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Collaborative outcomes study on health and functioning during infection times (COH-FIT): Insights on modifiable and non-modifiable risk and protective factors for wellbeing and mental health during the COVID-19 pandemic from multivariable and network analyses

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ABSTRACT

There is no multi-country/multi-language study testing a-priori multivariable associations between non-modifiable/modifiable factors and validated wellbeing/multidimensional mental health outcomes before/during the COVID-19 pandemic. Moreover, studies during COVID-19 pandemic generally do not report on representative/weighted non-probability samples. The Collaborative Outcomes study on Health and Functioning during Infection Times (COH-FIT) is a multi-country/multi-language survey conducting multivariable/LASSO-regularized regression models and network analyses to identify modifiable/non-modifiable factors associated with wellbeing (WHO-5)/composite psychopathology (P-score) change. It enrolled general population-representative/weighted-non-probability samples (26/04/2020-19/06/2022). Participants included 121,066 adults (age=42±15.9 years, females=64 %, representative sample=29 %) WHO-5/P-score worsened (SMD=0.53/SMD=0.74), especially initially during the pandemic. We identified 15 modifiable/nine non-modifiable risk and 13 modifiable/three non-modifiable protective factors for WHO-5, 16 modifiable/11 non-modifiable risk and 10 modifiable/six non-modifiable protective factors for P-score. The 12 shared risk/protective factors with highest centrality (network-analysis) were, for *non-modifiable* factors, country income, ethnicity, age, gender, education, mental disorder history, COVID-19-related restrictions, urbanicity, physical disorder history, household room numbers and green space, and socioeconomic status. For *modifiable factors, we identified* medications, learning, internet, pet-ownership, working and religion as coping strategies, plus pre-pandemic levels of stress, fear, TV, social media or reading time, and COVID-19 information. In multivariable

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models, for WHO-5, additional non-modifiable factors with |B|>1 were income loss, COVID-19 deaths. For modifiable factors we identified pre-pandemic levels of social functioning, hobbies, frustration and loneliness, and social interactions as coping strategy. For P-scores, additional non-modifiable/modifiable factors were income loss, pre-pandemic infection fear, and social interactions as coping strategy. COH-FIT identified vulnerable sub-populations and actionable individual/environmental factors to protect well-being/mental health during crisis times. Results inform public health policies, and clinical practice.

1. Introduction

On March-5-2023, over three years since the COVID-19 outbreak, the WHO Emergency Committee on COVID-19 and the Director-General announced that the COVID-19 pandemic no longer met the definition of a Public Health Emergency of International Concern (World Health Organization, 2023). The downgrading of the emergency status does not mean that the COVID-19 pandemic had ended, and rather reflected the reduced impact on health and healthcare systems globally, mainly due to the increased population vaccination and immunity. Until July-12-2023 COVID-19 infected > 767,970,000 persons globally and caused over 6950,000 deaths (World Health Organization, 2020), in addition to direct complications of the COVID-19 infection, which include short- and long-term neuropsychiatric and physical health consequences (Groff et al., 2021). These consequences have not been the same across all strata of the general population, with a more pronounced detrimental impact in some subgroups, and minimal to no effect in others (Ahrens et al., 2021). Additionally, the pandemic has caused a dramatic drop in access to healthcare globally (Deng et al., 2022; Stanworth et al., 2020), causing an unprecedented shift and adjustment of healthcare services to cope with the COVID-19 infection, leading to delays in non-COVID-19 related physical and mental healthcare, directly and indirectly causing a general worsening of the physical and mental health of the general population (Dragioti et al., 2022).

Besides existing health conditions and barriers to care, numerous additional non-modifiable factors have been reported to be associated with poor well-being and mental health, including but not limited to female sex or being a healthcare worker (Salazar de Pablo et al., 2020). While identifying groups at risk during crisis times is extremely important to target fragile populations with preventive strategies and close monitoring, descriptive analyses do not contribute to mechanistic understanding, nor they account for the more complex interactions of multidimensional factors affecting outcomes. To the best of our knowledge, none of the studies published to date has been conducted in multiple languages (which can exclude linguistic and ethnic minorities), across all continents and reported on outcomes measured for over two years in the pandemic (Salanti et al., 2022; Sun et al., 2023), which also conducted a priori planned multivariable analyses, accounting for the complex interactions of non-modifiable and modifiable environmental and individual factors, reporting on validated outcomes, measuring also a validated composite score of mental health.

The Collaborative Outcomes study on Health and Functioning during Infection Times (COH-FIT, www.coh-fit.com) (Solmi et al., 2022a, b) is a survey study conducted by 230 researchers and translated in 30 languages, recruiting responses from both representative as well as weighted non-representative samples longitudinally at the population level since April-26-2020. COH-FIT has been measuring the well-being and the mental health of the general population, using the WHO-5 (Topp et al., 2015) questionnaire and estimating a validated multidimensional psychopathology factor (P-score) (Solmi et al., 2022c), and has collected information on a comprehensive panel of non-modifiable and modifiable risk/protective factors expected to affect wellbeing and mental health. Here, we report globally in adults findings of the pre-planned multivariable analyses and network analyses aiming to identify the 12 non-modifiable and 12 modifiable factors with the largest association with the two co-primary outcomes, well-being and the P-score.

1.1. Experimental procedures

The COH-FIT protocol has been published (Solmi et al., 2022a, b). For additional details, references and Consensus-Based Checklist for Reporting of Survey Studies (CROSS) (Sharma et al., 2021) see eMethods, and eChecklist.

1.2. Outcomes

The two co-primary outcomes were pre- vs. intra-pandemic changes in the WHO-5 wellbeing score (Topp et al., 2015), and the "P-score", a validated multidimensional measure of general psychopathology, composed of anxiety, depression, post-traumatic symptoms, psychotic symptoms, stress, sleep, and concentration (Solmi et al., 2022c). Participants were asked to rate symptoms during the last two weeks, and "during the last two weeks of their regular life" before the pandemic on a 0–100 visual-analogue scale for the WHO-5 and P-score outcomes. We conducted a smoothed spline regression across time since the COVID-19 pandemic outbreak to test whether the worsening in outcomes bounced back over the pandemic course.

1.3. Predictors

The initial 58 candidate predictors were selected *a-priori* based on theoretical criteria and/or clinical knowledge (Solmi et al., 2022a, b) (eTable 1). Where predictor items were collected both before and during the pandemic, we used the former, since we were interested in pre-pandemic moderators of outcomes, and since mediation analyses would have gone beyond the aims of this work. We included time/region-specific stringency measure (https://covidtracker.bsg.ox.ac.uk/) (0–100 score, representing the severity of restrictions based on nine comprehensive metrics) and change in COVID-19 daily deaths (publicly available data from Johns Hopkins University, https://coronavirus.jhu.edu/data).

1.4. Survey weighting

We recategorized COH-FIT age and education to match population statistic classifications and to minimize low cell counts. Calibration weights were computed for each country to optimize representativeness of the general population's sex, age, education, and employment status. We also computed an alternative set of calibration weights to correct for survey over-representation in specific countries. Specifically, we multiplied the demographic weights by each country's population/survey sample size ratio, and normalised them by giving them a mean individual unit case weight of 1 (apart from countries with <100 participants). Iterative proportional fitting (raking) was used to compute representative weights. If calibration weights exceeded 12, we instead computed post-stratification weights on sex x age, only provided that this resulted in a sampling weight <12.

