



# Psychometric Properties of the Multidimensional Assessment of Covid-19-Related Fears (MAC-RF) in French-Speaking Healthcare Professionals and Community Adults

## RESEARCH

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## ABSTRACT

The Multidimensional Assessment of COVID-19-Related Fears (MAC-RF) is an 8-item self-report measure, which is based on the theoretical premise that fear responses to COVID-19 involve different yet intertwined domains (i.e., bodily, relational, cognitive, and behavioural). In this multi-step study, we tested the psychometric properties of the French version of the MAC-RF and examined the reciprocal relationships among COVID-19-related fears. Data were collected in two French-speaking samples (N = 521 individuals from the community and N = 328 healthcare professionals). Internal reliability, convergent validity, construct validity, and internal structure of the MAC-RF were tested. The French version of the MAC-RF demonstrated good psychometric properties and a two-factor structure, with bodily and relational fears tapping into the first factor, and cognitive and behavioural fears tapping into the second factor. Healthcare professionals reported greater COVID-19-related fears than community participants. Correlation network analysis showed that fear for one's own body and fear of taking action might increase the risk of experiencing other COVID-19-related fears. Limitations comprised the cross-sectional design of the study, risk of bias associated with self-report instruments, and use of online surveys. A careful assessment of different types of fear related to COVID-19 may have implications for prevention and clinical practice during the current coronavirus pandemic. The French version of the MAC-RF is valid and reliable and can thus be used for this purpose.

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## INTRODUCTION

The coronavirus disease 2019 (COVID-19) pandemic is having a serious impact on individuals' well-being (Cusinato et al. 2020; Hansen et al. 2022; Kimhi et al. 2020). Besides increased mortality due to COVID-19-related illness, especially among the elderly population (Parohan et al. 2020), the pandemic has dramatically challenged the healthcare system (Rosenberg et al. 2020) and negatively affected people's everyday life (Ammar et al. 2020; Helsingen et al. 2020). Notably, research has indicated that the pandemic situation is associated with high rates of psychopathological symptoms among both individuals from the community (Xiong et al. 2020) and healthcare professionals (Saragih et al. 2021). This includes depressive and post-traumatic stress symptoms, anxiety, and emotional distress (Schimmenti et al. 2020a).

Fear is a response to an imminent threat, which involves an acute state of autonomic hyperarousal and prompt behavioural changes, such as fighting, escaping or freezing (Barlow 1988; Starcevic, Schimmenti & Billieux 2020). Along with fear, a potentially lethal and invisible threat such as the SARS-CoV2 that causes COVID-19, may also evoke chronic anxious states, including continuous autonomic hyperarousal, a sense of intolerable uncertainty, anticipation of future dangers, hypervigilance and avoidant behaviors (Starcevic, Schimmenti & Billieux 2020). It is noteworthy that the worldwide pandemic has triggered fear responses in many individuals. Indeed, according to Freeston and colleagues (2020), the COVID-19 pandemic represents a perfect illustration of an uncertain, distressing, and threatening situation which could trigger fear responses.

Research has shown that fear of COVID-19 is associated with various psychological problems, including generalized anxiety (Muyor-Rodríguez, Caravaca-Sánchez & Fernández-Prados 2021; Stankovic et al. 2021), health anxiety (Akbari et al., 2021), depression (Çikrikçi, Çikrikçi & Griffiths 2022; Rodríguez-Hidalgo et al. 2020), somatic symptoms (Zolotareva 2022), and post-traumatic stress (Coloma-Carmona & Carballo 2021).

Fear of COVID-19 relates to a sense of uncertainty about the degree of the COVID-19-associated danger, as it is not possible to know if and when the infection will occur and what its consequences will be. This may engender feelings of anxiety (Heeren et al., 2020; Starcevic, Schimmenti & Billieux 2020) and preoccupation with one's own health (Akbari et al. 2021). Also, the unpredictability of COVID-19 pandemic may lead to a persistent state of fear, with further consequences being higher levels of somatization and somatic symptoms (Zolotareva 2022), as well as post-traumatic stress symptoms (Coloma-Carmona & Carballo 2021).

In this unprecedented situation, it is critical to better understand how fear responses to the COVID-19 manifest themselves and affect human behaviour, as

this understanding might contribute to a more effective coping with the pandemic. Schimmenti, Billieux and Starcevic (2020b) proposed a model of fear responses to perceived COVID-19 threats based on an integrated, biopsychosocial perspective, suggesting that fear of COVID-19 might be conceptualized as a multidimensional construct, involving bodily, interpersonal, cognitive, and behavioural spheres. Each of these four fear domains entails seemingly opposite facets that may be alternatively experienced.

The bodily domain consists of the fear *for* the body and fear *of* the body: individuals perceive one's own body as vulnerable to the COVID-19 infection, being afraid that the body might be damaged and feeling a need to protect it (i.e., "fear for the body"). Also, people experience their own body as a source of danger for one's own health (i.e., "fear of the body"). The interpersonal domain consists of the fear *of* others and fear *for* others. The recommendation about social distancing as a strategy to prevent COVID-19 infection undermines a sense of safety and trust in close relationships: accordingly, contacts with significant others might be perceived as a threat for oneself (i.e., "fear of others") and/or for them (i.e., "fear for others"). The cognitive domain consists of the fear of knowing and fear of not knowing. While the acquisition of new information may increase a sense of mastery during the pandemic and some individuals are afraid of lacking information about COVID-19 (i.e., "fear of not knowing"), other people avoid searching for that information because it is perceived as frightening or overwhelming (i.e., "fear of knowing"). Finally, the behavioural domain consists of the fear of action and fear of inaction. The former indicates resistance to taking action because even simple activities carry a certain health risk, while the latter is a tendency to "do anything" as a way of coping, even if it increases the risk of becoming infected. It is noteworthy that these COVID-19-related fears may become severe to the extent that they impair functioning (Schimmenti et al. 2020a).

Based on their theoretical model, Schimmenti et al. (2020a) developed the *Multidimensional Assessment of COVID-19-Related Fears* (MAC-RF), a self-report instrument assessing COVID-19-related fears. Other instruments assessing emotional responses to COVID-19 have also been developed, including the *Fear of COVID-19 Scale* (FCV-19S; Ahorsu et al. 2022), the *Coronavirus Anxiety Scale* (CAS; Lee 2020), and the *COVID-19 Anxiety Scale* (CAS; Silva, de Sampaio Brito & Pereira 2022). The MAC-RF offers the advantage of being based on a consistent theoretical model and concurrently evaluating four facets of COVID-19-related fears: affective, interpersonal, cognitive, and behavioural.

