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# Connecting psychosocial and personality characteristics with mental health outcomes. An Italian co-twin control study

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<sup>a</sup> Centre of Reference for Behavioural Sciences and Mental Health, Istituto Superiore di Sanità, Viale Regina Elena, 299, Rome 00161, Italy <sup>b</sup> Department of Public Health Sciences and Pediatrics, University of Turin, via Santena 5 bis, 10126 Turin, Italy

A R T I C L E I N F O	A B S T R A C T				
Keywords: Anxiety Depression Stress Mental health COVID-19 Twin	Exposure to stressful life events is common, and it is linked to increased psychological issues. As most likely people respond to stressors depending on environmental and genetic factors, we assessed in a twin study the association of some personal characteristics such as resilience and self-perception with anxiety, depression and stress in the late Covid pandemic period, to verify the underlying genetic and shared familial components. With this design, the strength of the associations was compared between individual-level and intrapair-level analyses. From June 2020 to December 2021, the Italian Twin Registry conducted a three-wave longitudinal study among adult twins using validated questionnaires, and 1,763 adult twins participated in the study (mean age 46 years, 67 % females, 70 % monozygotic). A regression-based within-pair differences model was applied to control for genetic and shared environmental confounding. Results showed that anxiety was linked negatively with resilience, social support and perceived health, and positively with risk perception and hypochondria. Depression was associated negatively with resilience, social support and perceived negatively with resilience and perceived health, and positively with financial concern and hypochondria. Stress was associated negatively with resilience and perceived health, and positively with financial concern, risk perception and hypochondria. These results suggest potential etiological effects of the above-mentioned risk factors. While our findings need to be confirmed by longitudinal studies, they propose potential etiological models for mental disorders, indicating that addressing in the clinical practice factors such as self-perception, personality traits (resilience), environmental resources (social support), and comorbid disorders (hypochondria) could have therapeutic benefits while treating certain common mental disorders.				

# 1. Introduction

Exposure to stressful life events is common, and it is linked to an increase in mental health issues, such as anxiety, perceived stress and depression (Jacoby et al., 2021). The study of connection between stressful life events and worst mental health has gained relevance as our world has faced the common COVID-19 stressor. People respond to stressors in different ways: while someone could experience severe psychiatric symptoms, others may remain asymptomatic (Jacoby et al., 2021). Factors influencing adaptation to adversities include environmental conditions, past experiences, personal resources, gender, and culture (Jacoby et al., 2021). Some factors, as explained below, are known from previous literature to be associated with anxiety, perceived stress and depression expression, but there is still very limited understanding of the role of genetic and environmental factors in explaining

those associations.

Resilience, defined as an individual's ability to overcome stress while maintaining psychophysical functioning, plays a major role in stress response (Sheerin et al., 2018). It has been shown, in prior studies, to be protective against stressful exposures such as widowhood (King, 2019) and adults' reactivity to adverse events such as onset of new chronic illness (Manning et al., 2016). Also, in the COVID-19 era, an important role has been attributed to resilience in contrasting the worsening of people's mental health (Zhang et al., 2020). It should be noted, however, that a recent longitudinal study has evidenced that resilience had no influence on both subjective and biological stress markers during the first wave of the Covid-19 pandemic (Engert et al., 2021). Perceived social support is known to protect against depressive and anxiety symptoms, as well as suicidal ideation and attempts, even in individuals who experienced mental health problems (Scardera et al., 2020).

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Economic conditions and physical health are also pivotal and influence subjective well-being and life satisfaction, which are the key components of positive mental health (Diener et al., 2009). Consistently, some studies have documented that individuals who reported moderate or poor health condition had significantly higher odds ratios for anxiety or depression than those who reported good health condition (Tran et al., 2017; Ibrahim et al., 2013). Low socioeconomic status has been also established as a risk factor for poor mental health (Lorant et al., 2003; Marmot et al., 1991). Finally, increased health risk perception and health anxiety were found to be associated with poorer stress management and poor mental health (Mousavi et al., 2021; Fitzpatrick et al., 2020; Lee et al., 2020; Montano and Acebes, 2020).

On the basis of the above-mentioned studies, one may speculate that specific psychosocial factors could causally influence mental health outcomes. However, the analysis of the relationship between those factors and mental health problems can be influenced by familial confounders. Using genetically informative data from twins allows for optimal control of confounding effects. Some previous twin studies further supported the association between financial problems and increased risk of depression (Kendler et al., 2010; Kendler & Gardner, 2014; Kendler and Halberstadt, 2013; Lam et al., 2019). A prospective population-based twin cohort study has revealed that poor or moderate self-rated health was an independent predictor of mental disorders after accounting for genetic and familial confounders (Samuelsson et al., 2013). While accounting for genetic and environmental factors, two twin studies provide mixed evidence for the association between social support and mental health problems. One study has shown that the levels of social support from the co-twin, other relatives, parents, and the spouse were strongly associated with the risk for depression (Kendler, 2005), while a subsequent discordant monozygotic twin study has showed that the effect of perceived social support was neither a significant antecedent to, nor sequela of depression (Coventry et al., 2009).

In the present study, we contributed to the limited existing work by analyzing data from a twin dataset, using indicators (for the most part validated questionnaires and scales) of psychological resilience, social support, self-perception of physical health condition, financial status and subjective perception of risk to acquire SARS-CoV-2 infection, and validated measures of anxiety, depression and stress. We suppose that there are not strong pleiotropic effects between those indicators and mental health outcomes, indicative of shared genetic susceptibility between them. In partial consistence with previous limited research, we expect, when controlling for genetic and environmental shared factors between those constructs, to find significant unshared possible direct causal effects of those psychosocial factors on anxiety, depression and stress outcomes.

# 2. Materials and methods

#### 2.1. Study design and participants

At the end of the Italian lockdown, the Italian Twin Register (ITR, Medda et al., 2019) started a longitudinal study to investigate prospectively the effect of the Covid-19 pandemic on the general population, and conducted three online surveys in June 2020, December 2020 and December 2021. About 7000 adult twins (age 18–92 years) previously enrolled in the ITR, residing in Italy at the time of the pandemic, and contactable by email were selected and invited to participate in the survey. Each selected twin received a personal link via email to be able to take part in the study, and once used, the access to the platform was blocked to avoid duplication or fraudulent use. A reminder was sent to those who did not respond within a 3-week period.

A total of 2,164 adult twins joined the survey, resulting in a response rate of 31%. This rate is in line with other studies conducted by the ITR; however, to exclude major selection biases, the main socio-demographic characteristics were compared between participants and non-participants.

All the twins filled-out the Italian versions of the questionnaires online through the LimeSurvey platform (LimeSurvey GmbH).

This research was carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) and was approved by the Ethical Committee of the Istituto Superiore di Sanità (ISS Ethical Committee approval PRE BIO CE n.0020797, June 6, 2020).

Before filling out the online questionnaire, all the twins were invited to read the information note and sign the informed consent form. The request for consent was also reiterated at the end of the questionnaire completion. The ITR systematically stimulates the participation of twins by emphasizing the importance of their contribution to public health, and sometimes at the end of the study, the twin's willingness is acknowledged and rewarded with a small and low-value gadget (as in this study) or with the return of health-relevant information.

