

## Empirical Article

# Elevated perceived stress in university students due to the COVID-19 pandemic: Potential contributing factors in a propensity-score-matched sample

SVEN AUERSWALD,  CHRISTINE KODDEBUSCH and CHRISTIANE HERMANN*Department of Clinical Psychology and Psychotherapy, Justus-Liebig-University, Giessen, Germany*

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## Objective

Onset of the Coronavirus Disease 2019 (COVID) pandemic has increased students' perceived burdens. The current study aimed to examine COVID-related changes and to identify potential factors that contribute to students' stress.

## Method

Adopting a cross-sectional cohort-study design, we examined perceived stress and depressive and anxiety symptoms with a specific focus on the role of study-related variables such as perceived study-related demands, study-related resources, academic procrastination, and stress-enhancing beliefs. Two cohorts ( $N_{\text{pre-COVID}} = 2,175$ ;  $N_{\text{COVID}} = 959$ ) were recruited at the same university and matched with regard to their propensity score (age, gender, semester).

## Results

Compared with the pre-COVID cohort, university students in the COVID cohort reported more perceived stress, more depressive and anxiety symptoms, more academic procrastination due to fear of failure, more stress-enhancing beliefs, more distress due to the housing situation, and more perceived study-related challenges (Cohen's  $d = 0.15$ – $0.45$ ). A stepwise regression analysis identified depressive symptoms, procrastination due to fear of failure, general self-efficacy, increased study demands, perceived difficulties with self-organized learning, distress due to housing, and stress-enhancing beliefs as predictors of perceived stress in the COVID cohort.

## Discussion

Findings suggest that the switch to online-only education increased the study-related burden for students, primarily due to exams being replaced by a greater amount of regular coursework and imposing demands on self-organized learning. Possibly, stress-enhancing beliefs and procrastination due to fear of failure might have been elevated due to less opportunity for social referencing and lack of felt social support by peer students.

## Conclusion

Experienced increased burden in students during the COVID pandemic was mostly accounted for by a lack of perceived individual resources rather than by an increase in objective study-related demands.

**Key words:** Corona pandemic, Germany, online education, pandemic, stress, study problems, university students.

Christiane Hermann, Justus-Liebig-University Giessen, Department of Clinical Psychology and Psychotherapy, Otto-Behaghel-Str. 10F, D-35394, Giessen, Germany. E-mail: [christiane.hermann@psychol.uni-giessen.de](mailto:christiane.hermann@psychol.uni-giessen.de)

## KEY PRACTITIONER MESSAGES

- With the rise of online education, it is important for practitioners to consider the increased burden placed on university students due to increased stress-enhancing beliefs, more procrastination due to fear of failure, and more study-related difficulties.
- A pre- to COVID increase of perceived study demands was attributable to the online education format being perceived as more demanding than face-to-face instruction.
- The burden of online education is greater for students with low self-regulated learning skills and (possibly already) low general self-efficacy.
- Our findings also suggest that reduced social interactions may not only be detrimental in contributing to depressive symptoms but also affect study-related behaviors such as procrastination due to fear of failure and stress-enhancing beliefs.

## INTRODUCTION

University students exhibit consistently higher stress levels than the general population (Cotton, Dollard & Jonge, 2002; Turiaux & Krinner, 2014). Associated with such chronic stress levels is a prolonged activation of the sympathetic nervous system and the hypothalamic–pituitary–adrenal (HPA) axis, resulting in the release of proinflammatory cytokines (Chrousos, 2009; Schneiderman, Ironson & Siegel, 2005). Such a chronic stress response may result in adverse somatic (e.g., coronary heart diseases; Kivimäki, Virtanen, Elovainio, Kouvonen, Väänänen & Vahtera, 2006) and psychological consequences (e.g., depressive or anxiety symptoms; Chrousos, 2009). Accordingly, students may be particularly vulnerable for developing mental disorders (Auerbach, Mortier, Bruffaerts *et al.*, 2019; Herbst, Voeth, Eidhoff, Müller & Stief, 2016; Stallman, 2010). During the COVID pandemic, studying has become even more stressful than before, which has only exacerbated existing burdens for students

(Abraham, Chaabna, Sheikh *et al.*, 2024; Fang, Ji, Liu *et al.*, 2022; Sivertsen, Knapstad, Petrie, O'Connor, Lønning & Hysing, 2022; Supke, Hahlweg, Kelani, Muschalla, Schulz, 2021; Xiong, Lipsitz, Nasri *et al.*, 2020).