We ran regression analyses with and without sample weights. Initial regression analysis on the co-primary outcomes using demographic calibration weights produced similar results to unweighted analyses and these sampling weights were used throughout, and their results are reported. Alternative weighting for population size to achieve a more globally representative sample produced a less stable pattern of results, which differed across parametric and bootstrapped regression analyses.

This is likely due to the very high weights needed for countries with poor representation; therefore, population weights were not employed in the final analysis.

1.5. Outlier detection and missing data

After an initial check for out-of-range values, we screened for univariate outliers using a relatively high threshold of $|z| = 5.0$, with two iterations, winsoring outliers to the next highest non-outlying value.

All missing item data were imputed using multivariate chained equations, using predictive mean matching for continuous values, and logistic regression for categorical variables.

1.6. Multivariable regression analyses

Backward elimination (BE) regression analyses with Bayesian information criterion (BIC) optimization was used to select an initial predictor pool (eTable 1). To mitigate possible overfitting, we defined the most robust predictors as those meeting both of the following criteria: (a) bootstrap inclusion frequency (BIF) values ≥90 % based on 100 bootstrapped samples, and (b) inclusion in the predictor set from LASSO regression (see supplementary material for full detail).

All continuous predictors were standardised, but outcome variables were left in their original metric. This means that the regression coefficient B reflects the change in the number of points on the original outcome scale that is associated with $a + 1$ SD change in a predictor. Analyses were conducted on the entire dataset pooling both representative and non-probability samples, as well as individually in representative and weighted non-probability samples for transparent reporting (sensitivity analyses).

1.7. Network analyses

We conducted network analyses following available guidance (Epskamp et al., 2018). A network was composed by modifiable and non-modifiable factors, and each of the two coprimary outcomes. Each factor was a node of the network, and nodes were connected by edges. A pairwise mixed graphical model was estimated, which allowed to estimate undirected associations among factors, without any assumptions on the direction of the association or causal modeling. Also, the mixed graphical model allowed to pool together categorical and continuous factors. To reduce false positive findings, we applied a "least absolute shrinkage and selection operator" (LASSO) regularization (a penalization of small edges to zero). The degree of regularization was determined by the Extended Bayesan Information Criterion (EBIC), which was set to 0.5 (BIC = 0 would allow sparse and meaningless correlations to survive regularization).

Three centrality indices were estimated, namely strength (i.e., the absolute sum of edge weights), closeness (i.e., the inverse of the sum of the distances of the focal node from all the other nodes in the network, and betweenness (i.e., the number of shortest paths between any two nodes that pass through the node of interest). Regarding network stability, we re-estimated the network correlational matrix with increasingly smaller proportions of the sample, conducting a case-dropping subset bootstrapping, calculating the correlation stability coefficient (CS, ideally above 0.75).

1.8. Software

All analyses were performed in R (R Core Team, 2020) using *abe, glmnet, gglasso, MICE, qgraph* and *mgm* packages. Bootstrapped analyses were performed across multiple processors using the built-in package *parallel*.

2. Results

Out of 142,364 surveys that were initiated between April-26–2020 and June19–2022, 121,066 adults provided data suitable for the regression and network analyses (participant flow details in eTable 2). A comparison of the final sample and the excluded sample showed similar basic participant characteristics (eTable 3). The mean age of the final unweighted sample was 42±15.9 years (*range*=18–100) and of mixed gender: male=35.4 %, female=64 %, non-binary=0.4 %, transgender/intersex=0.2 % (Table 1, eTable 4). Basic participant characteristics are provided in Table 1, and in more detail in eTable 4.

2.1. Change in WHO-5 during the pandemic, and associated factors

The WHO-5 wellbeing decreased by 11.1 ± 21.1 points from before (71.5 ± 19.3) to during (60.4 ± 24.5) the pandemic (paired $t = 183.68$, $p<.001$, standardized mean difference (SMD)=0.53), bouncing back towards the end of the pandemic ($F = 116.20$) (eFigure 1). Factors that might amplify or buffer this decline were examined in the regression model, which showed that 13.8 % of change in wellbeing scores could be explained by the final predictor set, R^2=0.138, Adj. R^2=0.138, $p<.001$. Table 2 presents a summary of the results from both the BE and LASSO regression analysis (with more detailed results of LASSO shown in eTable 5).

Among non-modifiable factors, nine were associated with greater worsening of WHO-5, all having a |B| >1. In descending order these risk factors were: living in a low-income country, higher education, mental disorder history, higher urbanicity, non-binary or female gender, physical disorder history, income loss during the pandemic, stringency of restrictions, and COVID-19 deaths. Three non-modifiable factors were associated with smaller WHO-5 change, of which two had a |B| >1. In descending order, these protective factors were higher individual socioeconomic status and older age.

Among modifiable factors, 15 factors were associated with larger worsening of WHO-5. In descending order, those risk factors with a |B| >1 were having received too little or too much COVID-19 information, higher pre-pandemic functioning regarding hobbies, importance of social interactions as coping strategy, pre-pandemic loneliness, and higher pre-pandemic social functioning. Overall, 13 modifiable factors were associated with smaller worsening. In descending order, these protective factors with a |B| >1 were learning as a coping strategy and higher pre-pandemic frustration.

2.2. Change in P-score during the pandemic, and associated factors

The P-score increased by 13.2 ± 17.9 points from before 27.5 ± 19.9 to during 40.7 ± 23.6 the pandemic (paired $t = 256.23$, $p<.001$, SMD=0.74), returning to pre-pandemic values later during the pandemic ($F = 83.38$). Regression analysis showed that 10.9 % of change in P-scores could be explained by the final model, R^2=0.109, Adj. R^2=0.109, $p<.001$. Table 2 presents a summary of the results from the regression analysis (with more detailed results of LASSO shown in eTable 6).

Among non-modifiable factors, 11 were associated with larger worsening of the P-score. In descending order, these risk factors with a |B| >1 were living in a low-income country, mental disorder history, physical disorder history, female, non-binary and trans-gender/intersex gender, income loss during the pandemic and higher urbanicity. Among six non-modifiable factors associated with smaller worsening in P-score, all had a |B| >1. In descending order, these protective factors were African, Asian, or Hispanic race/ethnicity, lower education, higher age, and higher socioeconomic status.

Among modifiable factors, 16 were associated with larger worsening. In descending order, these risk factors with a |B| >1 were higher importance of social interactions as coping strategy, and too little or too much COVID-19 information. Among 10 modifiable factors associated

Table 1
Basic participant characteristics for overall, representative and non-probability samples.

