in accordance with recent studies indicating that levels of depression and anxiety are increased after the COVID-19 outbreak, both in pregnant women (Fan et al., 2021; López-Morales et al., 2021) and in the general population (Pan et al., 2021; van der Velden et al., 2021).

In the multivariable analyses, depression does not appear to influence prenatal attachment. On the contrary, state anxiety resulted to be a significant predictor of prenatal attachment after adjusting for the other socio-demographic and obstetric information. Thus, those who have higher state of anxiety may therefore experience lower prenatal attachment. These results are in the line with previous studies published during pre-COVID-19 period (Coflkun et al., 2019; McNamara et al., 2019). Women with elevated state anxiety reported poorer prenatal attachment, meaning less time on attachment-related behavior (e.g., thinking, palpating, and talking to the fetus). It is possible, therefore, that state anxiety negatively affects the emotional experiences concerning the fetus (i.e., related to less quality of attachment). This makes sense because state anxiety relates to the conscious experience of anxiety symptoms, which might have distracted the women from focusing on bonding with fetus. Thus, when pregnancy associated with the COVID-19 outbreak takes the form of psychological distress, it may become a hindrance for maternal fetal attachment. A woman who experiences her pregnancy with a high degree of anxiety during this pandemic is likely to be more vulnerable to worrisome thoughts and negative mood states. These would interfere in her indulging in thoughts and behavior (e.g. talking to the baby in the womb) which shape the development of a positive attachment with the fetus.

Psychological distress can be transmitted to the fetus in a variety of complex ways, including epigenetic changes (Palma-Gudiel et al., 2015). Epigenetic mechanisms regulate the expression of genes and are especially sensitive to adverse environmental exposures (Roth, 2013; Roth and Sweatt, 2011). A considerable body of empirical research indicating that the early exposure of the fetus and the infant to sources of maternal stress is associated with the epigenetic status of genes related to the early caregiving environment, stress response and neuromaturation (Provenzi et al., 2020, 2018), such as NR3C1, SLC6A4, FKBP5, BDNF, OXTR (Cicchetti et al., 2016; Craig et al., 2021; Isgut et al., 2017; Krol et al., 2019; Montirosso and Provenzi, 2015; Szyf, 2019). Moreover, when pregnant women showed a high level of anxiety, the adrenal glands in their bodies raise the secretion of glucocorticoids such as cortisol (Garcia-Gonzalez et al., 2018). These hormones pass through the placental barrier and are transmitted to the fetus; this mechanism can adversely affect the development of the fetus, leading to long-term negative effects on the child (Isgut et al., 2017). Considering these data, we speculate that anxiety experienced during the COVID-19 emergency may affect the prenatal attachment process which is essential to the baby's neurobiological and psychological development. Further longitudinal research should be undertaken to explore the

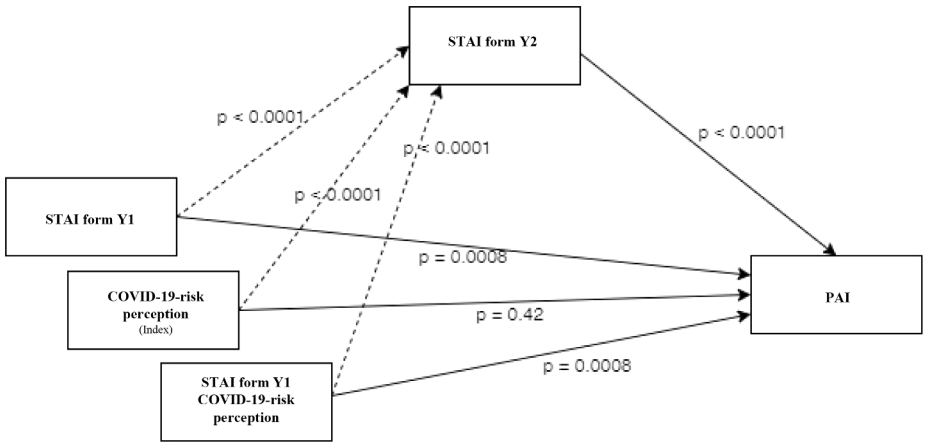

Fig. 2. Path diagram summarizing the relationships between COVID-19 risk perception, STAI form Y1, STAI form Y2, and PAI. The continuous lines refer to the model for PAI, while the dashed lines refer to the model for the mediator STAI form Y2. All the p-values account for the effects by other confounding variables not reported for the sake of readibility.