Explanations for increased burden on students due to COVID have focused on two areas. First, stressors due to external constraints and demands drastically increased. As governments and universities imposed restrictive measures to slow down the spread of the virus, students were forced to rapidly reorganize their lives due to campus closures and delay of studies (Schröpfer, Schmidt, Kus, Koob & Coenen, 2021). Similarly, students reported decreased financial income and increased financial constraints (Gewalt, Berger, Krisam, Krisam & Breuer, 2022) as well as more difficulties in focusing on academic work (Kecojevic, Basch, Sullivan & Davi, 2020). In a longitudinal study of 274 US students, Keyserlingk, Yamaguchi-Pedroza, Arum, and Eccles (2022) found that pre- to COVID increase of perceived stress were associated with students reporting that they have less time and energy to complete coursework. A large cross-sectional study of more than 5,000 German university students (conducted in May 2020) reported similar findings: Every second student reported a significantly increased pre- to COVID university workload, and students endorsed significantly more stress related to the switch to digital teaching methods, which led to heightened stress (Matos Fialho, Spatafora, Kühne *et al.*, 2021; Xu & Wang, 2023).

Yet, it is well established that perceived stress is not a direct consequence of being exposed to (potentially) stressful experiences. The *transactional stress model* (Lazarus & Folkman, 1987) postulates that perceived stress depends on an individual's appraisal of the stressors and of one's own resources. Seeking to validate the transactional stress model in a cross-sectional pre-COVID sample of more than 1,300 university students, Dickhäuser, Koddebusch, and Hermann (2022) showed that perceived stress was not accounted for by study-related objective demands (i.e., exam load, study-related workload, and time needed for preparation). Rather, stress was determined by individual maladaptive beliefs, coping, and resources (i.e., social support and self-efficacy), consistent with the *secondary appraisal* proposed by the transactional stress model.

Second, previous literature has highlighted the lack of perceived individual resources as contributing to increased burden during COVID: Lack of social support (Hubbard, Den Daas, Johnston & Dixon, 2021; Ozer, 2024), stress-modulating beliefs such as increased procrastination (Keyserlingk, Yamaguchi-Pedroza, Arum & Eccles, 2022) and negative rumination (Sheldon, Simmonds-Buckley, Bone *et al.*, 2021), and worries about health (Spatafora, Matos Fialho, Busse *et al.*, 2022), finances (Rose, 2020) and graduation (Lyons, Wilcox, Leung & Dearsley, 2020; Plakhotnik, Volkova, Jiang *et al.*, 2021) have been considered to reflect students' perceived inability to meet those demands using their own resources (i.e., lack of self-efficacy; Bandura, 2001). However, only a few studies have included study-related challenges, or have investigated how altered stress levels in students as related to the COVID pandemic are accounted for by study-relevant variables (e.g., procrastination, study-related demands) and beliefs (e.g., self-efficacy).

Notably, most studies investigated students' stress experience and COVID-related challenges in a cross-sectional design. Since

the COVID pandemic could not have been foreseen, longitudinal studies are sparse. Given the heterogeneity of student populations (especially with respect to their sociodemographic characteristics) and the setting of cross-sectional studies, they cannot easily be compared with each other or with previous studies. Due to different sociocultural contexts, student samples from different universities may differ in terms of self-reported stress. As Charles, Strong, Burns, Bullerjahn, and Serafine (2021) pointed out, it is uncertain whether the reported stress levels and related symptoms are indeed elevated and may not, in fact, be typical for a particular cohort. Hence, when potential changes in stress levels and study problems (as related to the COVID pandemic) are cross-sectionally investigated, it would seem important to compare student cohorts which are from the same university and, therefore, maximally similar.

The aim of the present study was two-fold. First, we were interested in determining whether university students during the COVID pandemic reported being more burdened than their fellow students prior to the pandemic. In order to maximize the similarity of the cohorts, the pre-COVID and COVID samples were propensity-score-matched.