#### 2.2. Measurements

The online survey included the following validated self-reported questionnaires:

1) Patient Health Questionnaire (PHQ-9), a 9-item psychological screening test for depression in the previous two weeks. The score ranges from 0 to 27 (Kroenke et al., 2001). The Italian validated translation of the PHQ-9 showed to possess good psychometric properties (Mazzotti et al., 2003).

2) State-Trait Anxiety Inventory (STAI-6), a 6-item questionnaire measuring symptoms of anxiety. The score ranges from 20 to 80 (Marteau & Bekker, 1992). It derives from the original full form of the STAI-Y (Spielberger, 1983). The Italian version of the STAI-Y shows high internal consistency (alpha Cronbach = 0.91) and good test–retest reliability (Spearman correlation = 0.49; p < 0.01) (Pedrabissi and Santinello, 1989).

3) Impact of Event Scale - Revised (IES-R), a 22-item questionnaire assessing subjective distress in the previous seven days. The score ranges from 0 to 88 (Weiss & Marmar, 1997). The Italian translation of the IES-R showed satisfactory internal consistency in studies on different at-risk populations, as reported by Craparo et al. (2013) (Intrusion,  $\alpha = 0.78$ ; Avoidance,  $\alpha = 0.72$ ; Hyperarousal,  $\alpha = 0.83$ ) and Converso & Viotti (2014) (Intrusion,  $\alpha = 0.91$ ; Avoidance,  $\alpha = 0.81$ ; Hyperarousal,  $\alpha = 0.87$ ).

4) Dispositional Resilience Scale (DRS-15), a 15-item instrument measuring subject's resilience or hardiness, with a 0–45 score range (Bartone, 2007). A relatively recent study provided evidence of both validity and reliability for the Italian version of the DRS-15 (Picardi et al., 2012).

5) Health Anxiety Questionnaire (HAQ), a 21-item questionnaire to identify individuals with high levels of concern about their health. Total score ranges from 21 to 84 (Lucock & Morley, 1996). The Italian version of the HAQ demonstrated excellent internal consistency (alpha = 0.91) and a good stability over time (r = 0.89); the factor analysis highlighted the presence of four main dimensions, which together account for 58.4% of the total variance: fear of death and diseases, interference with daily activities, worries about health condition, and need for reassurance (Melli et al., 2007).

6) Level of financial concern was measured using four questions (1. *My or my family's financial situation will get much worse over the next 12 months; 2. I am worried about my or my family's financial situation over the next 12 months; 3. I am worried about providing for myself financially over the next 12 months; 4. I have enough means to secure food and housing for myself or my family over the next 12 months).* Participants rated their agreement with each of the four questions on a six-point Likert scale. A total score ranging from 4 to 24 was obtained by summing responses across the four questions.

7) Multidimensional scale of perceived social support (MSPSS), a 12item questionnaire to measure perceived social support from others. Total score ranges from 12 to 84 (Zimet, 1988). The Italian version of the instrument has good psychometric properties (Grassi et al., 2000) and

#### Table 1

Descriptive statistics of levels of anxiety, depression and stress in adult twins at Wave 1 (Italy, June 2020), Wave 2 (Italy, December 2020) and Wave 3 (Italy, December 2021) in the first and fourth quartiles for each risk factor.