	Overall		Representative		Non-probability	
	N	Percent	N	Percent	N	Percent
Representative sample						
non-probability	86,017	71	0	0	86,017	100
representative	35,049	29	35,049	100	0	0
Age						
18–34	46,159	38.1	10,216	29.1	35,943	41.8
35–49	33,947	28	9829	28	24,118	28
50–64	28,769	23.8	10,058	28.7	18,711	21.8
65+	12,191	10.1	4946	14.1	7245	8.4
Gender						
Male	42,891	35.4	17,242	49.2	25,649	29.8
Female	77,487	64	17,696	50.5	59,791	69.5
Non-binary	462	0.4	67	0.2	395	0.5
Transgender or intersex	226	0.2	44	0.1	182	0.2
Marital Status						
Single never married	45,398	37.5	10,163	29	35,235	41
Married or co-living partner	62,233	51.4	20,376	58.1	41,857	48.7
Widowed	2984	2.5	1069	3.1	1915	2.2
Divorced or separated	10,451	8.6	3441	9.8	7010	8.1
Ethnicity						
White	83,498	69	28,641	81.7	54,857	63.8
African/African-descent	3375	2.8	632	1.8	2743	3.2
Hispanic	3366	2.8	884	2.5	2482	2.9
Asian	23,795	19.7	2765	7.9	21,030	24.4
Mixed	5121	4.2	1561	4.5	3560	4.1
Other	1403	1.2	449	1.3	954	1.1
Prefer not to answer	508	0.4	117	0.3	391	0.5
Education						
None	671	0.6	196	0.6	475	0.6
Primary school	3401	2.8	2018	5.8	1383	1.6
High school	38,726	32	18,706	53.4	20,020	23.3
College/university degree	68,335	56.4	12,986	37.1	55,349	64.3
PhD	9933	8.2	1143	3.3	8790	10.2
Socio-economic status						
0–24	7104	5.9	2298	6.6	4806	5.6
25–49	23,091	19.1	7253	20.7	15,838	18.4
50–74	71,109	58.7	21,148	60.3	49,961	58.1
75–100	19,762	16.3	4350	12.4	15,412	17.9
Employment						
No	46,890	38.7	13,909	39.7	32,981	38.3
Yes	74,176	61.3	21,140	60.3	53,036	61.7
Mental health diagnosis						
No	101,325	83.7	30,523	87.1	70,802	82.3
Yes	19,741	16.3	4526	12.9	15,215	17.7
Physical disease diagnosis						
No	66,840	55.2	20,404	58.2	46,436	54
Yes	54,226	44.8	14,645	41.8	39,581	46
Urbanicity						
Village/rural	21,415	17.7	8459	24.1	12,956	15.1
Small city/town (10,000–100.000 population)	30,037	24.8	10,199	29.1	19,838	23.1
Medium city/town (100,000–500.000 population)	27,312	22.6	7186	20.5	20,126	23.4
Large city/town (over 500.000 population)	42,302	34.9	9205	26.3	33,097	38.5
Restrictions						
No restrictions	38,963	32.2	17,087	48.8	21,876	25.4
Recommendations to stay home only	63,531	52.5	15,052	42.9	48,479	56.4
Sued or fined if leave home, unless necessary	16,226	13.4	2205	6.3	14,021	16.3
Arrested if leave home, unless necessary	1575	1.3	372	1.1	1203	1.4
Cannot go out under any circumstances (goods delivered to homes by government)	771	0.6	333	1	438	0.5

with smaller P-score worsening, the only protective factor with a |B| >1 was higher pre-pandemic fear of having other infections.

2.3. Comparison of regression analysis results in the representative and non-probability samples

Results from regression analysis of the representative sample (N = 35,049) and weighted regression analysis of the non-probability sample (N = 86,017) are shown in eTable 7 (WHO-5) and eTable 8 (P-score). For both outcomes, R^2 was higher for the non-probability (WHO-5 R^2=0.154; P-score R^2=0.116) compared to the representative (WHO-5 R^2=0.094; P-score R^2=0.076) sample, with more variables included in the selection model for the non-probability sample. A comparison of each predictor selected in both non-probability and representative samples, however, showed no obvious systematic differences in the direction or magnitude in the regression coefficients.

2.4. Network analysis

The network is reported in Fig. 1, strengths of the multidimensional nodes are reported in eTable 9, and centrality indices are reported in Fig. 2. In descending order, the 12 non-modifiable nodes with highest centrality indices were, country income, followed by ethnicity, age, marital status, gender, education, history of mental disorders,

Table 2
WHO-5 wellbeing change: predictors identified by variable selection models ($N = 121,066$).

Predictor	BE Regression					Lasso	Bootstrap BE				
	B	CI. low	CI. high	B	p		BIF %	Median (B)	low.2.5 %	high.2.5 %	RMSD_ratio
WHO-5											
Continuous											
Modifiable											
Functioning with hobbies before the pandemic	−2.80	−2.94	−2.66	−0.13	0.00000	*	100	−2.77	−3.02	−2.56	1.86
Importance of social interactions as coping strategy during the pandemic	−1.95	−2.06	−1.84	−0.09	0.00000	*	100	−1.94	−2.10	−1.79	1.44
Loneliness before the pandemic	−1.41	−1.55	−1.27	−0.07	0.00000	*	100	−1.37	−1.70	−1.18	1.79
Social functioning before the pandemic	−1.31	−1.46	−1.17	−0.06	0.00000	*	100	−1.30	−1.51	−1.05	1.64
Importance of substance use as coping strategy during the pandemic	−0.91	−1.01	−0.80	−0.04	0.00000	*	100	−0.93	−1.06	−0.71	1.67
Prosocial behaviour before the pandemic	−0.82	−0.93	−0.71	−0.04	0.00000	*	100	−0.82	−0.97	−0.61	1.60
Perceived social support before the pandemic	−0.70	−0.82	−0.58	−0.03	0.00000	*	100	−0.71	−0.90	−0.50	1.68
Time spent reading before the pandemic	−0.52	−0.64	−0.39	−0.02	0.00000	*	100	−0.51	−0.75	−0.34	1.63
Household functioning satisfaction before the pandemic	−0.48	−0.60	−0.36	−0.02	0.00000	*	99	−0.48	−0.71	−0.28	1.88
Importance of social media as coping strategy during the pandemic	−0.35	−0.47	−0.23	−0.02	0.00000	*	91	−0.38	−0.56	0.00	2.25
Time spent listening to music before the pandemic	−0.33	−0.44	−0.22	−0.02	0.00000	*	96	−0.34	−0.51	0.00	1.83
Adherence to restrictions during the pandemic	−0.31	−0.42	−0.21	−0.01	0.00000	*	92	−0.35	−0.49	0.00	2.18
Importance of internet as coping strategy during the pandemic	−0.27	−0.39	−0.15	−0.01	0.00001	*	86	−0.32	−0.48	0.00	2.27
Importance of medications as coping strategy during the pandemic	−0.22	−0.34	−0.10	−0.01	0.00045	*	57	−0.24	−0.47	0.00	2.74
Importance of a hobby as coping strategy during the pandemic	0.32	0.20	0.44	0.02	0.00000	*	88	0.32	0.00	0.53	2.21
Boredom before the pandemic	0.34	0.20	0.48	0.02	0.00000	*	73	0.33	0.00	0.53	2.68
Stress before the pandemic	0.34	0.19	0.49	0.02	0.00001	*	67	0.31	0.00	0.58	2.44
Time spent on social media before the pandemic	0.39	0.26	0.53	0.02	0.00000	*	95	0.40	0.00	0.61	1.89
Religion as a coping strategy during the pandemic	0.40	0.28	0.52	0.02	0.00000	*	95	0.39	0.00	0.58	2.03
Time spent gaming before the pandemic	0.52	0.41	0.63	0.02	0.00000	*	100	0.54	0.38	0.71	1.57
Access to protective devices	0.54	0.43	0.65	0.03	0.00000	*	100	0.54	0.36	0.69	1.53
Time spent watching TV before the pandemic	0.61	0.49	0.72	0.03	0.00000	*	100	0.59	0.43	0.73	1.42
Time spent on internet before the pandemic	0.63	0.50	0.77	0.03	0.00000	*	100	0.63	0.43	0.82	1.56
Fear of having other infections before the pandemic	0.68	0.57	0.80	0.03	0.00000	*	100	0.71	0.50	0.89	1.86
Resilience before the pandemic	0.80	0.68	0.92	0.04	0.00000	*	100	0.82	0.56	1.03	2.02
Frustration before the pandemic	1.01	0.84	1.17	0.05	0.00000	*	100	1.01	0.70	1.33	1.87
Importance of learning as coping strategy during the pandemic	1.69	1.57	1.82	0.08	0.00000	*	100	1.68	1.52	1.93	1.73
Non-modifiable											
Loss of income during the pandemic	−2.18	−2.29	−2.06	−0.10	0.00000	*	100	−2.18	−2.36	−1.99	1.73
Stringency of restrictions	−1.64	−1.76	−1.52	−0.08	0.00000	*	100	−1.64	−1.83	−1.40	1.79
COVID-19 deaths daily increase during the pandemic	−1.49	−1.60	−1.38	−0.07	0.00000	*	100	−1.50	−1.70	−1.28	1.82
Numbers of rooms in the household	0.36	0.24	0.48	0.02	0.00000	*	97	0.38	0.10	0.60	2.04
Age	1.23	1.10	1.36	0.06	0.00000	*	100	1.19	0.95	1.41	1.61
Socioeconomic status	1.79	1.67	1.90	0.08	0.00000	*	100	1.77	1.56	2.00	1.81
Categorical											
Modifiable											
Information received on COVID-19: Too little	−3.50	−3.87	−3.14	−0.05	0.00000	*	100	−3.51	−4.14	−3.02	1.56
Information received on COVID-19: Too much	−3.56	−3.81	−3.31	−0.08	0.00000	*	100	−3.54	−3.89	−3.06	1.61
Non-modifiable											
Country income: Low income	−6.28	−6.95	−5.61	−0.06	0.00000	*	100	−6.29	−7.36	−5.09	1.84
Country income: Middle income	−1.36	−1.66	−1.06	−0.03	0.00000	*	100	−1.34	−1.94	−0.76	2.03
Education: College/university degree	−4.33	−5.35	−3.31	−0.10	0.00000	*	100	−4.51	−6.35	−2.58	1.82
Education: High school	−3.87	−4.87	−2.86	−0.09	0.00000	*	100	−4.11	−5.92	−2.29	1.91
Education: PhD	−3.95	−5.08	−2.83	−0.05	0.00000	*	100	−3.93	−6.12	−2.31	1.70
Education: Primary school	−0.91	−1.98	0.17	−0.01	0.09809	*	100	−1.16	−3.33	0.92	1.87
Mental disorder: Yes	−3.85	−4.17	−3.53	−0.07	0.00000	*	100	−3.91	−4.33	−3.29	1.87
Urbanicity: Large city/town (over 500.000 population)	−2.96	−3.29	−2.64	−0.07	0.00000	*	100	−2.98	−3.59	−2.35	1.98
Urbanicity: Medium city/town (100,000–500.000 population)	−2.80	−3.13	−2.46	−0.06	0.00000	*	100	−2.79	−3.32	−2.26	1.73
Urbanicity: Small city/town (10,000–100.000 population)	−1.80	−2.12	−1.48	−0.04	0.00000	*	100	−1.77	−2.32	−1.36	1.48
Physical disorder: Yes	−1.73	−1.97	−1.49	−0.04	0.00000	*	100	−1.77	−2.16	−1.40	1.63
Gender: Female	−2.90	−3.13	−2.67	−0.07	0.00000	*	100	−2.84	−3.26	−2.51	1.59
Gender: Non-binary	−3.27	−5.02	−1.52	−0.01	0.00024	*	100	−3.33	−5.45	−1.57	1.21
Gender: Transgender or intersex	−0.47	−2.95	2.02	0.00	0.71254	*	100	−0.65	−2.76	1.98	1.09
Ethnicity: African/African-descent	0.86	0.16	1.55	0.01	0.01530		79	0.62	−0.29	1.69	1.69