Schimmenti et al. (2020a) investigated the psychometric properties of the MAC-RF in an Italian-speaking sample and demonstrated adequate internal reliability (Cronbach's alpha = .84). Also, an item response

theory (IRT) analysis showed that all MAC-RF items tapped into a single coherent construct, with sufficient precision and capacity for discrimination. Significant correlations between scores on the MAC-RF and scores on clinical symptom scales (including depression, anxiety, anger, mania, somatic symptoms, suicidal ideation, psychosis, sleep problems, memory problems, obsessive-compulsive symptoms, dissociation, and maladaptive personality functioning) supported the construct validity of the scale in terms of convergence between constructs. A receiver operating characteristic (ROC) curve analysis revealed that the MAC-RF had adequate sensitivity and specificity in identifying individuals with high levels of clinical symptoms.

Further research has been conducted with the MAC-RF. In a Croatian sample (Bagarić & Jokić-Begić 2022), the MAC-RF showed a two-factor structure (Fear of becoming infected and Fear of doing the wrong thing) and was associated with health anxiety, anxiety sensitivity, and cyberchondria (a pattern of repeated searches for reassuring health information on Internet platforms that increases anxiety or distress, see Starcevic & Berle 2013), which supported its construct and convergent validity. Research in mothers of asthmatic children demonstrated more prominent bodily and interpersonal domains of COVID-19-related fears than cognitive and behavioral domains (Di Riso et al. 2021), further supporting the MAC-RF construct validity. However, the psychometric properties of the MAC-RF have not been investigated in French-speaking samples and further research was needed to better understand the relationships between the facets of COVID-19-related fears. This additional psychometric work would support clinicians to plan targeted clinical interventions for people suffering from high levels of COVID-19 fears. The current study was thus performed to explore the psychometric characteristics of the French version of the MAC-RF and expand knowledge about the relationships between various facets of COVID-19-related fears through a correlation network approach.

Correlation network analysis is a statistical method based on the estimation of partial correlations among variables (i.e., each pair of variables is controlled for the effects of all other variables), allowing the depiction of the relationships between these variables through a graphical network structure. Variables are represented by nodes, whereas correlation coefficients are represented by edges (Epskamp & Freid 2018). A theoretical assumption underlying the correlation network approach is that a clinical phenomenon might be conceptualized as the result of the reciprocal effects of the variables in a network of symptoms (Borsboom 2017). Correlation network analysis has been widely used to improve understanding of the associations between clinical symptoms and their domains (Forbush, Siew & Vitevitch 2016; Schimmenti & Sar 2019).

The current study applied a multi-step procedure. In Step 1, we investigated the validity, reliability, and factor structure of the French version of the MAC-RF in a group of individuals from the community. Correlations between scores on the MAC-RF and scores on clinical symptom scales were examined to investigate its convergent validity; McDonald's  $\omega$  was calculated to examine internal reliability; and Exploratory Graph Analysis (EGA) – a statistical method aimed at estimating the number of dimensions in a network model – was computed to investigate dimensions underlying the MAC-RF. In Step 2, we aimed at extending the findings of Step 1 by testing the factor structure of the French version of the MAC-RF through a Confirmatory Factor Analysis (CFA) in a sample of healthcare professionals. Finally, in Step 3 we compared the scores on the facets of COVID-19-related fears among individuals from the community and healthcare professionals through a univariate analysis of covariance (ANCOVA). In this step, we also compared the network structure of COVID-19-related fears in the two samples to ascertain whether these fears distribute differently among people working in health services and people from the community.

## METHOD

### TRANSLATION PROCEDURE

Schimmenti and colleagues (2020a) developed the English version of the MAC-RF and translated it into Italian and French. The French translation was performed by the French-speaking authors from the research team that originally developed the MAC-RF, whereas the back translation from French to English was independently performed by other bilingual authors engaged in the current study. The discrepancies between the original and back-translated versions were discussed by the research team and further modifications of the French version of the MAC-RF were made until the authors reached an agreement on cross-language equivalence. All the items of the English and French versions of the MAC-RF are reported in Table 1.

### PARTICIPANTS

The current multi-step study was conducted among 328 healthcare professionals (260 females, 79.3%), and participants from a community sample, consisting of 521 individuals (289 females, 55.5%). Healthcare professionals were between 23 and 65 years of age ( $M = 43.44$ ,  $SD = 12.95$ ), with more than half of them (171, 52.1%) stating that they worked in a COVID-19 Unit for several months after the onset of the pandemic. Community-dwelling individuals were between 18 and 77 years of age ( $M = 35.32$ ,  $SD = 13.82$ ). Considering previously established associations between the MAC-RF and psychopathology with correlations ranging between 0.05 (substance

ENGLISH VERSION	FRENCH VERSION
1. I don't trust my own body to protect me against the coronavirus infection.	1. Je n'ai pas confiance dans la capacité de mon corps à résister à l'infection par le coronavirus.
2. I am frightened about my body being in contact with objects contaminated by the coronavirus.	2. Je suis effrayé(e) à l'idée que mon corps puisse être en contact avec des objets contaminés par le coronavirus.
3. I fear that people who are around me can infect me.	3. J'ai peur que mon entourage puisse m'infecter.
4. I am frightened about my family members or close friends being in contact with other people and becoming infected with the coronavirus.	4. Je suis effrayé(e) à l'idée que les membres de ma famille ou mes amis proches soient en contact avec d'autres personnes, et puissent se faire contaminer par le coronavirus.
5. I do not want to be exposed to information about the coronavirus infection because it makes me feel upset and anxious.	5. Je ne veux pas être confronté(e) aux informations liées au coronavirus car cela me perturbe et me rend anxieux(se).
6. I feel upset if I cannot collect all the information I need about the coronavirus.	6. Je suis contrarié(e) si je n'ai pas accès à toutes les informations dont j'ai besoin concernant le coronavirus.
7. During the coronavirus pandemic I feel paralyzed by indecisiveness or fear of doing something wrong.	7. Pendant cette pandémie de coronavirus, je suis paralysé(e) par l'incertitude et la peur de faire quelque chose de mal.
8. During the coronavirus pandemic I constantly feel that I have to do something.	8. Pendant cette pandémie de coronavirus, j'ai constamment le sentiment de devoir être en train de faire quelque chose.

**Table 1** Items of the English and French versions of the MAC-RF.

use) and 0.63 (anxiety) (Schimmenti et al., 2020a), we determined sample sizes based on a correlation level of 0.20 and on alpha and beta values of 0.05 to minimize both type I and type II errors, resulting in a minimum sample size of 319. However, sample size of the control group was set to be about 1.5 the minimum sample size to allow better stability of the correlation network and avoid type II error in the LASSO analysis. Further information about the two samples is provided in Table 2.

## PROCEDURES

Participants in the healthcare professionals' group were recruited from a Belgian university hospital. Healthcare personnel working at the Cliniques Universitaires Saint-Luc (Brussels, Belgium) was invited to participate in the study between June 23, 2020 and July 30, 2020. This corresponds to a period after the 'first peak' of COVID-19-related hospital admissions that occurred in March 2020 in Belgium. Email invitation containing a link to the survey was sent to 2706 healthcare professionals. The local ethics committee approved the procedures carried out to investigate COVID-19-related fears in healthcare personnel (code number 2020/15JUI/321).