<table-container>NameNoNoNNNNNAndery - Ward324.4531.214243.741.014Andery - Ward306.745.04243.753.40Depression - Ward306.745.242.473.753.40Depression - Ward331.741.55261.1231.33Bard1.741.55261.741.341.34Depression - Ward331.741.56271.34Bard1.741.75271.741.74Bard1.741.741.741.741.74Bard1.741.741.741.741.74Andery - Ward1.741.741.741.741.74Andery - Ward1.741.741.741.741.74</table-container>		Resilience - Low	Resilience - Lower 25th percentile		Resilience - Upper 75th percentile			
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N   D   Mean   N   Mean   D     Anxiety - Wave2   428   38.886   10.809   17.7   42.927   11.567     Anxiety - Wave2   434   40.484   10.907   183   49.505   13.270     Anxiety - Wave2   434   4.042   3.893   181   5.048   5.030     Depression - Wave2   433   4.205   4.187   187   5.742   4.894     Stress - Wave1   432   16.090   12.005   184   2.542   14.504     Stress - Wave1   434   4.414   12.005   184   2.542   14.504     Stress - Wave1   434   4.411   12.005   184   2.542   14.504     Anxiety - Wave1   28   4.7728   12.305   281   3.1060   11.799     Anxiety - Wave2   30   6.613   5.520   291   4.0751   1.562     Depression - Wave2   29   6.663   5.330   286   1.7659   1.3466		<b>Risk Perception</b>	isk Perception - Lower 25th percentile Risk Perception - Upper 75th percentile		e			
Anxiety - Wave142838.881.009174.2.9.21.5.67Anxiety - Wave343440.8410.09718345.051.3.270Anxiety - Wave343440.4023.8931815.0244.133Depression - Wave24314.4443.6441875.0244.133Depression - Wave24331.2.44310.13317918.7241.1.676Stress - Wave14321.6.0901.2.661875.2.421.4.14Stress - Wave24341.1.141.0.0317918.7241.1.676Stress - Wave34341.1.141.0.031842.5.421.4.14Anxiety - Wave34344.1.141.0.031791.6.2.421.5.291Anxiety - Wave32844.4.111.2.0972813.8.16.601.7.99Anxiety - Wave32864.7.7281.2.0752814.0.601.5.52Anxiety - Wave3396.6135.502844.6633.567Depression - Wave3396.6135.502843.6691.3.07Stress - Wave33421.7.451.2.1072831.6.691.3.17Depression - Wave22822.1.651.3.243.3.163.3.17Stress - Wave33421.7.451.2.072851.3.62Anxiety - Wave23822.1.661.5.571.3.463.3.17Anxiety - Wave23823.1.691.3.171.4.24 <t< td=""><td></td><td>N</td><td>SD</td><td>Mean</td><td>Ν</td><td>Mean</td><td>SD</td></t<>		N	SD	Mean	Ν	Mean	SD	
Anciety - Wave243241.3401.56018645.20811.906Depression - Wave14344.0423.893185.0244.133Depression - Wave14314.4444.364185.0244.137Depression - Wave34334.2064.1871775.7424.804Stress - Wave243216.09012.66518425.24214.504Stress - Wave343414.14112.03818825.66715.289Anciety - Wave122847.72812.96728141.06011.799Anciety - Wave232844.41112.09728140.69111.562Depression - Wave23266.6265.05529140.7511.1562Depression - Wave23296.6805.1332403.1483.203Stress - Wave23296.6135.52028313.69910.996Stress - Wave134117.1261.10728313.69910.996Stress - Wave2321.4561.42832861.337282.55613.244Stress - Wave23421.4501.42832861.304282.55613.244Stress - Wave23421.4501.42832861.6363.5703.5703.576Depression - Wave2343.9171.5262243.5813.5103.5723.54Stress - Wave23423.5401.5282863.5	Anxiety – Wave1	428	38.886	10.809	177	42.927	11.567	
Andrey Ward Depression Wave2434.04841.0987185.0241.1906Depression Wave2434.2064.1871.836.0485.030Stress Wave1434.2064.1871.875.7424.84Stress Wave1431.6.0001.2.0601.842.5.2421.5.084Stress Wave34341.4.141.2.0381.842.5.2421.5.084Andrey Wave1284.4.111.2.071.863.8.1951.0.98Andrey Wave2284.7.281.2.9362.814.0.0611.7.96Andrey Wave2366.0265.0052843.0543.56Depression Wave1366.0265.0052843.0543.604Depression Wave1366.0265.1332843.0543.604Depression Wave2396.6135.502843.6543.604Stress Wave1347.1261.1622921.5.431.1076Stress Wave23242.4531.42832921.3.486Stress Wave23843.0543.6643.6643.664Stress Wave3363.9.171.0.813.17Andrey Wave13743.7082921.5.433.146Andrey Wave13833.9.191.9.161.9.16Andrey Wave13643.9.171.0.812921.5.431.5.16Andrey Wave13653.3.9.53.64292 <t< td=""><td>Anxiety – Wave2</td><td>432</td><td>41.347</td><td>11.560</td><td>183</td><td>49.505</td><td>13.270</td></t<>	Anxiety – Wave2	432	41.347	11.560	183	49.505	13.270	
pepersion - Warel4344.4444.3644.3641.815.0244.153pepersion - Wave34334.2644.1671835.0485.030Stress - Wave143212.44310.13317918.72418.87Stress - Wave243216.0001.26051842.524214.504Stress - Wave243414.14112.09718.72418.7019.90Anxlety - Wave132844.711.20972813.819510.989Anxlety - Wave232847.72812.9352814.0653.576pepersion - Wave23286.0205.0052843.6643.600pepersion - Wave23296.6835.1332843.6643.600pepersion - Wave23296.6835.13328617.65913.466stress - Wave13417.1261.10728313.66910.996Stress - Wave13417.1261.210728617.65913.476Stress - Wave13417.1261.210728617.65913.476Anxlety - Wave1343.018202015.04313.177Anxlety - Wave13773.01810.2262844.525513.247Anxlety - Wave36563.977810.4612844.525513.474Anxlety - Wave36563.977810.4612844.525613.244Anxlety - Wave36563.9782842	Anxiety – Wave3	434	40.848	10.987	186	48.208	11.906	
perpersion	Depression – Wave1	434	4.042	3.893	181	5.024	4.153	
pepsion - Wave3 stress - Wave3131.2.051.871.87Stress - Wave34341.2.031.931.941.876Stress - Wave34341.4.141.2.031.842.5.421.4.504Stress - Wave34341.4.141.2.031.842.5.4671.5.90Anxiety - Wave13284.4.111.2.0972.813.8.1.951.0.989Anxiety - Wave33284.7.7281.2.3752.914.0.7511.5.62Depression - Wave33366.0265.0352843.6643.650Depression - Wave33396.6135.502843.6643.650Depression - Wave33396.6135.022933.1483.2013Stress - Wave13341.7.1261.2.1072831.6.991.0.996Stress - Wave33241.2.1672831.6.991.0.966Stress - Wave33241.2.1672831.6.991.0.966Stress - Wave13447.7181.4.832921.5.4631.5.17Anxiety - Wave33431.7.261.2.1672831.6.991.3.177Stress - Wave33422.1.631.4.8432921.6.411.1.77Anxiety - Wave1373.2.233.6042842.6.913.044Depression - Wave23843.0933.6042843.6973.2.64Anxiety - Wave23853.2.933.6042.0.943.9.94<	Depression – Wave2	431	4.484	4.364	183	6.048	5.030	
Stress - Wavel Stress - Wavel431.2.431.0.131791.8.721.8.72Stress - Wavel4321.6.091.6.051842.5.421.5.09Stress - Wavel501882.5.6715.289N8001098Number - Stress - Wavel3284.4.111.2.0382001.0.98Anxiety - Wavel3284.4.411.2.9362813.1.06011.799Anxiety - Wave23284.7.7281.2.9362813.6053.576Anxiety - Wave23366.0265.0052843.6543.560Oppression - Wave23396.6135.2052843.6543.660Stress - Wave23282.1.1651.3.372.903.1483.203Stress - Wave23282.1.631.5.4282861.6.133.1.77Stress - Wave23282.1.631.6.4282861.6.631.3.177Anxiety - Wave23283.2.131.6.4282861.6.631.3.177Anxiety - Wave23283.2.131.6.4282861.6.631.3.177Anxiety - Wave23283.2.131.6.921.2.516Anxiety - Wave23.8.53.3.642.696.8095.098Anxiety - Wave23.8.53.9.632.696.7274.957 <td>Depression – Wave3</td> <td>433</td> <td>4.206</td> <td>4.187</td> <td>187</td> <td>5.742</td> <td>4.894</td>	Depression – Wave3	433	4.206	4.187	187	5.742	4.894	