(*continued on next page*)

Table 2 (*continued*)

Predictor	BE Regression					Lasso	Bootstrap BE				
	B	CI. low	CI. high	B	p		BIF %	Median (B)	low.2.5 %	high.2.5 %	RMSD_ratio
Ethnicity: Asian	1.01	0.68	1.34	0.02	0.00000		79	0.94	0.00	1.50	2.88
Ethnicity: Hispanic	1.49	0.83	2.15	0.01	0.00001		79	1.44	0.00	2.18	2.31
Ethnicity: Mixed	−0.51	−1.07	0.06	0.00	0.07810		79	−0.55	−1.60	0.31	1.88
Ethnicity: Other	−1.61	−2.53	−0.70	−0.01	0.00053		79	−1.53	−3.48	0.14	2.55
Ethnicity: Prefer not to answer	0.35	−1.40	2.10	0.00	0.69401		79	0.00	−1.95	3.44	1.46
Employment status: Yes, has a job	0.65	0.42	0.88	0.02	0.00000		87	0.68	0.00	1.03	2.20
Intercept	−0.36	−1.40	0.68	0.00	0.49692	*	100	−0.07	−1.74	2.29	1.89

Legend. IF = bootstrapped Inclusion Frequency; Lasso: * = also selected in LASSO model; RMSD = Ratio of coefficient standard error for BE v global model.
Reference categories are: City Size = Village / rural; Job = None; CovidInfo = Adequate; Degree = None, Ethnicity = White; Gender = Male; Restrictions = None; Marital status = Single / never married; Income gp = 1. High income.
B coefficients represent the change in WHO5 scores with $a + 1$ SD change in the predictor (as only predictors were standardized). B values indicate the number of points change on the wellbeing or P-score scale with negative and positive values indicating increased deterioration during the pandemic, respectively.