The second aim was to identify those factors that contributed to students' perceived stress during the COVID pandemic. We relied on those factors that were identified by Dickhäuser *et al.* (Dickhäuser, Koddebusch & Hermann, 2022) based on the transactional stress model adapted for students. Specifically, depressive and anxiety symptoms, general self-efficacy, perceived study-related demands, study-related resources, personal stressors (i.e., distress due to housing, distress due to funding), and study-related stress-modulating beliefs (i.e., academic procrastination) were identified as significant predictors of perceived stress using a cross-sectional design. Here, we were interested in replicating these variables as relevant predictors in accounting for students' stress levels during COVID, and in elucidating whether perceived demands related to online-only teaching further contribute to students' perceived stress.

## MATERIALS AND METHODS

### Research design

Using a cross-sectional design, we compared a sample of students recruited during the COVID pandemic and a propensity-matched pre-COVID student sample. The latter was drawn from a large student sample from the same university who had participated in the online survey assessing students' stress and possible contributing factors prior to the pandemic (i.e., 2016–2017).

### Participants

All participants were recruited at a mid-size German university (ca. 28,000 students). Participants in the pre-COVID cohort ( $N = 2,175$ ) were recruited in two different cross-sectional waves, in 2016 ( $n = 1,604$ ; cf. Dickhäuser, Koddebusch & Hermann, 2022) and 2017 ( $n = 571$ ) for a study on stress in students. Participants were recruited by advertisements via emails and lectures. Since the aim was to obtain representative data on the stress level of students at this university, the 2017 sample was specifically recruited among those students enrolled in study programs having participated less in the 2016 wave. Participants in the COVID cohort ( $n = 959$ ) were recruited between March and June 2021 by advertising via emails and online lectures (i.e., during the second nationwide lockdown in Germany).

The study was approved by the local ethics committee (#2015-0004), and informed consent of the participants was obtained. Characteristics of both cohorts at baseline can be seen in Table 1.

There were slight differences between the two cohorts regarding sociodemographic characteristics prior to propensity matching (see table 1). The COVID cohort included more female participants (82.6% vs. 74.7%), more international students (4.5% vs. 2.3%), more psychology students (14.8% vs. 5.3%), more veterinary students (15.6% vs. 8.1%), but fewer students in social and cultural sciences (5.4% vs. 9.6%) and fewer teacher training students (15.3% vs. 19%) than the pre-COVID cohort. The participants in the COVID cohort had, on average, completed a higher number of semesters, which is partially explained by government regulations extending the allowed duration of study programs due to the pandemic. During the online-only teaching semester, more students in the COVID cohort lived with their parents as compared with the pre-COVID cohort. Fewer students in the COVID cohort (20.3% vs. 26.9%) reported relying on loans to finance their studying.

### Questionnaires

**Study-related objective demands.** Study-related objective demands were captured with four questions: (1) "How many written exams do you have this semester?," (2) "How many oral exams do you have this semester?," (3) "How many presentations do you have to give this semester?," and (4) "How many essays do you have to write this semester?" For these four items, there were five frequency categories (0 = "none," 1 = "1–2," 2 = "3–4," 3 = "5–6," 4 = "7 or more"). *Study-related working hours* was captured with the single question: "How many hours per week do you usually spend on doing class work?"

**Perceived stress.** The subjective stress level was assessed by the Perceived Stress Scale (PSS-10; Cohen & Williamson, 1988; German version: Klein, Brähler, Dreier *et al.*, 2016). The items assess the extent to which life is appraised as unpredictable and overwhelming (e.g., "In the last month, how often have you felt nervous and 'stressed'?"). Participants indicate the frequency of stress responses on a five-point Likert scale, ranging from 0 = *never* to 4 = *very often*. Previous studies have used a cutoff score of 27 for severely elevated stress levels (Graves, Hall, Dias-Karch, Haischer & Apter, 2021). Construct validity as well as good internal consistency (Cronbach's  $\alpha = 0.84$ ) has been established in various German populations (Klein, Brähler, Dreier *et al.*, 2016; Reis, Lehr, Heber & Ebert, 2019). Internal consistency in both cohorts was equally good in both cohorts (pre-COVID cohort: Cronbach's  $\alpha = 0.87$ ; COVID cohort:  $\alpha = 0.88$ ).