Stress - Wave243416,09012,60518425,24214,504Stress - Wave363414,14112,097805050Anxiety - Wave132844,41112,09728138,19510,989Anxiety - Wave332847,72812,39528341,06011,799Anxiety - Wave33366,0265,0052843,6613,576Depression - Wave33366,6135,0052843,6643,650Depression - Wave33396,6135,0002843,6643,650Depression - Wave33396,6135,0002843,6643,650Depression - Wave332822,18614,8332021,179Market - Wave33421,1261,21072831,3691,096Stress - Wave33422,14331,5432021,5433,013Stress - Wave33422,14331,6432021,6431,137Market - Wave33423,1271,6482021,5431,2516Anxiety - Wave1373,2253,6412696,8971,2516Anxiety - Wave1373,2253,6412696,8971,512Anxiety - Wave23853,2303,6412696,8971,452Anxiety - Wave23853,2333,6632696,8971,518Anxiety - Wave23853,2333,6642605,0781,452 <td>Stress – Wave1</td> <td>433</td> <td>12.443</td> <td>10.133</td> <td>179</td> <td>18.724</td> <td>11.876</td>	Stress – Wave1	433	12.443	10.133	179	18.724	11.876	
stress - Wave314414.14112.03818825.66715.289Anciery - Wave1Solist Support - Wave1Solist Support - Wave1Solist Support - Wave1Solist Support - Wave1Anciery - Wave228847.47112.09728341.06011.799Anciery - Wave234047.74112.3752843.6543.560Depression - Wave23936.6135.5202843.6543.660Stress - Wave232822.18612.8328617.65913.486Stress - Wave232822.18614.4329215.40313.77Stress - Wave232822.18614.4329215.40313.77Stress - Wave23283.12713.88529215.40313.77Anxiety - Wave13743.70110.22627245.88712.516Anxiety - Wave13743.70110.8852845.25513.244Anxiety - Wave23853.9612906.6035.0985.098Depression - Wave13763.2503.6442845.25613.224Anxiety - Wave23853.2903.6442845.25613.224Anxiety - Wave23853.2903.6442845.25613.244Anxiety - Wave23853.2903.6442845.25613.244Anxiety - Wave23853.2903.6442905.078 </td <td>Stress – Wave2</td> <td>432</td> <td>16.090</td> <td>12.605</td> <td>184</td> <td>25.242</td> <td>14.504</td>	Stress – Wave2	432	16.090	12.605	184	25.242	14.504	
	Stress – Wave3	434	14.141	12.038	188	25.667	15.289	
N   Name   D   Near   D     Ansiet – Wavel   28   41.411   1.2097   283   3.8.195   10.989     Ansiet – Wavel   283   47.782   12.396   283   41.060   11.592     Depression – Wavel   360   6.026   5.005   284   3.695   3.576     Depression – Wavel   390   6.613   5.520   290   3.148   3.203     Stress – Wavel   342   2.166   14.283   286   17.690   13.486     Stress – Wavel   342   2.165   14.283   286   17.690   13.486     Stress – Wavel   342   2.163   15.43   266   17.650   13.246     Ansier – Wavel   374   3.7018   10.226   272   4.587   12.516     Ansier – Wavel   363   3.9778   10.461   269   4.894   3.044     Depression – Wavel   373   3.235   3.644   269   6.897   3.984     Depression – Wavel </td <td></td> <td>Social Support -</td> <td colspan="2">Social Support - Lower 25th percentile</td> <td>Social Support -</td> <td colspan="3">Social Support - Upper 75th percentile</td>		Social Support -	Social Support - Lower 25th percentile		Social Support -	Social Support - Upper 75th percentile		
Ankiety - Wavel32844.41112.0728138.19510.989Ankiety - Wavel34047.72412.37528341.06011.799Depression - Wavel3366.0265.0052843.6953.576Depression - Wavel3296.6135.5202843.6543.650Depression - Wavel3396.6135.5202903.1483.203Stress - Wavel33417.12612.10728313.69910.996Stress - Wavel3242.145315.43329215.0313.177Stress - Wavel3242.145315.43329215.0313.177Stress - Wavel3247.01812.2627245.88712.516Ankiety - Wavel3823.9.12710.8852845.25513.224Ankiety - Wavel3833.2033.66426948.94713.044Depression - Wavel3773.2353.66426948.94713.044Depression - Wavel3853.2903.6042847.9025.078Depression - Wavel3681.27821.12422712.18813.493Stress - Wavel3681.27821.12422712.18813.169Depression - Wavel3641.6071.19892294.46261.274Stress - Wavel3641.1791.4612204.9091.316Depression - Wavel3641.0271.198		N	Mean	SD	N	Mean	SD	
Analety - Wave228847.7812.9528341.06011.799Analety - Wave334047.74112.37529140.75111.562Depression - Wave13366.0805.1332843.6543.650Depression - Wave33996.6135.5202903.1483.203Stress - Wave133417.12612.10728313.69910.996Stress - Wave33422.145315.44329215.40313.17Earth anxiety - Extrement	Anxiety – Wave1	328	44.411	12.097	281	38.195	10.989	
Anxiev34047.74112.37529140.75111.562Depression - Wave23296.6605.1332843.6953.576Depression - Wave23396.6135.5202903.1483.203Stress - Wave134417.12612.10728313.69010.996Stress - Wave232822.18614.28328617.65913.486Stress - Wave232221.45315.44328617.65913.486Anxiety - Wave137437.01810.22627245.88712.516Anxiety - Wave238239.12710.88528452.55613.224Anxiety - Wave336639.77810.46126948.84713.044Depression - Wave33653.5633.6642805.0985.098Depression - Wave23833.2903.6642805.0985.098Depression - Wave33653.5533.6642805.0985.098Depression - Wave33683.2903.66428023.27813.493Stress - Wave137810.2808.77828023.27813.493Stress - Wave33681.24211.422712.18815.198Depression - Wave33681.2781.4222712.18313.64Anxiety - Wave13781.2823.642696.7274.352Arress - Wave33641.2782903.64 <td>Anxiety – Wave2</td> <td>328</td> <td>47.728</td> <td>12.936</td> <td>283</td> <td>41.060</td> <td>11.799</td>	Anxiety – Wave2	328	47.728	12.936	283	41.060	11.799	
Depresion - Wave1   366   6.026   5.037   284   3.695   3.576     Depression - Wave2   329   6.613   5.520   290   3.148   3.203     Stress - Wave1   334   17.126   12.107   283   13.699   10.996     Stress - Wave2   328   2.21.66   14.283   292   15.403   13.177     Enerst-Wave3   342   21.453   15.443   292   15.403   13.177     Anxiety - Wave1   374   37.018   10.226   72   45.887   12.516     Anxiety - Wave1   374   37.018   10.226   229   48.947   13.044     Depression - Wave2   382   39.127   10.885   284   5.556   13.224     Anxiety - Wave3   366   39.778   10.461   269   48.947   13.044     Depression - Wave2   385   3.230   3.664   3.607   5.078     Depression - Wave3   365   3.385   3.653   260   2.577   4.95	Anxiety – Wave3	340	47.741	12.375	291	40.751	11.562	
$\begin{array}{ c c c c c c c c c c c c c c c c c c c$	Depression – Wave1	336	6.026	5.005	284	3.695	3.576	