Participants from the community were recruited through advertisements posted in online social networks (e.g., Facebook, Twitter) and also distributed by French-speaking investigators in this study. Data collection for the participants from the community started on May 4, 2020 and ended on June 10, 2020, which corresponds to the first wave of the COVID-19 pandemic in Europe. At the time of the recruitment, French-speaking countries in Europe (France, Switzerland, Belgium, and Luxembourg) all implemented lockdown or semi-lockdown measures. All advertisements were linked to an online informed consent. Participants were administered a socio-

demographic questionnaire, the French version of the MAC-RF, and measures evaluating clinical symptoms. The procedures involving individuals from the community were approved by the Internal Review Board of the UKE-Kore University of Enna in Italy (code UKE-IRBPSY-04.20.04) in the context of a research program conducted in several European countries (Schimmenti et al. 2020a). Studies unrelated to the French validation of the MAC-RF have been conducted using a part of the current dataset and some data collected in the current multi-step study have already been published elsewhere (Infanti et al. 2023; Mennicken et al. 2022). Data are available from the Open Science Framework (OSF): <https://osf.io/rzvpy/>.

Only people 18 years or older and fluent in French participated in the study; there were no other specific eligibility criteria, and all participants had to provide informed consent before starting the survey. Data were collected anonymously and neither healthcare professionals nor community-dwelling individuals received compensation for their participation.

Study procedures and study analyses were not pre-registered prior to the research being conducted.

## MEASURES

A socio-demographic questionnaire was administered to both the community and healthcare professional groups to collect information about gender, age, education, and professional status. The MAC-RF was also administered to both groups, whereas the remaining measures were administered only to the community group for the purpose of examining convergent validity of the MAC-RF in French-speaking individuals from the community.

		INDIVIDUALS FROM THE COMMUNITY	HEALTHCARE PROFESSIONALS
		(n = 521)	(n = 328)
		n (%)	n (%)
Gender <sup>a</sup>			
	Male	226 (43.4)	58 (17.7)
	Female	289 (55.5)	260 (79.3)
	Non-binary	6 (1.2)	
Highest level of education <sup>b</sup>			
	Primary education	0 (0)	0 (0)
	Lower secondary education	18 (3.5)	0 (0)
	Upper secondary education	64 (12.3)	1 (.3)
	Bachelor's degree	213 (40.9)	170 (51.8)
	Master's degree	183 (35.1)	110 (33.5)
	Phd	43 (8.3)	44 (13.4)
Employment status			
	Student	138 (26.5)	
	Manual worker	6 (1.2)	
	Employee	118 (22.6)	
	Manager	92 (17.7)	
	Free-lance	70 (13.4)	
	Unemployed	48 (9.2)	
	Pensioner	17 (3.3)	
	Other	32 (6.1)	
Health profession <sup>c</sup>			
	Physician		82 (25)
	Nurse		237 (72.3)
	Dentist		3 (.9)
	Midwife		5 (1.5)
Age <sup>d</sup>			
	Range	18–77	23–65
	M (SD)	35.32(13.82)	43.44 (12.95)

**Table 2** Descriptive statistics for the community group and the healthcare professionals' group.

Note: <sup>a</sup> n = 10 (3.0%) missing data for healthcare professionals' group; chi-square test was computed taking into account gender categories such as male and female; <sup>b</sup> n = 3 (.9%) missing data for healthcare professionals' group; <sup>c</sup> n = 1 (.3%) missing data for healthcare professionals' group; <sup>d</sup> n = 24 (7.3%) missing data for healthcare professionals' group.

The *Multidimensional Assessment of COVID-19-Related Fears* (MAC-RF; Schimmenti et al. 2020a) is an eight-item self-report instrument assessing the facets of COVID-19-related fears, derived from Schimmenti and colleagues' theoretical model (Schimmenti, Billieux & Starcevic 2020b). Participants were asked to report to what extent each item applied to them by rating them on a five-point Likert scale (0 = 'Very unlike me' to 4 = 'Very like me'). The following statement is an example of item:

'I fear that people who are around me can infect me' (related to fear of others). The total score was computed by summing scores on all items, with higher scores reflecting higher levels of COVID-19-related fears. The MAC-RF demonstrated an adequate internal consistency and split-half reliability in a sample of Italian community-dwelling adults (Schimmenti et al. 2020a), with further research supporting its construct and convergent validity (Bagarić & Jokić-Begić 2022; Di Riso et al. 2021). In the

current study, internal consistency of the French version of the MAC-RF was .73 in the healthcare professionals' group and .79 in the community-dwelling group.

The *Short Health Anxiety Inventory* (SHAI, Salkovskis et al. 2002) is an 18-item self-report instrument assessing health anxiety symptoms, including the estimated negative consequences of a serious illness. Each item is rated via four statements scored on a four-point scale (from 0 to 3). The following statements provide an example of the scoring system: a) 'As a rule I am not afraid that I have a serious illness' (rated as 0); b) 'I am sometimes afraid that I have a serious illness' (rated as 1); c) 'I am often afraid that I have a serious illness' (rated as 2); d) 'I am always afraid that I have a serious illness' (rated as 3). Scores on all items are summed to obtain the total score, and higher scores indicate higher levels of health anxiety. Meta-analytic findings support the concurrent and divergent validity of the SHAI (Alberts et al. 2013). The internal consistency of the measure in our community sample was 0.88.

The *Brief Symptom Inventory-18* (BSI-18; Derogatis, 2001) is a self-report instrument assessing the severity of somatization, depression, and anxiety symptoms during the previous week. It includes a checklist of 18 symptoms rated on a five-point Likert scale (0 = 'Not at all' to 4 = 'Extremely'). The BSI-18 comprises three subscales, measuring symptoms of somatization, depression and anxiety, respectively (6 items for each scale). Sample items are: 'Feeling weak in parts of your body' (related to somatization); 'Feelings of worthlessness' (related to depression); 'Nervousness or shakiness inside' (related to anxiety). The BSI-18 has shown a three-factor structure matching its three subscales across many populations (Abraham et al. 2017; Calderon et al. 2020; Wang et al. 2010). The internal consistency of the BSI-18 in our community sample was 0.78 for somatization, 0.85 for depression, and 0.87 for anxiety.

## STATISTICAL ANALYSES

### Step 1

No outlier criteria were employed for the current multi-step study, as we were interested in the entire range of intensity of the fear experiences related to COVID-19. Descriptive statistics were computed for all variables in the study. Subsequently, we examined the correlations between MAC-RF scores and scores on clinical symptom measures to test the convergent validity of the MAC-RF in participants from the community. Pearson's  $r$  correlations among scores on the MAC-RF items, MAC-RF total scale, and measures of health anxiety, somatization, depression, and anxiety were calculated. Cases with missing data ( $n = 31$ ) on the SHAI were identified and excluded from the analyses. A  $t$ -test showed that included and excluded cases did not differ significantly in terms of the scores on individual MAC-RF items and MAC-RF total scores.