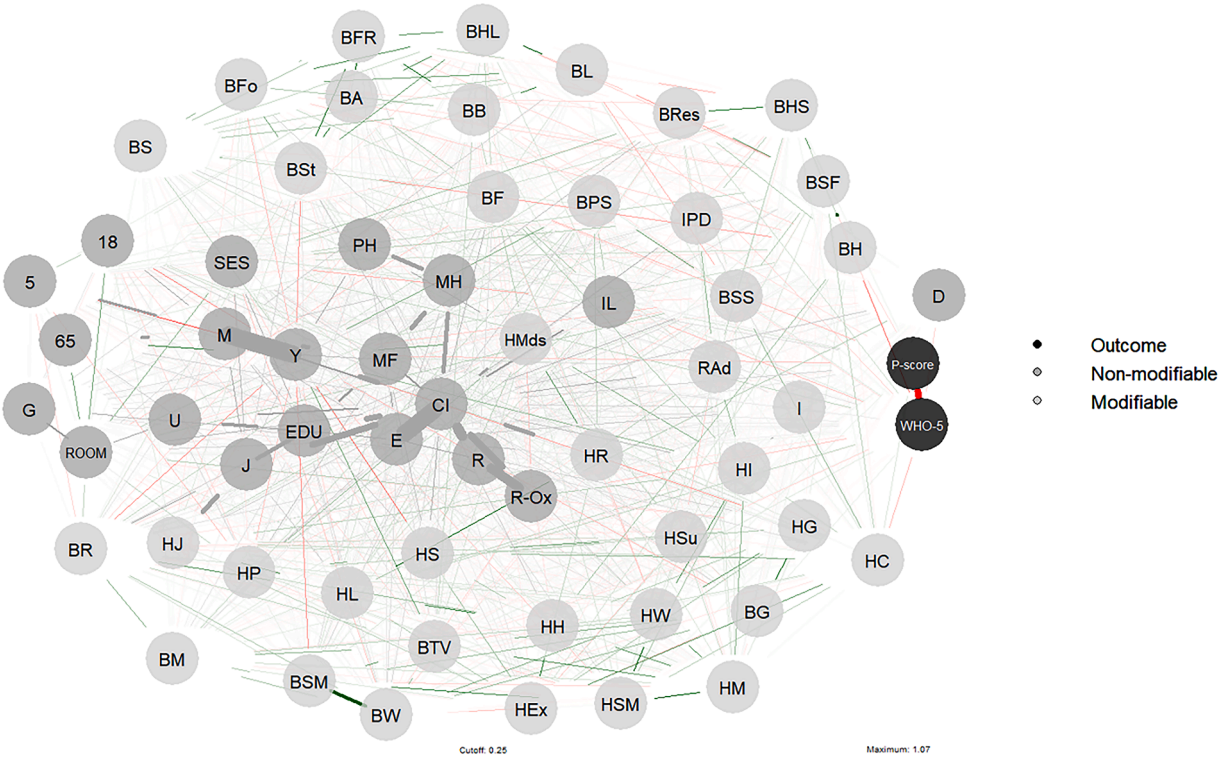

Fig. 1. Network with modifiable and non-modifiable risk or mitigating factors, and change in wellbeing and P-score during COVID-19 pandemic.
Legend. 65, 18, 5, number of co-living persons with age older than 65, between age 6 and 17, or 5 or younger; BA, anger before the pandemic; BB, boredom before the pandemic; BF, fear before the pandemic; BFo, focus before the pandemic; BFR, frustration before the pandemic; BG, gaming before the pandemic; BH, hobbies before the pandemic; BHL, helplessness before the pandemic; BHS, satisfaction with household before the pandemic; BL, loneliness before the pandemic; BM, music before the pandemic; BPS, prosocial behaviour before the pandemic; BR, reading before the pandemic; BRes; resilience before the pandemic; BS, sleep before the pandemic; BSF, social functioning before the pandemic; BSM, social media before the pandemic; BSS, social support before the pandemic; BSt, stress before the pandemic; BTV, TV before the pandemic; BW, internet before the pandemic; CI, country income group; D, COVID-19 death increases; E, ethnic; EDU, education; G, household with greenspace; HC, contacts as coping strategy; HEX, exercise as coping strategy; HG, gaming as coping strategy; HH, hobby as coping strategy; HI, information on COVID-19 as coping strategy; HL, learning as coping strategy; HM, media as coping strategy; HMds, medications as coping strategy; HP, pet as coping strategy; HR, religion as coping strategy; HS, sex as coping strategy; HSM, social media as coping strategy; HSU, substances as coping strategy; HJ, job as coping strategy; HW, web as coping strategy; I, information on COVID-19; IL, income loss; IPD, protective devices; J, employment status; M, marital status; MF, gender; MH, mental health condition; P-score, change in P-score; PH, physical health condition; R, severity of enforcement of restrictions; RAd, adherence to restrictions; ROOM, number of rooms in household; R-OX, Oxford stringency index; SES, socio-economic status; U, urbanicity;. WHO-5, change in WHO-5; Y, age.

restrictions (both COH-FIT restriction severity item and Oxford standardized metric), employment status, urbanicity, and history of physical health disorders. In descending order, the 12 most central modifiable factors were medications and learning as a coping strategy, pre-pandemic stress, information on COVID-19, using sex, internet, or a pet as coping strategies, pre-pandemic frustration, work and religion as a coping strategy, and finally pre-pandemic time spent watching TV and being on social media.

The correlational matrix is reported in eTable 10, and the corresponding heatmap in Table 3.

Stability and accuracy of the network were excellent. In more detail, the stability of the network measured with the central stability coefficient for strength (maximum drop proportions to retain correlation of 0.7 in at least 95 % of the sample) was 0.75. The average correlations

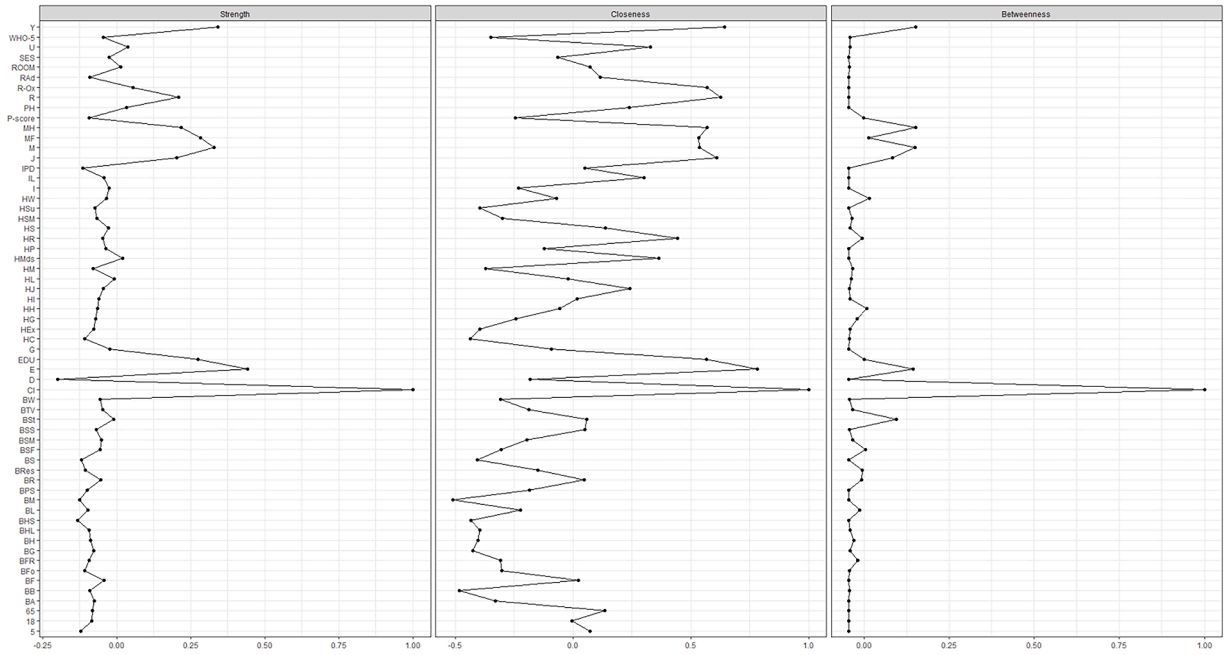

Fig. 2. Standardized centrality indices of modifiable and non-modifiable risk or mitigating factors, and change in wellbeing and P-score during COVID-19 pandemic. Legend. 65, 18, 5, number of co-living persons with age older than 65, between age 6 and 17, or 5 or younger; BA, anger before the pandemic; BB, boredom before the pandemic; BF, fear before the pandemic; BFO, focus before the pandemic; BFR, frustration before the pandemic; BG, gaming before the pandemic; BH, hobbies before the pandemic; BHL, helplessness before the pandemic; BHS, satisfaction with household before the pandemic; BL, loneliness before the pandemic; BM, music before the pandemic; BPS, prosocial behaviour before the pandemic; BR, reading before the pandemic; BRes; resilience before the pandemic; BS, sleep before the pandemic; BSF, social functioning before the pandemic; BSM, social media before the pandemic; BSS, social support before the pandemic; BSt, stress before the pandemic; BTV, TV before the pandemic; BW, internet before the pandemic; CI, country income group; D, COVID-19 death increases; E, ethnic; EDU, education; G, household with greenspace; HC, contacts as coping strategy; HEX, exercise as coping strategy; HG, gaming as coping strategy; HH, hobby as coping strategy; HI, information on COVID-19 as coping strategy; HL, learning as coping strategy; HM, media as coping strategy; HMds, medications as coping strategy; HP, pet as coping strategy; HR, religion as coping strategy; HS, sex as coping strategy; HSM, social media as coping strategy; HSU, substances as coping strategy; HJ, job as coping strategy; HW, web as coping strategy; I, information on COVID-19; IL, income loss; IPD, protective devices; J, employment status; M, marital status; MF, gender; MH, mental health condition; P-score, change in P-score; PH, physical health condition; R, severity of enforcement of restrictions; RAd, adherence to restrictions; ROOM, number of rooms in household; R-OX, Oxford stringency index; SES, socio-economic status; U, urbanicity;. WHO-5, change in WHO-5; Y, age.

between centrality indices of networks sampled with increasing proportions of persons dropped from the original sample is reported in eFigure 2. The accuracy of the estimated edges among nodes is represented in eFigure 3.