Depresion – Wave3 Stress - Wave1   339   6.613   5.520   290   3.148   3.203     Stress - Wave1   324   17.126   12.107   283   13.699   10.996     Stress - Wave2   328   2.2.186   14.283   292   15.403   13.177     Endth anxiety - Sth percentile   Health anxiety - Sth percentile   Health anxiety - Sth percentile   No   No   No     Anxiety - Wave1   374   37.018   10.226   272   4.5.887   12.516     Anxiety - Wave2   382   3.9.127   10.885   280   6.809   5.098     Depression - Wave1   366   3.9.778   10.461   269   48.947   13.044     Depression - Wave2   385   3.663   269   6.727   4.957     Depression - Wave3   365   3.290   3.604   284   3.204   14.528     Stress - Wave3   368   1.2.78   11.427   274   2.378   13.493     Stress - Wave3   364   1.0.200   8.77 <t< td=""><td>Depression – Wave2</td><td>329</td><td>6.680</td><td>5.133</td><td>284</td><td>3.654</td><td>3.650</td></t<>	Depression – Wave2	329	6.680	5.133	284	3.654	3.650	
Stress - Wave1 Stress - Wave2 Stress - Wave333417.12612.10728313.69910.996Stress - Wave332822.18614.28329617.65913.486Stress - Wave332212.45315.44329617.65913.486Anxiety - Wave1Health anxiety-resth percentileHealth anxiety-resth percentileNMeanSDAnxiety - Wave236239.12710.88528452.55613.224Anxiety - Wave336639.77810.6462806.8095.098Depression - Wave13773.2353.3642806.8095.098Depression - Wave137810.2808.77828023.27813.493Depression - Wave23681.278211.4179.44228023.27813.493Stress - Wave33681.28211.4179.44228132.01414.528Stress - Wave33681.02811.04212944.6261.2774Anxiety - Wave147438.20310.4212949.69731.107Anxiety - Wave14813.7903.7432326.2355.059Anxiety - Wave14813.7903.7432326.2355.059Depression - Wave14813.7683.9092327.4211.978Depression - Wave14813.7683.9092327.4211.978Depression - Wave24813.7683.909232 <t< td=""><td>Depression – Wave3</td><td>339</td><td>6.613</td><td>5.520</td><td>290</td><td>3.148</td><td>3.203</td></t<>	Depression – Wave3	339	6.613	5.520	290	3.148	3.203	
Stress - Wave2   328   22.186   14.283   286   17.659   13.486     Stress - Wave3   342   21.453   15.443   292   15.403   13.177     Health anxiety - Wave3   Health anxiety - Sth percentil-   Health anxiety - Wave1   Sh   N   Mean   Sh     Anxiety - Wave1   374   37.018   10.226   272   45.887   12.516     Anxiety - Wave2   366   39.177   10.885   284   52.556   13.224     Anxiety - Wave3   366   39.778   10.461   269   48.947   13.044     Depression - Wave2   365   3.280   3.653   269   6.727   4.957     Stress - Wave1   378   10.280   8.778   280   23.278   13.493     Stress - Wave3   368   12.782   11.242   271   27.188   15.198     Anxiety - Wave1   378   10.280   8.778   284   32.010   13.453     Anxiety - Wave1   474   38.203   10.421	Stress – Wave1	334	17.126	12.107	283	13.699	10.996	
Stress - Wave3   342   21.453   15.443   292   15.403   13.177     Health anxiety - Wave1   N   Mean   SD   N   Mean   SD     Anxiety - Wave2   374   37.018   10.226   272   45.887   12.516     Anxiety - Wave3   363   39.177   10.885   284   52.556   13.224     Anxiety - Wave3   366   39.778   10.461   269   48.947   13.044     Depression - Wave1   376   3.235   3.364   280   6.809   5.098     Depression - Wave2   385   3.290   3.604   284   7.902   5.078     Depression - Wave1   378   10.280   8.778   280   2.3278   13.493     Stress - Wave2   364   1.1417   9.442   284   32.014   14.528     Stress - Wave3   364   1.2782   11.242   271   27.188   15.198     Anxiety - Wave3   461   1.0270   11.989   229   49.909	Stress – Wave2	328	22.186	14.283	286	17.659	13.486	
$ \begin{array}{ c c c c c } \hline Health anxiety - Lower 25th percentile \\ \hline N & Mean & SD \\ \hline Depression - Wave1 & 481 & 3.790 & 3.743 \\ Depression - Wave2 & 481 & 3.768 & 3.909 \\ Depression - Wave2 & 481 & 3.768 & 3.909 \\ \hline Depression - Wave2 & 481 & 3.768 & 3.909 \\ \hline N & S122 & 6.502 & 4.827 \\ \hline Stress - Wave1 & 481 & 13.271 & 10.701 \\ \hline S22 & 227 & 6.502 & 4.827 \\ \hline Stress - Wave3 & 470 & 1.4713 & 12.289 \\ \hline P & 227 & 22.483 & 14.734 \\ \hline \end{array}$	Stress – Wave3	342	21.453	15.443	292	15.403	13.177	
NMeanSDNMeanSDAnxiety - Wave137437.01810.2627245.88712.516Anxiety - Wave238239.12710.88528452.55613.224Anxiety - Wave336639.77810.46126948.94713.044Depression - Wave13773.2353.3642806.8095098Depression - Wave23653.3853.6632696.7274.957Stress - Wave137810.2808.77828023.27813.493Stress - Wave238411.4179.44228432.01414.528Stress - Wave336812.78211.24227127.18815.198Financial concert - Exthereaction of the second		Health anxiety -			pper 75th percentile			
Anxiety - Wave1 374 37.018 10.226 272 45.887 12.516   Anxiety - Wave2 382 39.127 10.885 284 52.556 13.224   Anxiety - Wave3 366 39.778 10.461 269 48.947 13.044   Depression - Wave2 385 3.290 3.604 284 7.902 5.078   Depression - Wave3 365 3.290 3.604 284 7.902 5.078   Stress - Wave1 378 10.280 8.778 280 23.278 13.933   Stress - Wave2 384 11.417 9.442 284 3.014 14.528   Stress - Wave3 368 12.782 11.242 271 27.188 15.198   Anxiety - Wave1 474 38.203 10.421 29 44.626 12.774   Anxiety - Wave2 481 41.027 11.989 29 49.909 13.126   Anxiety - Wave3 471 40.599 10.876 227 47.421 11.978   Depression - Wave3 467 3.452 3.592		Ν	Mean	SD	Ν	Mean	SD	
Anxiety - Wave238239.12710.88528452.55613.224Anxiety - Wave336639.77810.46126948.94713.044Depression - Wave13773.2353.3642806.8095.098Depression - Wave33653.3853.6532696.7274.957Depression - Wave33653.3853.6532696.7274.957Stress - Wave137810.2808.77828023.27813.493Stress - Wave236411.4179.44228432.01414.528Stress - Wave336812.78211.24227127.18815.198Financial concurre 25th percurreFinancial concurreNMeanSDNMeanSDAnxiety - Wave147438.20310.42122944.62612.774Anxiety - Wave248141.02711.98922949.90913.126Anxiety - Wave347140.59910.8762274.5255059Depression - Wave24813.7683.9092327.4275.216Depression - Wave34673.4523.5922276.5024.827Depression - Wave34673.4523.5922276.5024.827Stress - Wave148113.27110.70123218.35212.198Depression - Wave34673.4523.5922276.5024.827Stress	Anxiety – Wave1	374	37.018	10.226	272	45.887	12.516	
Anxiety - Wave336639.77810.46126948.94713.044Depression - Wave13773.2353.3642806.8095.098Depression - Wave23853.2903.6042847.9025.078Depression - Wave33653.3853.6532696.7274.957Stress - Wave137810.2808.77828023.27813.493Stress - Wave238411.4179.44228432.01414.528Stress - Wave336812.78211.24227127.18815.198Anxiety - Wave147438.20310.42122944.62612.774Anxiety - Wave248141.02711.98922949.90913.126Anxiety - Wave347140.59910.87622747.42111.978Depression - Wave34673.4523.5922276.5024.827Depression - Wave34673.4523.5922276.5024.827Stress - Wave34701.07123218.35212.198Stress - Wave34701.07312.33723225.05115.781Stress - Wave34701.607312.33723225.05115.781Stress - Wave34701.617312.2892272.48314.734	Anxiety – Wave2	382	39.127	10.885	284	52.556	13.224	