**Depressive and anxiety symptoms.** The German version of the Patient Health Questionnaire (Löwe, Zipfel & Herzog, 2002) was used for assessing depressive mood (PHQ-9) and anxiety symptoms (GAD-7). Each item of the PHQ-9 checks one of the nine DSM-IV criteria of major depression (e.g., loss of interest, suicidal ideation) over the last 4 weeks. For each symptom, the frequency is to be rated on a four-point Likert scale (0 = *not at all* to 3 = *nearly every day*). The scale sum score is used for analysis (the cutoff for clinical levels of depressive symptoms is  $\geq 10$ ; Gilbody, Richards, Brealey & Hewitt, 2007; Venanzi, Dickey, Green *et al.*, 2022). The GAD-7 captures the presence and frequency of anxiety symptoms over the last 4 weeks (e.g., "Feeling nervous, anxious or on edge," "Trouble relaxing") and is rated on a three-point Likert scale (0 = *not at all* to 2 = *more than half of the days*). Reliability and validity have been well established for both the PHQ-9 and GAD-7 (Arroll, Goodyear-Smith, Crengle *et al.*, 2010; Gilbody, Richards, Brealey & Hewitt, 2007; Gräfe, Zipfel, Herzog & Löwe, 2004; Kroenke, Spitzer & Williams, 2001; Kroenke, Wu, Yu *et al.*, 2016). In the present study, internal consistency was high for both the PHQ-9 (pre-COVID: Cronbach's  $\alpha = 0.86$ ; COVID cohort:  $\alpha = 0.85$ ) and the GAD-7 ( $\alpha = 0.71$  for pre-COVID and COVID cohorts).

**Personal stressors.** *Distress due to housing* and *Distress due to funding*: Two items assessed perceived stress due to the students' housing

situation ("To what extent do you feel stressed because of your current housing situation?") and due to a strained financial situation ("To what extent do you feel stressed because of your current financial situation?"). The level of stress is indicated on a five-point Likert scale (1 = *not at all* to 5 = *a lot*).

**Perceived study-related demands and study-related resources.** As part of the assessment of students' stress and contributing factors, 12 items were constructed to measure students' perceived study-related demands. In order to identify underlying dimensions, a factor analysis was carried out for the pre-COVID cohort data. First, item intercorrelations were computed and items with at least one significant inter-correlation ( $0.3 < r < 0.9$ ) were included in the factor analysis (Williams, Onsmann & Brown, 2010). At this step, one item was excluded. Next, a parallel analysis (Hayton, Allen & Scarpello, 2004; Lautenschlager, 1989) was conducted identifying two underlying factors. Subsequently, an exploratory factor analysis (EFA) with two pre-set factors was run using oblimin rotation ( $\Delta = 0$ ) and principal axis factoring as the extraction method. The Kaiser-Meyer-Olkin measure confirmed sampling adequacy for the analysis (KMO = 0.81). Items were retained, if they loaded on factors  $> 0.5$  and had cross-loadings  $< 0.3$  (Matsunaga, 2010). Factor 1 (eight items, labeled "*Perceived study-related demands*") represents perceived difficulties in cognitive functioning (e.g., "I think that I remember things worse and slower than my fellow students.") and problems in self-organizing studying behavior (e.g., "I struggle with self-directed studying."). Factor 2 (three items, labeled "*Study-related resources*") entails items addressing lecturers' helpful behaviors (e.g., "My teachers guide me well to solve tasks."). Factor 1 and factor 2 accounted for 38.9% and 14.9% of total variance, respectively. Internal consistency of both factors was good for both factors (factor 1: Cronbach's  $\alpha = 0.85$ ; factor 2: Cronbach's  $\alpha = 0.73$ ). The complete pattern matrix is provided in the Supplementary Materials (Table S1). The parallel analysis was repeated in the COVID cohort and yielded the same factor structure and good internal consistency for factor 1 (Cronbach's  $\alpha = 0.84$ ) and factor 2 ( $\alpha = 0.73$ ). Mean item scores for factor 1 and factor 2 are used for analysis.