Internal reliability of the MAC-RF was examined through McDonald's  $\omega$ . Finally, the internal structure of the MAC-RF was examined via a correlation network approach. Schimmenti, Billieux and Starcevic (2020b) suggested that the COVID-19-related fears could be conceptualized as a multidimensional construct. In the same vein, Bagarić and Jokić-Begić (2022) found a two-factor solution (the first factor comprising bodily and interpersonal fears, the second comprising cognitive and behavioural fears) in a Croatian sample of 477 adults. Therefore, we used EGA to capture the dimensions underlying COVID-19-related fears.

EGA is a statistical analysis that can be used to estimate and display the number of dimensions in a network model (Golino & Epskamp 2017; Golino et al. 2020). First, a correlation network was computed through the glasso algorithm and the EBIC selection model. The graphical least absolute shrinkage and selection operator (gLASSO; Friedman, Hastie & Tibshirani 2008) estimation method inverts the sample variance-covariance matrix to compute a sparse correlation network. The glasso algorithm involves a LASSO estimation technique aimed at reducing some correlation coefficients to 0. The level of sparsity of the correlation network model is controlled by the tuning parameter  $\lambda$ . If  $\lambda$  values are low, few edges are reduced to 0, increasing the likelihood of obtaining a network model containing many spurious associations; in contrast, if  $\lambda$  values are high, many edges are removed, increasing the likelihood of removing both spurious and true associations (see Epskamp & Fried 2018). The Extended Bayesian Information Criterion (EBIC; Chen & Chen 2008) model selection was employed to reveal the proper network model among several models estimated under different  $\lambda$  values. The EBIC model selection is based on a hyperparameter  $\gamma$ . Higher hyperparameter  $\gamma$  values involve network models with fewer edges, whereas lower hyperparameter  $\gamma$  values involve denser network models. In the current study, the hyperparameter  $\gamma$  was manually set to 0.5 to compute a network model with high specificity (Foygel & Drton 2010). The dimensions of the MAC-RF were then investigated in the community sample using the Walktrap algorithm (Pons & Latapy 2006). This algorithm performs random walks on the basis of a transition matrix representing the likelihood that each node crosses another one. Research suggested that EGA is comparable to other traditional methods aimed at identifying underlying dimensions (e.g., parallel analysis; Golino et al 2020). The EGA was performed through the *EGAnet* package (Golino & Christensen 2021) for R (R Core Team, 2021). Results were displayed through *GGally* (Schloerke et al. 2021) and *ggplot2* (Wickham 2021) packages.

### Step 2

The factor structure resulting from EGA was further tested in the healthcare professionals' group through a CFA. The Mardia's test was preliminarily used to examine

the multivariate distribution of the data. The goodness of fit of the MAC-RF factor structure was then examined through the following indices (Hooper et al., 2008; Hu & Bentler, 1999): the ratio of the chi-square to degrees of freedom ( $\chi^2/df$ ; a value below 2 indicates a good fit); the Comparative Fit Index (CFI; a value above 0.95 indicates a good fit); the Tucker-Lewis Index (TLI; a value above 0.95 indicates a good fit); the Standardized Root Mean Square Residual (SRMR; a value less than 0.05 indicates a good fit); and the Root Mean Square Error of Approximation (RMSEA; a value less than 0.05 indicates a good fit). The Mardia's test and CFA were performed using R-packages psych (Revelle 2021) and lavaan, respectively (Rosseel 2012).

### Step 3

The construct validity of the MAC-RF was investigated by comparing scores of individuals from the community with those of healthcare professionals. As healthcare professionals were involved in the pandemic emergency much more than community-dwelling people, it was expected that they would have higher levels of COVID-19-related fears. An ANCOVA was performed to examine the differences in MAC-RF scores between participants from the community and healthcare professionals, using groups and gender as factors, and age as a covariate. Statistical differences were examined via Bonferroni-corrected *post-hoc t*-tests. As there were missing data in the group of healthcare professionals regarding gender ( $n = 10$ ) and age ( $n = 24$ ) and gender was non-binary in 6 participants from the community, these cases were excluded from the ANCOVA analysis, which was thus performed on a total sample of 813 participants. No significant differences on the MAC-RF total scores were found between included and excluded cases in both healthcare professionals and community groups. Correlation network analysis was then used to examine the regularized partial correlations among MAC-RF items in the community group and in the healthcare professionals' group, setting the hyperparameter  $\gamma$  of the EBIC selection model to 0.5. Centrality measures were estimated to examine how each node was connected to other nodes within the two networks: strength measure represents the sum of absolute values of the edge weights related to a node; betweenness measure indicates how many times a node is placed on the shortest path between any pair of other nodes; and closeness measure shows how distant a node is on average from all other nodes (McNally et al. 2017). Correlation network analyses were performed using the JASP 0.10.2 software (Jasp Team 2019). Finally, the structure invariance of the MAC-RF was investigated by examining differences between the networks of community-dwelling participants and healthcare professionals. A network comparison test (NCT) was performed to examine the differences between the two network models (i.e., healthcare professionals and adults from the community). The

NCT is a statistical procedure aimed at investigating the differences between two networks via the following three steps: 1) estimating network models and computing test statistics; 2) resampling the pooled data sets and performing reference distribution of test statistics based on each permutation; and 3) comparing the observed test statistics with reference distribution (van Borkulo et al. 2022). In this study, test statistics were computed to find potentially significant differences for the network structure (i.e., differences between networks for any edge), network global strength (i.e., differences between networks for the weighted absolute sum of edges), strength of each edge into the network (i.e., differences between networks for specific edges), and centrality indices. Data were permuted 1000 times. The NCT was performed using the NetworkComparisonTest package (van Borkulo et al. 2017) for R.

## RESULTS

### PRELIMINARY FINDINGS

Descriptive statistics for gender, age, education, employment status, and health profession are reported in Table 2. There was a significantly greater proportion of females in the healthcare professionals' group than in the community group ( $\chi^2_{(1)} = 57.54, p < .01$ ). Means and standard deviations of scores on the individual MAC-RF items, total MAC-RF scores, and scores on the measures of health anxiety, somatization, depression, and anxiety are shown in Table 3.

#### Step 1

In the community group, Pearson's  $r$  coefficients showed significant and positive associations between the MAC-RF scores and scores on the SHAI and BSI-18 (see Table 4).

The MAC-RF demonstrated satisfactory internal reliability (McDonald's  $\omega = 0.80$ ). An EGA examined the latent dimensions underlying the MAC-RF in the community group and revealed two dimensions (see Figure 1): the first included items evaluating the bodily and interpersonal facets of the COVID-19-related fears (items 1, 2, 3, 4), whereas the second comprised items assessing the cognitive and behavioural facets of the COVID-19-related fears (items 5, 6, 7, 8).