Depression - Wave13773.2353.3642806.8095.098Depression - Wave23853.2903.6042847.9025.078Depression - Wave33653.3853.6332696.7274.957Stress - Wave137810.2808.77828023.27813.493Stress - Wave238411.4179.44228432.01414.528Stress - Wave336812.78211.24227127.18815.198Financial concurre 25th percentreFinancial concurre 75th percentreNMeanSDNMeanSDAnxiety - Wave148141.02711.98922944.62612.774Anxiety - Wave24814.059910.87622747.42111.978Depression - Wave14813.7903.7432326.2355.059Depression - Wave24813.7683.9092327.4275.216Depression - Wave34673.4523.5922276.5024.827Stress - Wave148113.27110.70123218.35212.781Depression - Wave346016.07312.33723225.05115.781Stress - Wave347014.71312.28922724.8314.734	Anxiety – Wave3	366	39.778	10.461	269	48.947	13.044	
Depression - Wave23853.2903.6042847.9025.078Depression - Wave33653.3853.6532696.7274.957Stress - Wave137810.2808.77828023.27813.493Stress - Wave238411.4179.442284320.1414.528Stress - Wave336812.78211.24227127.18815.198Financial concert 25th percettyFinancial concert 25th percettyNMeanSDNMeanSDAnxiety - Wave147438.20310.42122944.62612.774Anxiety - Wave248141.02711.98922949.09913.126Anxiety - Wave347140.59910.87622747.42111.978Depression - Wave34673.4523.5922276.5024.827Depression - Wave34673.4523.5922276.5024.827Stress - Wave148113.27110.70123218.35212.198Stress - Wave34673.4523.5922276.5024.827Stress - Wave346016.07312.33723225.05115.781Stress - Wave347014.71312.28922722.48314.734	Depression – Wave1	377	3.235	3.364	280	6.809	5.098	
Depression – Wave33653.8853.6532696.7274.957Stress – Wave137810.2808.77828023.27813.493Stress – Wave238411.4179.44228432.01414.528Stress – Wave336812.78211.24227127.18815.198Financial concert 25th percentsFinancial concert 25th percentsNMeanSDNMeanSDAnxiety – Wave147438.20310.42122944.62612.774Anxiety – Wave248141.02711.98922949.90913.126Anxiety – Wave347140.59910.87622747.42111.978Depression – Wave24813.7683.9092327.4275.216Depression – Wave34673.4523.5922276.5024.827Stress – Wave148113.27110.70123218.35212.781Stress – Wave347014.71312.28922722.48314.734	Depression – Wave2	385	3.290	3.604	284	7.902	5.078	
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Stress - Wave238411.4179.44228432.01414.528Stress - Wave336812.78211.24227127.18815.198Financial concert 25th percentFinancial concert 25th percentNMeanSDMeanSDAnxiety - Wave147438.20310.42122944.62612.774Anxiety - Wave248141.02711.98922949.90913.126Anxiety - Wave347140.59910.87622747.42111.978Depression - Wave34673.7683.9092327.4275.216Depression - Wave24813.7683.9092327.4275.216Depression - Wave34673.4523.5922276.5024.827Stress - Wave148113.27110.70123218.35212.198Stress - Wave347014.71312.28922722.48314.734	Stress – Wave1	378	10.280	8.778	280	23.278	13.493	
Stress - Wave336812.78211.24227127.18815.198Financial concert 25th percentleNMeanSDNMeanSDAnxiety - Wave147438.20310.42122944.62612.774Anxiety - Wave248141.02711.98922949.90913.126Anxiety - Wave347140.59910.87622747.42111.978Depression - Wave14813.7903.7432326.2355.059Depression - Wave24813.7683.9092327.4275.216Depression - Wave34673.4523.5922276.5024.827Stress - Wave148113.27110.70123218.35212.198Stress - Wave347014.71312.28922722.48314.734	Stress – Wave2	384	11.417	9.442	284	32.014	14.528	
$ \begin{array}{ c c c c c } \hline Financial concert Sth percent I berrow Sth percent I$	Stress – Wave3	368	12.782	11.242	271	27.188	15.198	
NMeanSDNMeanSDAnxiety - Wave147438.20310.42122944.62612.774Anxiety - Wave248141.02711.98922949.90913.126Anxiety - Wave347140.59910.87622747.42111.978Depression - Wave14813.7903.7432326.2355.059Depression - Wave24813.7683.9092327.4275.216Depression - Wave34673.4523.5922276.5024.827Stress - Wave148113.27110.70123218.35212.198Stress - Wave347014.71312.28922722.48314.734		Financial concern - Lower 25th percentile		ile	Financial concern - Upper 75th percentile			
Anxiety - Wave147438.20310.42122944.62612.774Anxiety - Wave248141.02711.98922949.90913.126Anxiety - Wave347140.59910.87622747.42111.978Depression - Wave14813.7903.7432326.2355.059Depression - Wave24813.7683.9092327.4275.216Depression - Wave34673.4523.5922276.5024.827Stress - Wave148113.27110.70123218.35212.198Stress - Wave347014.71312.28922722.48314.734		Ν	Mean	SD	Ν	Mean	SD	
Anxiety - Wave248141.02711.98922949.90913.126Anxiety - Wave347140.59910.87622747.42111.978Depression - Wave14813.7903.7432326.2355.059Depression - Wave24813.7683.9092327.4275.216Depression - Wave34673.4523.5922276.5024.827Stress - Wave148113.27110.70123218.35212.198Stress - Wave347014.71312.28922722.48314.734	Anxiety – Wave1	474	38.203	10.421	229	44.626	12.774	
Anxiety - Wave347140.59910.87622747.42111.978Depression - Wave14813.7903.7432326.2355.059Depression - Wave24813.7683.9092327.4275.216Depression - Wave34673.4523.5922276.5024.827Stress - Wave148113.27110.70123218.35212.198Stress - Wave347014.71312.28922722.48314.734	Anxiety – Wave2	481	41.027	11.989	229	49.909	13.126	
Depression – Wave14813.7903.7432326.2355.059Depression – Wave24813.7683.9092327.4275.216Depression – Wave34673.4523.5922276.5024.827Stress – Wave148113.27110.70123218.35212.198Stress – Wave347014.71312.28922722.48314.734	Anxiety – Wave3	471	40.599	10.876	227	47.421	11.978	
Depression – Wave24813.7683.9092327.4275.216Depression – Wave34673.4523.5922276.5024.827Stress – Wave148113.27110.70123218.35212.198Stress – Wave248016.07312.33723225.05115.781Stress – Wave347014.71312.28922722.48314.734	Depression – Wave1	481	3.790	3.743	232	6.235	5.059	
Depression – Wave34673.4523.5922276.5024.827Stress – Wave148113.27110.70123218.35212.198Stress – Wave248016.07312.33723225.05115.781Stress – Wave347014.71312.28922722.48314.734	Depression – Wave2	481	3.768	3.909	232	7.427	5.216	
Stress - Wave1   481   13.271   10.701   232   18.352   12.198     Stress - Wave2   480   16.073   12.337   232   25.051   15.781     Stress - Wave3   470   14.713   12.289   227   22.483   14.734	Depression – Wave3	467	3.452	3.592	227	6.502	4.827	
Stress - Wave2   480   16.073   12.337   232   25.051   15.781     Stress - Wave3   470   14.713   12.289   227   22.483   14.734	Stress – Wave1	481	13.271	10.701	232	18.352	12.198	
Stress – Wave3 470 14.713 12.289 227 22.483 14.734	Stress – Wave2	480	16.073	12.337	232	25.051	15.781	
	Stress – Wave3	470	14.713	12.289	227	22.483	14.734	