A visual summary of results, accounting for results of multivariable and network analyses is available in Fig. 3.

3. Discussion

COH-FIT confirmed on a global scale (as previously shown in Europe) (Ahmed et al., 2023) that the measurable negative impact of the pandemic on well-being and mental health was largely transitory, but at the same time that it had a moderate effect size when it occurred. However, COH-FIT also identified that the adverse effect of the pandemic on wellbeing and mental health affected different population strata differently, and that individual risk and protective factors can be identified, including specific coping strategies.

We conceptualized the pandemic environment as a network of interconnected nodes and opted to conduct a network analysis in addition to a multivariable regression model in order to identify those factors more centrally intertwined with other variables in a complex system, and at the same time to account for the magnitude of their associations with two co-primary outcomes. A visual inspection of the network showed that non-modifiable factors largely clustered together, at the centre of the network, and that these factors as well as those with larger regression coefficients in multivariable models had the highest centrality. This finding suggests that focusing on fragile strata of the population is crucial. Among modifiable factors, several coping strategies emerged as central actionable targets, as well as the amount of COVID-19-related information, but no unequivocal signal emerged from pre-pandemic subclinical psychological or behavioural characteristics.

This work confirms that the most direct consequences of the COVID-19 pandemic, i.e., restrictions that deeply changed individuals' routine, COVID-19-related deaths, and income loss secondary to the global impact of COVID-19 on the global economy, did adversely impact well-being and mental health. However, more factors affected the two co-primary outcomes, validating the broad multivariable and network analysis approach, accounting for multidimensional individual and environmental non-modifiable and modifiable factors. For instance, restrictions might have affected the mental health of those living in urban centres, many of whom were living in small apartments, with no/little access to green space. Being able to exercise, to be exposed to sun light, and potentially to have safe social interactions with physical distancing appears to have had a protective effects and should guide health policies and targeted restrictions during a pandemic as well as longer-term urban planning (Reid et al., 2022).

Additional results relevant for global policy making are that low-income countries suffered the largest impact on mental health, possibly due to less available/resourced health system and social welfare infrastructures, resulting in more profound direct and indirect COVID-19 consequences, affecting basic daily needs, including food insecurity (Waage et al., 2022).

Globally, substantial shifts of healthcare services design and priorities towards prevention and care of COVID-19 infections and related complications have posed significant barriers to access to care for persons in need of long-term care for chronic mental and physical

Table 3
P-score change: predictors identified by variable selection models ($N = 121,066$).

Predictor	BE Regression					Lasso	Bootstrap BE				
	B	CI. low	CI. high	B	p		BIF %	Median (B)	low.2.5 %	high.2.5 %	RMSD_ratio
P-score											
Continuous											
Modifiable											
Fear of having other infections before the pandemic	−1.46	−1.56	−1.35	−0.08	0.00000	*	100	−1.44	−1.62	−1.31	1.69
Boredom before the pandemic	−0.94	−1.06	−0.81	−0.05	0.00000	*	100	−0.93	−1.10	−0.72	1.53
Importance of learning as coping strategy during the pandemic	−0.91	−1.01	−0.80	−0.05	0.00000	*	100	−0.92	−1.08	−0.73	1.64
Time spent watching TV before the pandemic	−0.60	−0.70	−0.50	−0.03	0.00000	*	100	−0.58	−0.75	−0.45	1.54
Frustration before the pandemic	−0.50	−0.64	−0.37	−0.03	0.00000	*	98	−0.50	−0.71	−0.26	1.85
Time spent gaming before the pandemic	−0.43	−0.53	−0.33	−0.02	0.00000	*	100	−0.42	−0.53	−0.28	1.30
Importance of gaming as coping strategy during the pandemic	−0.40	−0.51	−0.30	−0.02	0.00000	*	100	−0.40	−0.53	−0.25	1.47
Time spent on internet before the pandemic	−0.36	−0.47	−0.26	−0.02	0.00000	*	86	−0.30	−0.48	0.00	2.24
Resilience before the pandemic	−0.36	−0.47	−0.25	−0.02	0.00000	*	99	−0.38	−0.53	−0.21	1.67
Access to protective devices	−0.19	−0.29	−0.10	−0.01	0.00009	*	61	−0.20	−0.34	0.00	2.67
Importance of information on COVID-19 as coping strategy during the pandemic	−0.19	−0.30	−0.09	−0.01	0.00043		56	−0.20	−0.37	0.00	2.66
Importance of medications as coping strategy during the pandemic	0.20	0.10	0.31	0.01	0.00017	*	52	0.20	0.00	0.36	2.75
Importance of a pet as coping strategy during the pandemic	0.25	0.14	0.35	0.01	0.00000	*	76	0.24	0.00	0.38	2.45
Time spent listening to music before the pandemic	0.27	0.17	0.37	0.02	0.00000	*	86	0.26	0.00	0.38	2.34
Helplessness before the pandemic	0.30	0.16	0.44	0.02	0.00002	*	69	0.31	0.00	0.51	2.65
Social functioning before the pandemic	0.30	0.18	0.43	0.02	0.00000	*	76	0.30	0.00	0.48	2.54
Time spent reading before the pandemic	0.42	0.31	0.53	0.02	0.00000	*	100	0.44	0.29	0.59	1.45
Adherence to restrictions during the pandemic	0.48	0.39	0.58	0.03	0.00000	*	100	0.46	0.30	0.59	1.61
Prosocial behaviour before the pandemic	0.50	0.40	0.60	0.03	0.00000	*	100	0.51	0.32	0.64	1.79
Household functioning satisfaction before the pandemic	0.54	0.44	0.65	0.03	0.00000	*	100	0.54	0.39	0.74	1.74
Perceived social support before the pandemic	0.56	0.45	0.66	0.03	0.00000	*	100	0.54	0.37	0.73	1.68
Importance of internet as coping strategy during the pandemic	0.57	0.47	0.68	0.03	0.00000	*	100	0.55	0.35	0.71	1.69
Functioning with hobbies before the pandemic	0.58	0.46	0.70	0.03	0.00000	*	100	0.59	0.35	0.82	2.01
Loneliness before the pandemic	0.58	0.45	0.71	0.03	0.00000	*	100	0.60	0.41	0.79	1.63
Importance of substance use as coping strategy during the pandemic	0.59	0.49	0.69	0.03	0.00000	*	100	0.58	0.43	0.73	1.69
Importance of social interactions as coping strategy during the pandemic	1.46	1.36	1.55	0.08	0.00000	*	100	1.45	1.34	1.64	1.70
Non-modifiable											
Age	−1.78	−1.90	−1.67	−0.10	0.00000	*	100	−1.86	−2.17	−1.58	2.41
Socioeconomic status	−1.03	−1.13	−0.93	−0.06	0.00000	*	100	−1.06	−1.24	−0.88	1.76
Numbers of rooms in the household	−0.43	−0.54	−0.33	−0.02	0.00000	*	100	−0.43	−0.57	−0.27	1.43
COVID-19 deaths daily increase during the pandemic	0.71	0.61	0.80	0.04	0.00000	*	100	0.71	0.55	0.88	1.90
Stringency of restrictions	0.76	0.66	0.86	0.04	0.00000	*	100	0.77	0.63	0.90	1.42
Loss of income during the pandemic	1.49	1.39	1.59	0.08	0.00000	*	100	1.48	1.33	1.67	1.74
Categorical											
Modifiable											
Information received on COVID-19: Too little	3.16	2.84	3.48	0.05	0.00000	*	100	3.19	2.63	3.68	1.75
Information received on COVID-19: Too much	3.32	3.10	3.55	0.08	0.00000	*	100	3.34	3.01	3.68	1.59
Non-modifiable											
Ethnicity: Prefer not to answer	−4.32	−5.84	−2.79	−0.02	0.00000	*	100	−4.32	−6.20	−2.27	1.40
Ethnicity: African/African-descent	−2.95	−3.55	−2.34	−0.03	0.00000	*	100	−2.99	−3.93	−2.14	1.45
Ethnicity: Asian	−2.71	−3.00	−2.42	−0.06	0.00000	*	100	−2.76	−3.33	−2.23	1.82
Ethnicity: Hispanic	−1.45	−2.02	−0.87	−0.01	0.00000	*	100	−1.27	−2.22	−0.41	1.54
Ethnicity: Mixed	−0.86	−1.35	−0.36	−0.01	0.00065	*	100	−0.90	−1.57	0.02	1.74
Ethnicity: Other	−0.95	−1.75	−0.15	−0.01	0.01954	*	100	−0.93	−2.58	0.50	2.05
Education: Primary school	−2.00	−2.94	−1.06	−0.02	0.00003	*	100	−2.11	−3.79	−0.28	2.07
Education: PhD	−0.63	−1.62	0.35	−0.01	0.20605	*	100	−0.75	−2.38	1.17	1.99
Education: High school	−0.14	−1.02	0.74	−0.00	0.75836	*	100	−0.40	−1.82	1.52	2.17
Education: College/university degree	0.13	−0.76	1.02	0.00	0.77771	*	100	−0.06	−1.45	1.89	2.10
Employment: Yes, has a job	−0.99	−1.19	−0.78	−0.03	0.00000	*	100	−0.99	−1.31	−0.71	1.46
Urbanicity: Small city/town (10,000–100.000 population)	1.39	1.10	1.67	0.04	0.00000	*	100	1.38	0.92	1.82	1.54
Urbanicity: Medium city/town (100,000–500.000 population)	1.28	0.99	1.58	0.03	0.00000	*	100	1.27	0.96	1.66	1.44
Urbanicity: Large city/town (over 500.000 population)	1.27	0.99	1.55	0.03	0.00000	*	100	1.33	0.95	1.69	1.42
Gender: Transgender or intersex	1.08	−1.10	3.25	0.00	0.33143	*	100	1.30	−1.18	3.51	1.11
Gender: Non-binary	2.13	0.60	3.66	0.01	0.00632	*	100	2.22	0.57	3.80	1.04