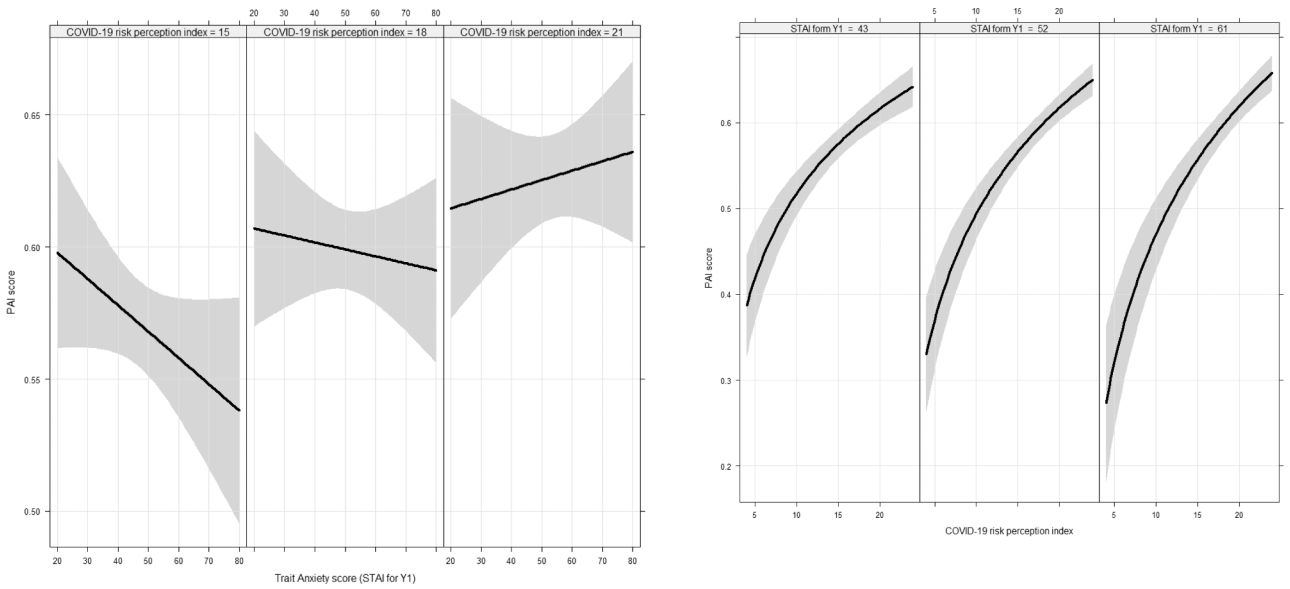

Fig. 3. The estimated direct effects on PAI of the synergy COVID-19 risk perception by STAI form Y1. Left panels: effects of the STAI form Y1 at three values (the quartiles) of COVID-19 risk perception index. Right panels: effects of the COVID-19 risk perception index at three values (quartiles) of STAI form Y1. In each panel the grey areas represent the 95% pointwise confidence intervals.

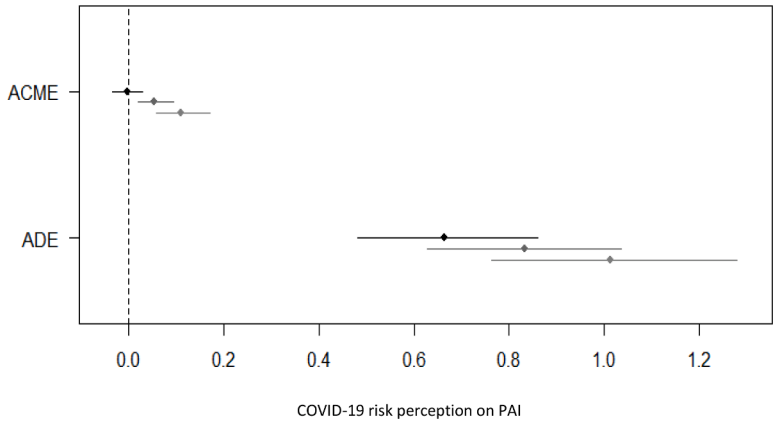

Fig. 4. Point estimates and 95% confidence intervals of ACMEs and ADEs of the COVID-19 risk perception index at the quartile values of STAI form Y1.

long-term effects of prenatal attachment during the COVID-19 pandemic on cognitive, behavioral, emotional, social, and neurobiological development outcomes in the offspring.