Abbreviation: SD, Standard Deviation

has been used in many previous studies (Picardi et al., 2005; Picardi et al., 2013).

8) General self-perceived health was measured by a single question (i.e., *Please choose one point in this 0–10 scale, which can best represent your health today – 0 means the worst and 10 means the best*).

# 2.3. Statistical methods

Data were analyzed with Stata version 16 (Stata Corporation, College

Station, TX, USA).

To obtain a higher sample homogeneity, only monozygotic (MZ) and same-sex dizygotic (DZ-SS) twin pairs participating in the third wave of the survey were included in the analyses.

The cumulative exposure distribution of risk factors – i.e., resilience, social support, financial concern, risk perception and hypochondria – was divided into quartiles. Means (standard deviations) of outcome variables – i.e., anxiety, depression and stress – were estimated for subjects in the first and fourth quartiles, and were then compared using

#### Table 2

Beta coefficients estimated using individual and intra-pair differences regression models by zygosity with respect to anxiety, depression and stress assessed in adult twins (Italy, 2021).

	INDIVIDUAL MODEL Beta coefficient	INTRA-PAIR MODEL – DZ-SS Beta coefficient	INTRA-PAIR MODEL - MZ Beta coefficient
	()3 /001)	(55 /001)	(55 /66)
ANXIETY (STAI-6)			
Financial concern	0.697 (0.536; 0.857)	0.384 (-0.206; 0.974)	0.264 (-0.103; 0.631)
Resilience	-0.699 (-0.797; -0.601)	-0.720 (-1.040; -0.401)	-0.747(-0.983; -0.511)
Social Support	-0.245 (-0.295; -0.195)	-0.238 (-0.407; -0.070)	-0.177 (-0.281; -0.072)
Risk Perception	1.402 (1.108; 1.696)	1.348 (0.166; 2.529)	0.691 (0.052; 1.330)
Self-perceived health	-3.695 (-4.163; -3.226)	-2.613 (-3.904; -1.323)	-2.808(-3.804; -1.811)
Health anxiety	0.379 (0.310; 0.450)	0.486 (0.254; 0.719)	0.288 (0.119; 0.458)
DEPRESSION (PHQ-9)			
Financial concern	0.313 (0.253; 0.374)	0.212 (-0.005; 0.429)	0.174 (0.041; 0.307)
Resilience	-0.308 (-0.348; -0.269)	-0.236 (-0.352; -0.120)	-0.316 (-0.400; -0.232)
Social Support	-0.127 (-0.147; -0.107)	-0.151 (-0.207; -0.095)	-0.072 (-0.110; -0.033)
Risk Perception	0.411 (0.284; 0.539)	0.558 (0.145; 0.971)	0.171 (-0.060; 0.403)
Self-perceived health	-1.581 (-1.763; -1.398)	-1.243 (-1.690; -0.799)	-1.172 (-1.525; -0.820)
Health anxiety	0.154 (0.126; 0.182)	0.147 (0.060; 0.234)	0.152 (0.093; 0.212)
STRESS (IES-R)			
Financial concern	0.804 (0.620; 0.988)	0.352 (-0.286; 0.989)	0.593 (0.199; 0.986)
Resilience	-0.496 (-0.620; -0.371)	-0.241 (-0.631; 0.149)	-0.337 (-0.610; -0.063)
Social Support	-0.181 (-0.244; -0.119)	-0.087 (-0.279; 0.106)	-0.001 (-0.119; 0.117)
Risk Perception	2.086 (1.691; 2.481)	2.555 (1.305; 3.805)	1.115 (0.394; 1.836)
Self-perceived health	-3.077 (-3.671; -2.483)	-1.645 (-3.069; -0.220)	-1.254 (-2.375; -0.132)
Health anxiety	0.578 (0.498; 0.658)	0.602 (0.363; 0.841)	0.333 (0.152; 0.513)

Statistically significant coefficients are indicated in bold (p < 0.05).

Abbreviation: 95 %CI, 95 % Confidence intervals; MZ: monozygotic twin pairs; DZ-SS same-sex dizygotic twin pairs.

t-tests.

Initially, a linear regression model based on twins as individual subjects was applied to estimate the association between risk factor variables and mental health outcomes, adjusting for the nonindependence of observations within twin pairs. To investigate if the observed associations between risk factors and outcomes persisted after adjustment for genetic and shared (familial) environmental confounding (thus being consistent with possible direct causal effects), the regressionbased within-pair differences model was fitted. According to this model, causal evidence was tested in MZ pairs (i.e., perfect genetic and familial matching scenario) by regressing within-pair differences of outcome scores on within-pair differences of risk factor scores, and evaluating both the magnitude and the significance of the association. Furthermore, the intra-pair differences regression model in DZ-SS pairs (i.e., partial genetic and perfect familial matching scenario) and the individual-level regression model (i.e., no matching scenario) were also applied: in the presence of causality, association estimates from all three models should be significant and of similar magnitude (McGue et al., 2010).

#### 3. Results

# 3.1. Participants and measurements

A total of 1,763 twins, belonging to MZ and DZ-SS pairs, completed the questionnaires. Mean age was 46 years, 33% of subjects were male, and more than half were from Northern Italy. Seventy percent of the subjects were MZ. No significant differences in the main sociodemographic characteristics were found between participants and non-participants, as well as between early and late respondents (i.e., between participants who filled out the questionnaire immediately after receiving the email and those who did it after a reminder). Cronbach's alpha has been calculated as 0.85 for PHQ-9 and STAI-6, 0.90 for IES-R, 0.79 for DRS-15, 0.93 for HAQ, 0.82 for level of financial concern, and 0.93 for MSPSS.

#### 3.2. Associations between risk factors and outcomes

For subjects participating in all three waves of the longitudinal Covid survey, the pattern of variation in outcomes (i.e., anxiety, depression, and stress) according to variation in risk factors was consistent across

the waves. For each wave, mean anxiety score was lower for subjects in the upper 75th percentile compared to subjects in the lower 25th percentile of both resilience and social support scores (risk factors); similar patterns emerged for depression and stress. Opposite pattern of variation in outcomes was observed for each wave according to financial concern, risk perception, and hypochondria (risk factors) (Table 1).

According to these patterns, outcome scores (i.e., anxiety, depression, and stress scores) were negatively associated with resilience, social support, and self-perceived health, whereas they were positively associated with financial concern, risk perception, and health anxiety (Table 2, Individual model).

# 3.3. Adjusted associations between risk factors and outcomes: The withinpair differences analysis

With respect to anxiety, regression models showed a negative (i.e., protective) effect of resilience, social support and perceived health, and a positive effect of risk perception and hypochondria; these effects were detected both at individual level and within MZ and DZ pairs.

As regards depression, a negative effect of resilience, social support and perceived health, and a positive effect of financial concern and hypochondria persisted in within-pair analyses.

As for stress, a negative association with resilience (at individual level and within MZ pairs) and perceived health (in all types of analysis) was found. A positive association with financial concern (at individual level and within MZ pairs), as well as with risk perception and hypochondria (in all types of analysis) emerged from regression models (Table 2).

#### 4. Discussion

#### 4.1. Interpretation of results and comparison with previous studies

Using a co-twin control study, we found that there were significant outcomes differences within twin pairs who were exposed to different levels of resilience, social support, financial condition, perception of one's health status and perception of risk for SARS-CoV-2 infection. This suggested possible causal effects since the magnitude of the exposure effects were controlled for genetic and shared environmental influences.

Significant associations provided evidence that the relationships of

financial concerns with depression and stress were not attributable to genetic and shared environmental confounding. This is in line with previous genetically informative studies that have found increased depression risk associated with financial problems (Kendler et al., 2010; Kendler & Gardner, 2014; Kendler and Halberstadt, 2013; Lam et al., 2019) and suggests that financial hardship is an important risk factor with probable causal influence on depression. With regard to stress, our result corroborates previous findings from non-genetically informative literature, which have demonstrated that financial hardship is typically accompanied by considerable stress (Cole et al., 2011). The observed initial association between financial concerns and risk of anxiety in the full sample vanished in the within-pair analyses, suggesting that the association was probably due to confounding by genetic factors or family environment. To our knowledge, no previous genetically informative studies have implicated financial concerns as risk factor for anxiety, or specifically reported within-twin pair estimates of a probable association.