#### Step 2

A CFA was performed in the healthcare professionals' group to test the two-factor solution of the MAC-RF resulting from the EGA computed in the community group. As the data were not normally distributed (kurtosis = 2.92;  $p = 0.004$ ), the Diagonally Weighted Least Squares (DWLS) method was used (Míndrila 2010). The model fitted well, thus supporting the two-factor structure of the MAC-RF:  $\chi^2 = 32.74$ ;  $df = 19, p = 0.03$ ; CFI = .98; TLI = .97; RMSEA = .05 [90% CI: .02 – .07]; SRMR = .05.

	INDIVIDUALS FROM THE COMMUNITY			HEALTHCARE PROFESSIONALS		
	(n = 521)			(n = 328)		
	M	(SD)	RANGE	M	(SD)	RANGE
MAC-RF Item 1	1.45	(1.18)	0–4	2.88	(1.05)	0–4
MAC-RF Item 2	1.82	(1.30)	0–4	2.80	(1.20)	0–4
MAC-RF Item 3	1.88	(1.28)	0–4	2.97	(1.17)	0–4
MAC-RF Item 4	2.74	(1.16)	0–4	1.77	(1.37)	0–4
MAC-RF Item 5	1.60	(1.29)	0–4	3.01	(1.23)	0–4
MAC-RF Item 6	1.73	(1.26)	0–4	2.09	(1.37)	0–4
MAC-RF Item 7	1.33	(1.23)	0–4	2.86	(1.19)	0–4
MAC-RF Item 8	1.67	(1.27)	0–4	2.49	(1.31)	0–4
MAC-RF total score	14.23	(6.33)	0–32	20.87	(5.80)	5–32
SHAI total score <sup>a</sup>	14.76	(7.88)	0–48	–	–	–
BSI-18 somatization	2.16	(3.16)	0–19	–	–	–
BSI-18 depression	5.12	(5.20)	0–24	–	–	–
BSI-18 anxiety	4.23	(4.78)	0–24	–	–	–

**Table 3** Means and standard deviations of MAC-RF item scores and total score for the community group and the healthcare professionals' group.

Note: MAC-RF = *Multidimensional Assessment of COVID-19-Related Fears*; SHAI = *Short Health Anxiety Inventory*; BSI-18 = *Brief Symptom Inventory-18*.

<sup>a</sup>N = 490 (31 missing cases).

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
1. MAC-RF Item 1	–	.49*	.39*	.30*	.14*	.24*	.43*	.23*	.63	.45*	.32*	.23*	.35*
2. MAC-RF Item 2		–	.56*	.56*	.29*	.32*	.58*	.27*	.80*	.41*	.28*	.23*	.37*
3. MAC-RF Item 3			–	.43*	.16*	.30*	.45*	.22	.69*	.35*	.20*	.20*	.30*
4. MAC-RF Item 4				–	.15*	.28*	.46*	.27*	.67*	.25*	.18*	.22*	.26*
5. MAC-RF Item 5					–	-.05	.37*	.21*	.46*	.20*	.17*	.21*	.30*
6. MAC-RF Item 6						–	.32*	.19*	.51*	.22*	.13*	.08	.19*
7. MAC-RF Item 7							–	.36*	.78*	.34*	.32*	.31*	.49*
8. MAC-RF Item 8								–	.55*	.17*	.23*	.30*	.49*
9. MAC-RF total score									–	.47*	.36*	.35*	.51*
10. SHAI total score <sup>a</sup>										–	.50*	.39*	.50*
11. BSI-18 somatization											–	.50*	.62*
12. BSI-18 depression												–	.67*
13. BSI-18 anxiety													–

**Table 4** Pearson's *r* correlations among the investigated variables.

Note: MAC-RF = *Multidimensional Assessment of COVID-19-Related Fears*; SHAI = *Short Health Anxiety Inventory*; BSI-18 = *Brief Symptom Inventory-18*; \**p* < .01.

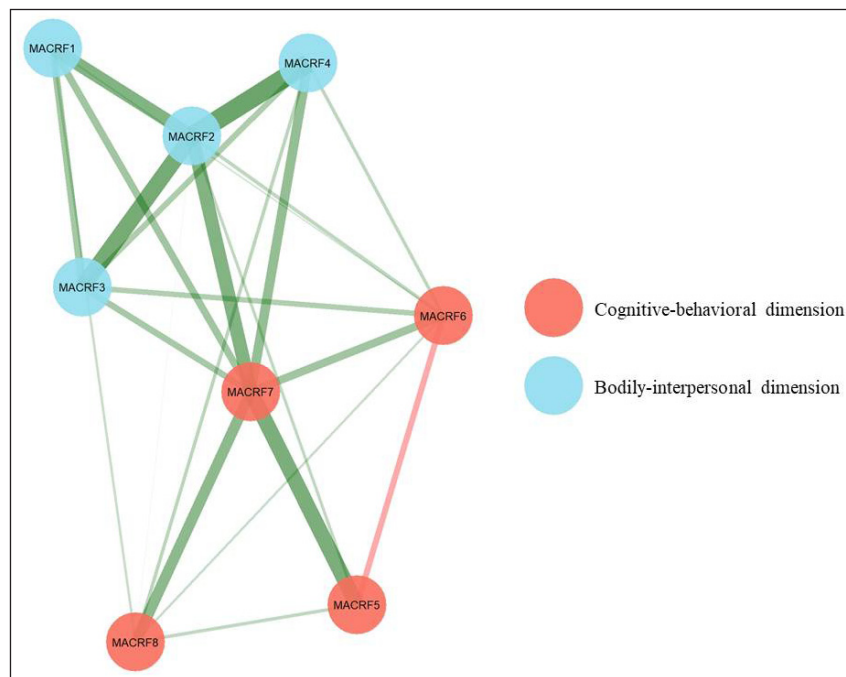
<sup>a</sup>Correlations based on valid data (n = 490).

### Step 3

The ANCOVA showed significant differences between the two samples. The group of healthcare professionals

reported significantly higher levels of COVID-19-related fears than the community group ( $F_{(1,808)} = 183.92$ ,  $p < 0.001$ ,  $\eta^2 = 0.19$ , observed power = 1); furthermore,





**Figure 1** Exploratory graph analysis of Covid-19-related fears in French individuals from the community.

males in the healthcare professionals' group reported significantly higher levels of COVID-19-related fears than males in the community group ( $F_{(1,808)} = 10.32$ ,  $p = 0.001$ ,  $\eta^2 = 0.01$ , observed power = 0.89). Mean total MAC-RF scores were 13.12 for males from the community, 15.04 for females from the community, 22.07 for male healthcare professionals, and 20.63 for female healthcare professionals. Age was not a significant covariate in the model ( $F_{(1,808)} = 0.96$ ,  $p = 0.33$ ,  $\eta^2 < 0.01$ , observed power = 0.17).