(*continued on next page*)

Table 3 (*continued*)

Predictor	BE Regression					Lasso	Bootstrap BE				
	B	CI. low	CI. high	B	p		BIF %	Median (B)	low.2.5 %	high.2.5 %	RMSD_ratio
Gender: Female	2.44	2.25	2.64	0.07	0.00000	*	100	2.41	2.06	2.78	1.81
Physical disorder: Yes	1.83	1.62	2.04	0.05	0.00000	*	100	1.83	1.56	2.12	1.44
Mental disorder: Yes	3.54	3.26	3.82	0.07	0.00000	*	100	3.56	3.10	4.01	1.66
Country income: Middle income	1.89	1.63	2.15	0.05	0.00000	*	100	1.86	1.42	2.29	1.73
Country income: Low income	7.33	6.74	7.91	0.08	0.00000	*	100	7.38	6.40	8.08	1.59
Intercept	8.44	7.53	9.35		0.00000	*	100	8.30	6.52	10.05	2.23

Legend. IF = bootstrapped Inclusion Frequency; Lasso: * = also selected in LASSO model; RMSD = Ratio of coefficient standard error for BE v global model.
Reference categories are: City Size = Village / rural; Job = None; CovidInfo = Adequate; Degree = None, Ethnicity = White; Gender = Male; Restrictions = None; Marital status = Single / never married; Income gp = 1. High income.
B coefficients represent the change in WHO5 scores with $a + 1$ SD change in the predictor (as only predictors were standardized). B values indicate the number of points change on the wellbeing or P-score scale with negative and positive values indicating increased deterioration during the pandemic, respectively.

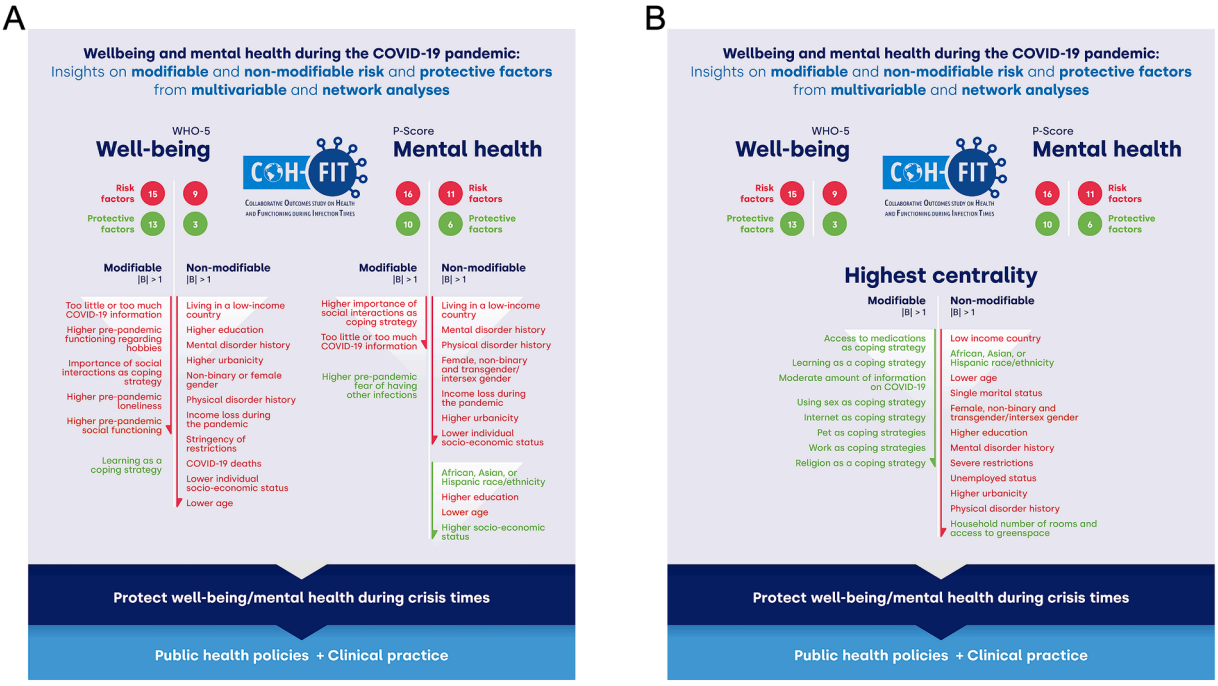

Fig. 3. Visual representation of main modifiable and non-modifiable protective and risk factors for wellbeing and P-score from multivariable (A) and network analyses (B) during COVID-19 pandemic.

conditions. Despite regulatory changes facilitating a shift towards telepsychiatry, the gap in physical health in persons with mental disorders (Solmi et al., 2020a) has widened during COVID-19 pandemic (Hassan et al., 2022).