Dispositional resilience was associated, in a potentially causal way, with anxiety, depression and stress symptoms. As stated before, resilience has been shown, in prior studies, to be protective against stressful exposures (King, 2019; Manning et al., 2016). Resilience has become even more relevant as our world has faced the common COVID-19 stressor. Our findings align with the limited existing literature of longitudinal investigations of the buffering effects of resilience against major depressive disorder and generalized anxiety disorder (Hjemdal et al., 2006; Sheerin et al., 2018). On the other hand, the observed association between resilience and stress is in contrast with the findings of a recent longitudinal study, which evidenced that resilience, irrespective of its conceptualization as a dynamic state or trait, had no influence on both subjective and biological stress markers during the first wave of the Covid-19 pandemic (Engert et al., 2021). However, in that study, some personality traits (e.g., neuroticism and extraversion) were also included in the regression model of analysis. As suggested by the same authors, it is possible that above and beyond the variance explained by those personality traits, resilience made no additional contribution to the pandemic stress load (Engert et al., 2021).

The significant within-pair effects of social support on depression suggested that the association could be of causal origin, consistently with the available genetically informative literature (Kendler et al., 2005) and with recent cohort research suggesting that poor social support and loneliness might underlie anxiety and depression symptoms (Matthews et al., 2022). However, as previously mentioned, this result does not align with a previous discordant monozygotic twin study, which showed that the effects of perceived social support on depression were not causal, although the same study found in males that perceived support in the face of multiple stressors was an antecedent mitigating subsequent depression (Coventry et al., 2009).

The relationship between social support and stress was likely to reflect shared familial and genetic effects, rather than causal effects. Some previous non-genetically informative research showed that personality traits (e.g., extraversion, agreeableness, conscientiousness, and neuroticism) might influence perceived stress because of the tendency to gain perceived or actual social support as resources to cope with stressful situations or not (Bowling et al., 2005; Swickert et al., 2002). This indicates that the experience of stress related to social support may be at least partially attributable to personality factors, whose genetic components were found to make substantial contribution to the genetic variance in perceived stress (Roberts et al., 2009). Therefore, the genetic and shared familial confounding effects that we observed in the association between social support and stress might be partially due to higher-order relations between personality facets and stress, and could attest to the notion of social support as a resource that has much in common with personality traits.

A possibly causal association of health status concerns with depression and anxiety symptoms was also found. Self-rated health has been found to be moderately heritable (Svedberg et al., 2005; Stevens et al., 2020). This shows the importance of accounting for potential familial confounding when studying the associations between self-rated health and mental disorders. Our findings align with the limited existing literature based on prospective population-based twin cohort studies which has revealed that poor or moderate self-rated health is an independent predictor of mental disorders even after accounting for genetic and familial confounders (Samuelsson et al., 2013).

A causal association between perceived risk of getting infected with SARS-CoV-2 and anxiety symptoms and stress appears in consonance with prior observed associations between specific worries and fear relating to the COVID-19 pandemic and increases in anxiety and stress (Fitzpatrick et al., 2020; Lee et al., 2020; Montano and Acebes, 2020).

Hypochondria was possibly causally associated with anxiety, stress and depressive symptoms. While hypochondria is known to overlap with several other psychiatric disorders, it has been proposed as a construct on its own (Scarella et al., 2016). In this regard, our findings demonstrate that individual differences in hypochondria could increase or attenuate the likelihood of reporting anxiety and depressive symptoms during COVID-19 pandemic, and this likelihood reflects personal history of exposure to hypochondria more that genetic/shared familial risk. Consistently, previous non-twin research (Mousavi et al., 2021) mentioned sense of vulnerability to disease and injury and job stress as probable consequences of corona-induced hypochondria.

# 4.2. Limitations

This study has some limitations. First of all, although the co-twin control design increases control over genetic and shared environmental confounders, it is unable to control for non-shared confounders that only affect one twin, which can bias estimated effects (Kendler & Gardner, 2010). Second, although we observed that the main sociodemographic characteristics did not differ between participants and non-participants, it cannot be ruled out that the low response rate (31%) may have resulted in residual selection bias. Moreover, the crosssectional nature of the data did not allow us to draw a definitive conclusion about the causal relationship between the examined variables, and therefore our results should be confirmed by longitudinal studies. In particular, it should be noted that, given the considerable comorbidity of hypochondria with other psychiatric disorders, especially anxiety disorders, differentiating hypochondria from these disorders in terms of which disorder is antecedent and which is subsequent is somewhat arbitrary. There are also limitations inherent to the self-report assessment. We did not have measures of mental health that were not self-reported, and it would be important for future studies to include measures that do not rely solely on participant's subjective perception of her/his current mental status. This common method bias, that includes social desirability bias, was partially minimized by participant anonymity. Finally, although our findings are in line with a causal model, we cannot rule out more complex mechanisms underlying the associations. Future studies could test whether the observed effects are influenced by gene-environment correlation and interactions, which were not analyzed here.

#### 5. Conclusions

Our study supported previous findings linking resilience, social support, and self-perceived health to mental health outcomes, and extended these findings by making use of a twin design that minimized the risks of genetic and familial confounding. The present twin investigation suggests potential etiological models for some mental disorders. Factors like self-perception (subjective perception of health status and risk to acquire infections), personality traits (resilience), environmental resources (social support) and comorbid disorders (hypochondria), may prove as compelling as major underlying unshared environmental triggers of common mental disorders and stress.

While our findings require confirmation in longitudinal studies, they

preliminarily suggest that in clinical practice, targeting specific hypochondriac thoughts, health status and social relationships concerns, may have specific therapeutic benefits in the treatment of depression, anxiety and stress. Individuals low in social support, for example, may benefit particularly from group counseling sessions.

From a public health point of view, study findings also highlight the need for calling all the relevant actors to implement training health programs to control anxiety and depression especially in vulnerable populations, such as people experiencing loneliness or who become worried about their health condition for the first time or have a progressive exacerbation of the perception to be at risk, and support them, in times of crisis and/or epidemic with tailored psychosocial interventions aimed at fostering adaptive coping as means of prevention for serious mental health sequelae.

Further, integrated policies should be recommended, which include education, research, and welfare, and engage a wide range of stakeholders within and beyond health in order to promote mental health. For example, school-based mental health promotion programs that optimize self-efficacy, resilience and satisfaction with life, which are fundamental components of positive mental health, could play a role in minimizing the burden that may be caused by stressful life events among young people. The hypothesis is that promoting the emotional strength of an individual, such as self-esteem and resilience, could act as a protective factor, in particular against anxiety and depression. This also concords with cognitive theories that posit negative views of the self, the world, and the future as fundamental aspects characterizing worst mental health.

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#### CRediT authorship contribution statement

**Corrado Fagnani:** Writing – original draft, Methodology, Formal analysis. **Antonella Gigantesco:** Writing – original draft, Methodology. **Gianmarco Giacomini:** Writing – original draft, Visualization. **Emanuela Medda:** Conceptualization, Methodology, Investigation, Formal analysis, Writing – original draft.

#### Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

# Data availability

Data will be made available on request.

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