Two correlation network models were performed to investigate the associations among MAC-RF items in both healthcare professionals and community groups. The network models are displayed in Figures 2a and 2b. In both network models, centrality measures showed the highest levels of strength, centrality, and closeness for MAC-RF items 2 (i.e., 'I am frightened about my body being in contact with objects contaminated by the coronavirus'), and 7 (i.e., 'During the coronavirus pandemic I feel paralyzed by indecisiveness or fear of doing something wrong') (see Figure 3). Bootstrap analyses showed that the centrality properties of the nodes in the community group network model were quite stable across the bootstrapped samples, whereas the centrality properties of the nodes in the healthcare professionals' group network model were less stable. Weights matrix of regularized partial correlation networks and results of bootstrap analyses are available from OSF: <https://osf.io/rzvpv/>.

The NCT showed no significant differences for the network structure ( $M = .19$ ;  $p = .14$ ) and network global strength ( $S = 0.11$ ;  $p = 0.75$ ) between the two groups. However, significant differences emerged for the strength of associations between items 1 and 2 ( $p = 0.02$ ), items 2 and 3 ( $p = 0.02$ ), items 2 and 4 ( $p = 0.04$ ), and items 6

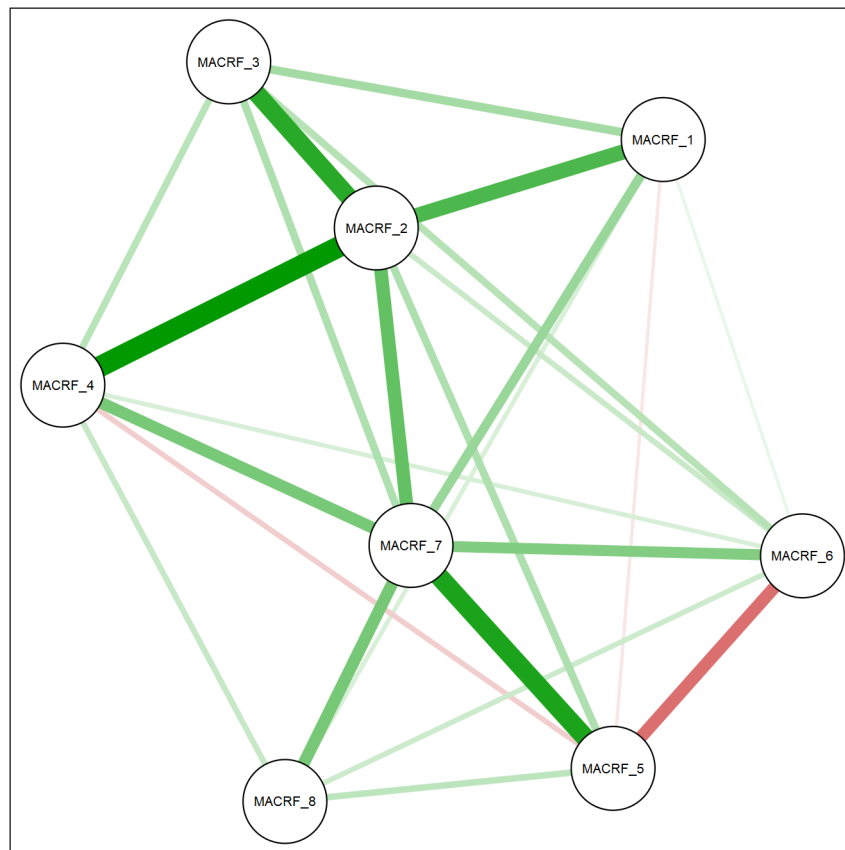
and 8 ( $p = 0.01$ ). Therefore, specific associations between facets of COVID-19-related fears might be different in individuals from the community and healthcare professionals.

The NCT revealed significant differences in the strength indices of items 7 ( $p = 0.01$ , higher in the community sample) and 8 ( $p = 0.02$ , higher among healthcare professionals) between the two groups. Notably, these findings indicate that healthcare professionals who are afraid of not acting during the pandemic are more likely to experience other COVID-19-related fears, perhaps because they are more aware of the increased risk of contagion; in contrast, fear of action is less likely to be associated to other COVID-19-related fears among healthcare professionals.

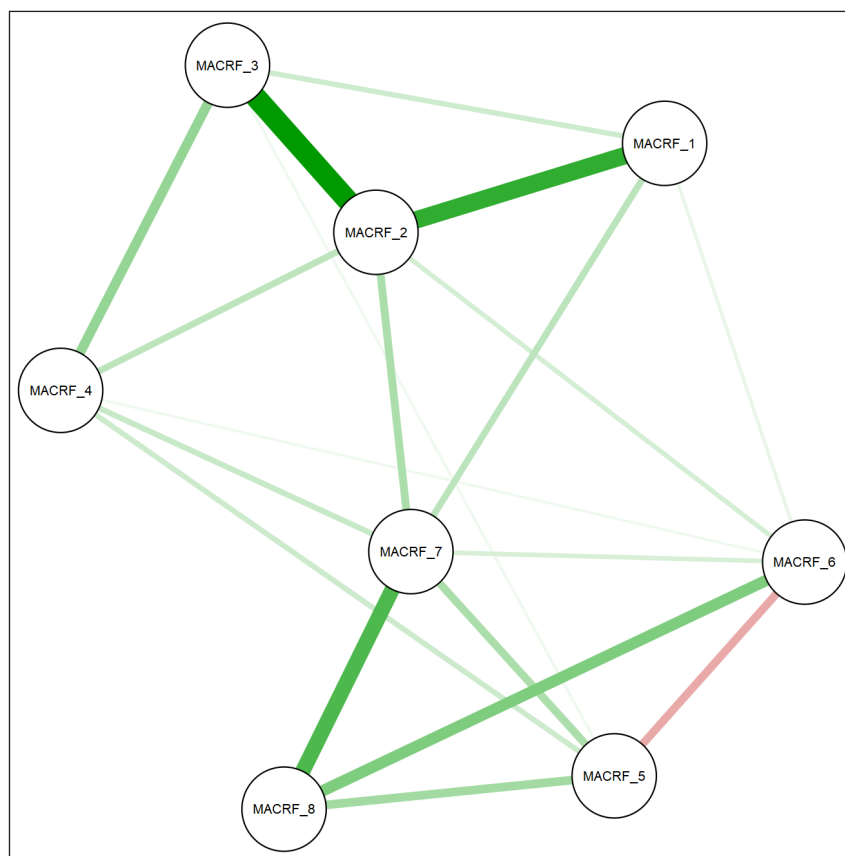
## DISCUSSION

This multi-step study examined the psychometric properties of the French version of the MAC-RF in a community-dwelling group and a group of healthcare professionals. Also, we investigated the relationships among various facets of COVID-19-related fears in these two samples.