Furthermore, the current study examined the moderating role of COVID-19-risk perception in the relationship between psychological distress and prenatal attachment. We hypothesized that women with anxiety symptoms and a great level of COVID-19-risk perception would show less maternal-fetal attachment than women with low COVID-19-risk perception. However, this hypothesis was not confirmed. The results indicated that trait anxiety and COVID-19-risk perception were significantly and jointly related to prenatal attachment. Indeed, we found that individuals with higher trait anxiety also reported a higher COVID-19 risk perception index. In addition to such quite clear-cut direct effect, a smaller, yet significant, synergic effect mediated through the STAI Form Y-2 was also noted.. Broadly speaking, we could argue that COVID-19-risk perception allows attenuation of the effect of other distress risk variables, such as trait anxiety, on attachment-related behaviors. There are several possible reasons to explain this data. Firstly, COVID -19 pandemic has not only produced evident traumatic effects, but it has also increased functional coping strategies. The psychological reaction to stressful stimuli activates patterns that individuals use to manage thoughts, feelings, and actions during a stressful situation and dealing with it. For example, under particular stress, individuals can activate emotion-focused coping strategies to deal with the challenges (Schoenmakers et al., 2015). Emotion-focused coping consists of efforts to change or reduce the negative emotions associated with stress (Lazarus and Folkman, 1984). It can therefore be assumed that pregnant women adopted emotional focused coping strategies to managing COVID-19-related stress exposure, which has attenuated the effect of anxiety on attachment-related behaviors. Second, another effect of the lockdown was the greater interactions between family members belonging to the same nucleus. This emergency scenario offered the opportunity to spend more time together, promoting more emotional assistance and social support. Zhou and colleagues (2020) suggested that pregnant women, as the focus of family attention, may obtain more social support from family members during the COVID-19 epidemic. Many studies have detected, in fact, the link between psychological distress and social support, where the most supported mothers experience the best psychological well-being outcomes (Hopkins et al., 2018; Morikawa et al., 2015).

Some limitations of our study should be noted. Firstly, we mainly collected data in the first wave of the pandemic when little was known about coronavirus infections in pregnant women and their offspring. For this reason, we did not apply a standardized questionnaire to assess the

risk perception to COVID-19. In addition, we did not assess other factors, like the resilience, coping strategies, and social support of pregnant women, that might have an impact on the prenatal attachment process. For example, previous studies showed that social support can play a direct protective role which can alleviate the adverse effects of stressful life events on pregnant women. This has been also reported by research during the COVID-19 pandemic. Recently, Yue and colleagues (Yue et al., 2020) revealed that pregnant women with a low level of social support were more susceptible to anxiety; and COVID-19-risk perception played a mediating role between social support and psychological distress. Another source of uncertainty is that most of the sample (48%) lived in the south of Italy, where the number of infections and observed deaths was significantly lower than in other areas of the country at the time of recruitment.

5. Conclusions

This study expands our knowledge on the effects of psychological distress and COVID-19 risk perception on the prenatal attachment process in a large population of pregnant women. The findings of this study suggest that the state anxiety symptoms in pregnant women may affect the prenatal attachment process of the expectant mother negatively. Therefore, evaluation of the psychological distress factors that affect the prenatal attachment process of pregnant women will lead maternity services to improve clinical assistance during the next phases of a pandemic. It is important to bear in mind that women identified as 'at risk' during early pregnancy should be followed throughout the prenatal and postpartum period with appropriate support, to promote a positive prenatal attachment and reduce anxiety. As suggested by Abasi et al. (2021), the best interventions should be focused on enriching prenatal attachment behaviors such as fetal movement counting, touching the belly, and talking to the fetus. Moreover, other interventions like mindfulness-based prenatal programs could further have a positive effect on mothers' anxiety and increase strong healthy mother-infant bonding which may lead to healthier childhood development (Boekhorst et al., 2020; Sbrilli et al., 2020). Furthermore, adequate and functional perception of COVID-19 could enhance prenatal attachment. We hereby recommend enhanced sensitization and health education sessions for pregnant women to reduce their risk perception, thereby decreasing their anxiety. In conclusion, further research is required to determine the long-term effects on postnatal attachment and neurobiological and psychological development outcomes in the offspring.

CRediT authorship contribution statement

Francesco Craig: Conceptualization, Data curation, Writing – review & editing, Writing – original draft. **Maria Cecilia Gioia:** Conceptualization, Data curation, Writing – review & editing, Writing – original draft. **Vito Muggeo:** Formal analysis, Data curation, Writing – original draft. **Juanita Cajiao:** Visualization, Writing – original draft. **Alessia Aloi:** Visualization, Funding acquisition. **Iolanda Martino:** Visualization, Funding acquisition. **Flaviana Tenuta:** Writing – review & editing. **Antonio Cerasa:** . **Angela Costabile:** .

Declaration of Competing Interest

None to declare.

Role of the funding source

All authors confirm that there is no financial or other conflicts of interest that may be related to the authors

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