In addition, younger age was associated with larger worsening of both outcomes, reflecting the more pervasive change in lifestyle and routine in young adults. Also, gender minorities suffered from a more severe impact of COVID-19 pandemic, confirming them as a vulnerable population across different social and health domains (Pharr et al., 2022), calling for policy making that accounts for intersectionality and equity principles.

Among actionable items (i.e., modifiable factors), a central role emerged for several coping strategies, some of which require actions from health systems and policy makers. Enabling continued access to medical consultations and provision of medications for physical and mental conditions is crucial to ensure continuity of care for those with chronic conditions. Maintaining active learning and access to knowledge sources including the internet (Riaz et al., 2023), as well as minimizing unemployment can foster a sense of control and purpose during crisis times. Religion also confirmed to be protective against poor mental health, and freedom of access and execution of religion should be facilitated (Riaz et al., 2023; Rosmarin et al., 2023), including via technologic solutions. Both loneliness (Solmi et al., 2020b) and importance of social connectedness as a coping strategy, which was restricted severely during especially the initial times of the pandemic, were associated with larger worsening of well-being, confirming the crucial role of facilitating as much as possible interpersonal interactions in preventing detrimental impacts on well-being and mental health.

Another important finding was that both too much and too little COVID-19-related information emerged as a risk factor for poor outcomes. This results underscores the importance of media but also that public and private media should provide updated but responsible information, balancing the need for transparent reporting of facts (i.e., avoid too little COVID-19-related information) (Tsao et al., 2021), yet being mindful of the risks associated with catastrophic scenarios or projections based on speculation without solid scientific basis, and of the need to maintain a diversified portfolio of themes (i.e., avoid too much COVID-19-related information) (Wong et al., 2021).

COH-FIT has several strengths. COH-FIT is an inclusive study that is available in as many as 30 languages, crossing borders globally, and being available to ethnic and linguistic minorities, who also frequently have lower socioeconomic status. This point is important since ethnic

minorities have suffered from more pronounced gaps in access to care, which has been associated with higher physical health (Magesh et al., 2021) burden from COVID-19 pandemic. COH-FIT also asked about the gender of study participants, which was among the factors that were associated with poorer outcomes. Results reflect two years of global data collection and a-priori multivariable analyses in representative and non-probability samples, considering associations of risk and protective factors with validated outcomes and actionable targets to mitigate the adverse effects of the pandemic. To the best of our knowledge, to date, there is no other report with the same characteristics (Salanti et al., 2022; Sun et al., 2023).

Limitations of the COH-FIT study include its cross-sectional design at the individual level. However, methodologically, the difference between COH-FIT and a cohort study is analogous to the difference between a population pharmacokinetic study (collecting numerous samples in different persons with the sample growing over time) versus a pharmacokinetic study (following a small sample of subjects over a limited time period, with frequent considerable drop-outs over time) (Charles, 2014). In that sense, COH-FIT studies the population rather than the individual in it. Also, COH-FIT assessed pre-pandemic well-being and mental health retrospectively. However, our analyses excluded the presence of recall bias. Nevertheless, the validity of a cohort study following up over 100,000 persons at multiple time points would have been superior to the COH-FIT estimates. Moreover, some non-modifiable factors could be seen as modifiable in the medium or long-term, or at least modifiable by different policies. For instance, the stringency of restrictions might be modulated in the medium term, or might allow access to open areas with appropriate physical distancing, or urbanicity and household patterns might prioritize access to green areas in the future. Hence, interpretation of findings should go beyond the proposed categorization of "modifiable" or "non-modifiable", and apply local and context-specific insight to identify what factors is modifiable, to which extent it is, and in what time it can be modified, to inform decision making processes. Also, some risk (e.g., higher pre-pandemic social functioning, higher functioning with hobbies) and protective factors (e.g., lower education or ethnic minorities) reflect higher/lower pre-pandemic well-being or psychopathology levels, resulting in larger/smaller outcome change, but possibly worse/better absolute outcome values during the COVID-19 pandemic. Finally, COH-FIT included also non-probability samples, yet it did weight them accounting for representative quota of demographic variables and found largely similar results across probability and non- probability subsamples.

In conclusion, groups at risk groups of poor mental health during COVID-19 pandemic were those characterized by living in a low-income country or in an urban centre, certain ethnicities, younger age, non-binary or female gender, higher level of education, having a history of mental or physical disorder, suffering from income loss, relying on social interactions as coping strategies, and those exposed to more stringent COVID-19-related restrictions or higher number of COVID-19 deaths. Protective factors were having access to green space and higher socioeconomic status. Factors that can be targeted to improve mental health and wellbeing during a pandemic were access to medications, using learning, internet, pet-ownership, working and religion as coping strategies, and providing measured and reliable COVID-19 information. These findings should be considered together with results according to subjective lived experience, e.g., using exercise as one the most important coping strategies.

COH-FIT accounted the mesh of interactions amongst multiple factors in a highly complex context, and provided a unique global and comprehensive picture of which subpopulations suffered the most during the COVID-19 pandemic, identifying vulnerable groups and minorities, underscoring the need for equity and inclusivity for guiding policies in crisis times. The results also identified key coping strategies and highlighted the need for the media to provide objective information in a responsible manner. Finally, COH-FIT showed that, over time, the impact of the pandemic on mental well- being lessened, presumably reflecting the beneficial influence of modifiable mitigating factors. Certain reports only focusing on the first months or year of the pandemic and claiming a global pandemic of anxiety and depressive disorders, should be interpreted cautiously.

Role of funding source

All the institutions and funding agencies are listed in eTable 11. COH-FIT PIs and collaborators have applied/are actively applying for several national and international grants to cover expenses related to the coordination of the study, website, nationally representative samples, advertisement of the study, and future dissemination of study findings. The funding bodies had no further role in study design; in the collection, analysis and interpretation of data; in the writing of the report; and in the decision to submit the paper for publication.

Contributors

For the overall COH-FIT project, MS, CUC wrote the study protocol. AK, CUC, DM, ED, FL, MS, TT wrote the statistical analysis plan designed the statistical analysis plan. TT conducted the analysis of this work. CUC, MS, TT wrote the first draft. All authors read, contributed to and approved the final version of the manuscript. All authors contributed to the final version of the COH-FIT survey and are involved in disseminating the COH-FIT survey link and collecting the data and designing and preparing research reports on national data. All local researchers contributed to and approved translations of the COH-FIT survey in their respective language. CUC, MS, AE, ED, TT, FL, AK had access to the global raw data on participation results.

Conflict of interest

Conflict of interest statements of all authors are detailed in eTable 12.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.euroneuro.2024.07.010.

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