Descriptive statistics showed that participants' fears of COVID-19 were in the moderate range. In fact, mean scores on the MAC-RF individual items indicate at least mild to moderate levels of each type of fear examined by the measure in both groups of participants. Notably, Italian-speaking individuals reported mild levels of COVID-19-related fears using the same instrument (Schimmenti et al. 2020a). Thus, COVID-19 pandemic could have evoked more fear in French-speaking individuals at the moment the survey was carried out.

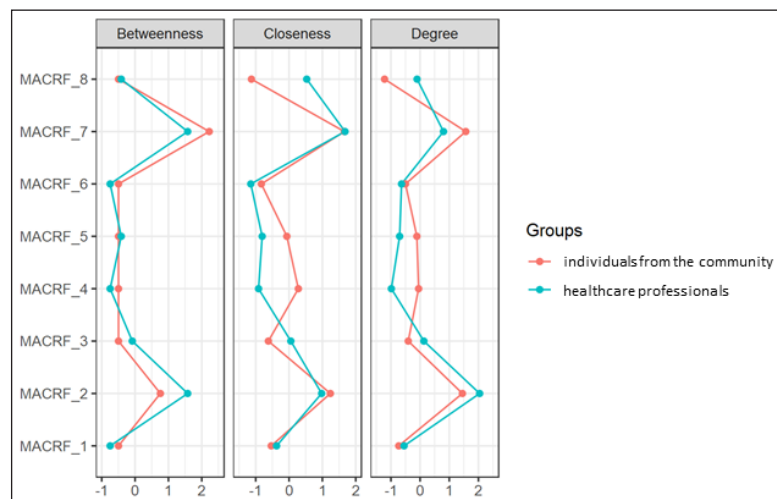


**Figure 2a** Correlation network of Covid-19-related fears in individuals from the community.



**Figure 2b** Correlation network of Covid-19-related fears in healthcare professionals.

Note: Thicker edges indicate stronger associations. Green edges indicate positive associations, red edges indicate negative associations.



**Figure 3** Centrality metrics of the networks of Covid-19-related fears.

### PSYCHOMETRIC PROPERTIES OF THE FRENCH VERSION OF THE MAC-RF

In Step 1, the psychometric properties of the French version of the MAC-RF were examined. Significant and positive correlations were found between MAC-RF scores and scores on the measures of health anxiety, somatization, depression, and anxiety among participants from the community. This finding extends results from previous research conducted in an Italian-speaking sample (Schimmenti et al. 2020a), supporting the convergent validity of the French version of the MAC-RF in a community sample. It also shows that COVID-19-related fears are associated with an increase in psychopathological symptoms, suggesting the relevance of examining fear responses in the context of the pandemic. MAC-RF scores were more strongly correlated with scores on the measures of general and health anxiety than with scores on the measures of depression and somatization, reflecting a more important relationship between COVID-19-related fears and these types of anxiety, along with an elusive distinction between fear and anxiety during the COVID-19 pandemic (Starcevic, Schimmenti & Billieux 2020).

McDonald's  $\omega$  of the MAC-RF was satisfactory. This supports the use of the MAC-RF as a brief and reliable measure of COVID-19-related fears.

With regards to the internal structure of the MAC-RF, the EGA identified two dimensions underlying the MAC-RF among the community individuals. A CFA performed in Step 2 demonstrated that the two-factor structure fitted well among healthcare professionals. In fact, the structure showed satisfactory fit indexes (i.e.,  $\chi^2/df = 1.72$ ; CFI = 0.98; TLI = 0.97; RMSEA = 0.05 [90% CI: 0.02 – 0.07]; SRMR = 0.05.). Our findings suggest that different facets of COVID-19-related fears tap into a bodily-interpersonal domain and cognitive-behavioural domain, which is different from the unidimensional solution based on IRT findings (Schimmenti et al. 2020a). Therefore, the four facets of COVID-19-related fears might represent two different

biopsychosocial processes evoked by COVID-19. The bodily-interpersonal domain is characterized by fears related to one's body and close relationships and operates at a representational and affective level because it involves the representation of the body and its vulnerability to infection in close relationships. The cognitive-behavioural domain pertains to difficulties in coping with the threat posed by COVID-19, with the extremes of frantically searching for information about COVID-19 or avoiding it completely and being aimlessly hyperactive or feeling "paralyzed" to take any action (Schimmenti, Billieux & Starcevic 2020b).

The apparently opposite facets of fear encompassed by the bodily-interpersonal and cognitive-behavioural domains may occur in the same person at different times. This may help explain their significant linkages in the correlation network analysis. Accordingly, our findings converge with those of Bagarić & Jokić-Begić (2022) who found the same factor structure of the MAC-RF in a Croatian adult sample, but labelled the two factors as fear of becoming infected and fear of doing the wrong thing. Notably, the two domains are highly interrelated, as findings of the correlation network analysis suggest, although they may have different implications.

### DIFFERENCES BETWEEN INDIVIDUALS FROM THE COMMUNITY AND HEALTHCARE PROFESSIONALS AND INTERACTIONS BETWEEN FACETS OF COVID-19-RELATED FEARS

In Step 3, an ANCOVA was performed to test the construct validity of the MAC-RF, comparing individuals from the community and healthcare professionals, taking into account the effects of gender and age. Previous research has indicated that females may be more likely to suffer from COVID-19-related fears (Broche-Pérez et al. 2022; Sakib et al. 2023) and that younger age may be associated with increased levels of psychopathological symptoms during the COVID-19 pandemic (Xiong et al. 2020) and increased levels of fear of COVID-19 (Andrade et al. 2022; Kassim et al. 2022). However, a recent meta-analysis has

found no significant associations between age and fear of COVID-19, as assessed by the FCV-19S (Luo et al. 2021).

The ANCOVA supported the construct validity of the MAC-RF, showing that healthcare professionals reported significantly higher levels of COVID-19-related fears than participants from the community. This finding could be a consequence of healthcare professionals' greater likelihood of being exposed to patients with COVID-19 and greater risk of infection due to the nature of their work. Accordingly, healthcare professionals' fear of becoming infected was quite prominent, as demonstrated by their scores on the relevant items of the MAC-RF. Moreover, males in the healthcare professionals' group reported the highest levels of COVID-19-related fears compared to all other participants, suggesting that the first wave of COVID-19 pandemic might have had a greater negative impact on them. However, small gender differences were observed for COVID-19-related fears in the healthcare professionals' group, which should be considered in light of the inconsistent findings regarding the relationship between gender and levels of COVID-19 related fears among healthcare professionals (e.g., Alnazly et al. 2021; Karadem et al. 2021; Sakib et al. 2023). This calls for further research. Results showed that age was not significantly associated with COVID-19-related fears, which is in accordance with the finding of the aforementioned meta-analysis (Luo et al. 2021).

The relationships between the facets of fears of COVID-19 were examined through correlation network analyses, which emphasized several positive associations among the MAC-RF items in both the community and healthcare professionals' groups. This finding supports the view that individuals may display, concurrently or alternately, different facets of COVID-19-related fears. In fact, it has been theoretically proposed that each facet of the COVID-19-related fears may coexist with other facets tapping into different domains, or with their seemingly opposite counterpart tapping into the same domain (Schimmenti, Billieux & Starcevic 2020b). However, a negative association was found between fear of knowing and fear of not knowing in both groups. In line with this observation, Starcevic and colleagues (2021) have suggested that uncertainty about the COVID-19 pandemic may engender either a need to be 'kept in the dark' about the pandemic or an urge to engage in compulsive online searches for health-related and COVID-19-related information (i.e., cyberchondria).

In both networks of participants from the community and healthcare professionals, fear for the body (i.e., fear of being in contact with sources of contamination) and fear of action (i.e., feeling paralyzed to take action) displayed the greatest number of associations with other fears and the strongest connections with these fears. This suggests that these specific facets of fear may increase the risk of experiencing other COVID-19-related fears (see the network approach of mental disorders, Borsboom 2017, for a detailed discussion). For example, fear for the body

was associated with fear of one's own body, fear for significant others, and both fears of knowing and not knowing. Moreover, fear for one's own body could lead to maladaptive emotion regulation strategies, such as those related to cyberchondria and based on compulsive searches for COVID-19-related information, or avoidance of such information (Siebenhaar, Köther & Alpers 2020; Starcevic et al. 2021). It is also noteworthy that the centrality of the fear of action testifies to the frequently paralyzing effect (in terms of people not knowing what to do) that the pandemic has had on the communities worldwide.

The network comparison test revealed that the two networks displayed no significant differences in terms of the structure and global strength, thereby supporting the structure invariance of the French version of the MAC-RF across the two groups. However, significant differences emerged with regards to the strength of particular associations. For example, the associations between fear of the body and fear for the body, and between fear for the body and fear of others, were stronger in the group of healthcare professionals than in the community group, suggesting that healthcare professionals might be more prone to perceiving themselves as having a higher risk of being infected by others.

A stronger association was found between fear of not knowing (i.e., fear of lacking critical information) and fear of inaction (i.e., impatience that may result in dysfunctional or impulsive behaviours) in the group of healthcare professionals than in the community-dwelling group. This may suggest that healthcare professionals have low tolerance for feeling relatively ignorant about the pandemic and for being passive in the pandemic situation and therefore tend to seek information about the COVID-19, although that would not necessarily result in an appropriate course of action. In contrast, a stronger association between fear for the body (i.e., fear of being infected) and fear for the others (i.e., fear that a family member or close friend may become infected) was identified in the community-dwelling group network, suggesting that community-dwelling individuals may be more preoccupied with a severe and potentially lethal infection, regardless of who may succumb to it.

Network comparison also revealed significant differences between the two networks in terms of the strength indices of fear of inaction and fear of action. Indeed, compared to community-dwelling individuals, healthcare professionals displayed stronger associations between fear of inaction and other facets of COVID-19-related fears and lower associations between fear of action and other facets of COVID-19-related fears. This finding suggests that unlike people in the community, medical and nursing staff could be more prone to act immediately in response to the perceived threat posed by COVID-19. Not doing so might increase healthcare professionals' fears of other aspects of COVID-19. Such an attitude is also in accordance with the role of these professionals.

## LIMITATIONS AND DIRECTIONS FOR FUTURE RESEARCH

The findings of the present study should be considered in light of several limitations. Even though the MAC-RF demonstrated satisfactory psychometric properties in current and previous research, self-report instruments are associated with a higher risk of response bias (e.g., due to relatively poor insight, impression management). Moreover, the cross-sectional nature of this study cannot allow us to disentangle possible causal relationships among the different facets of COVID-19-related fears. Participants in the current study were recruited through Internet platforms, thus limiting the generalizability of results. Also, participants were not asked if they were infected with COVID-19.

Future research should use interview-based instruments and longitudinal design in larger samples, including people infected with COVID-19, to test the replicability of the current findings and examine the specific effects of different types of fears during the COVID-19 pandemic. Also, future studies should assess additional psychometric properties of the MAC-RF, including test-retest reliability and discriminant validity with respect to measures assessing psychological constructs that might be related to responses to COVID-19 perceived threats, such as coping mechanisms or agency. Furthermore, the measure should be tested in various populations, including patients suffering from psychiatric disorders (e.g., anxiety disorders, depression, personality disorders). Finally, future research should investigate whether the spread of COVID-19-related variants, availability of COVID-19 vaccines and duration of COVID-19 pandemic, could affect fears of COVID-19.

## CONCLUSION

The present study provides evidence of reliability and validity of the French version of the MAC-RF as an assessment tool for fears related to COVID-19. The study also offers insights into the relationships among different facets of fears during the COVID-19 pandemic. The findings suggest that the fear for one's own body and fear of action may evoke other COVID-19-related fears in both individuals from the community and healthcare professionals. Against this background, psychoeducation interventions should improve understanding of the relationships among COVID-19-related fears and promote adaptive emotion regulation strategies (Behrouian et al. 2020; Brown et al. 2022; Kharatzadeh et al. 2020). This may reduce the risk of experiencing additional fears in response to the COVID-19 pandemic and improve compliance with healthcare policies, including vaccination programs. Psychoeducation interventions are of particular importance for healthcare professionals who might become better equipped to provide relevant and balanced information about psychological responses

to COVID-19. Furthermore, individuals experiencing increased levels of COVID-19-related fears might benefit from clinical interventions targeting the specific facets of fears. As the burden of COVID-19 lessens worldwide, findings of the present study may be of relevance for future pandemics and similar public health emergencies.

## DATA ACCESSIBILITY STATEMENT

Data and supplementary materials are available from the Open Science Framework: <https://osf.io/rzvpvy/>.

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## COMPETING INTERESTS

The second author of this article, Prof. Joël Billieux, serves as an editorial board member of *Swiss Psychology Open*. Please note, however, that he was not involved at any stage during the editorial process.

## TRANSPARENCY STATEMENT

We reported how we determined the sample size and the stopping criterion (pp. 7–8). We reported all experimental conditions and variables (pp. 8–11). We report all data eligibility criteria and whether these were determined before or during data analysis (pp., 11, 13). We report all outlier criteria and whether these were determined before or during data analysis (pp. 11).

## AUTHOR CONTRIBUTIONS

Gianluca Santoro: conceptualization, formal analysis, writing – original draft, and visualization. Joël Billieux: conceptualization, methodology, project administration, supervision, investigation, and writing – review & editing. Vladan Starcevic: writing – review & editing. Yasser Khazaal: writing – review & editing. Alessandro Giardino: investigation, writing – review & editing. Maëva Flayelle: writing – review & editing. Alexandre Infanti: investigation, writing – review & editing. Laurent Karila: writing – review & editing. Géraldine Petit: investigation, writing – review & editing. Philippe de Timary: investigation, writing – review & editing. Adriano Schimmenti: conceptualization, methodology, project administration, supervision, and writing – review & editing.

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