**Stress-modulating beliefs.** The General Self-Efficacy Scale (GSE; Schwarzer & Jerusalem, 1995) assesses general beliefs in one's ability to deal with demands and challenges. The questionnaire consists of 10 items (e.g., "I can always manage to solve difficult problems if I try hard enough.") which are answered on a four-point Likert scale (1 = *not at all true* to 4 = *exactly true*). The total sum score is used for analysis. The GSE is a well-established questionnaire, and its construct validity has been demonstrated in many studies using different language versions (e.g., Leganger, Kraft & Røysamb, 2000; Luszczynska, Scholz & Schwarzer, 2005; Schwarzer, Mueller & Greenglass, 1999). Internal consistency in both the pre-COVID (Cronbach's  $\alpha = 0.88$ ) and COVID cohorts ( $\alpha = 0.87$ ) compared well with previous findings (Luszczynska, Scholz & Schwarzer, 2005; Schwarzer, Mueller & Greenglass, 1999).

The Academic Procrastination State Inventory (APSI; Schouwenburg, 1995; German version: Helmke & Schrader, 2000) assesses the extent to which typical procrastination behaviors occurred over the last 3 months. The APSI consists of 23 items and three subscales: *state procrastination* (12 items; e.g., "I stopped studying to do something more pleasant."), *procrastination due to fear of failure* describing fear and uncertainty regarding studying (six items; e.g., "I experienced panic when studying."), and *procrastination due to lack of study motivation* (five items; e.g., "I had no energy to study."). Frequency of procrastination behaviors during the last 3 months is rated on a five-point Likert scale (0 = *never* to 4 = *always, constantly*). In the present cohorts, internal consistency of the three subscales was high (Cronbach's  $\alpha = 0.84$  and  $0.90$ ), corresponding well with previous reports (Patzelt & Opitz, 2014). For each subscale, the mean item score is obtained.

**Stress-enhancing beliefs** was captured with seven items (Dickhäuser, Koddebusch & Hermann, 2022). Items address excessive self-reliance ("I want to do everything by myself."), need for being liked ("I want to get along well with others."), avoiding to fail ("I'm not allowed to fail."), helplessness ("I cannot do this."), being relentless with oneself ("I'm not

Table 1. Group differences between the pre-COVID and COVID cohorts before and after matching

	Before matching			After matching		
	Pre-COVID (N = 2,175)	COVID (N = 959)	Group differences ( <i>t</i> -test or $\chi^2$ )	Pre-COVID (N = 959)	COVID (N = 959)	Group differences ( <i>t</i> -test or $\chi^2$ )
<b>Sociodemographics</b>						
Age, <i>M</i> ( <i>SD</i> )	22.62 (3.47)	22.88 (3.50)	−1.90	22.77 (3.20)	22.88 (3.50)	−0.70
Gender (female), <i>N</i> (%)	1,624 (74.7)	793 (82.6)	23.77***	796 (83.0)	792 (82.6)	0.24
Current Number of semesters, <i>M</i> ( <i>SD</i> )	4.56 (3.29)	4.98 (3.7)	−3.27***	4.94 (3.10)	4.99 (3.47)	−0.30
In a relationship (Yes), <i>N</i> (%)	1,169 (54.8)	463 (47.7)	4.66	541 (56.4)	456 (47.5)	9.43**
Caretaker responsibilities (children and relatives) (Yes), <i>N</i> (%)	81 (3.7)	52 (5.4)	4.70*	33 (3.4)	52 (5.4)	4.44*
Migration background (Yes), <i>N</i> (%)	496 (22.8)	246 (25.6)	2.93	228 (23.8)	246 (25.7)	0.91
International students (Yes), <i>N</i> (%)	49 (2.3)	43 (4.5)	11.59***	21 (2.2)	43 (4.5)	7.82**
Non-native German speaker (Yes), <i>N</i> (%)	139 (6.4)	76 (7.9)	5.30	63 (6.6)	76 (7.9)	5.27
<b>Enrolled university degree, <i>N</i> (%)</b>						
Bachelor <sup>a</sup>	933 (42.9)	428 (44.6)	0.60	433 (45.2)	441 (46.0)	0.14
Master <sup>a</sup>	333 (15.3)	144 (15.0)	0.13	167 (17.4)	144 (15.0)	2.03
State Licensure Program <sup>b</sup>	905 (42.2)	387 (40.3)	0.50	369 (38.5)	387 (40.4)	0.71
<b>Degree Course – field of study, <i>N</i> (%)</b>						
<b>Bachelor's &amp; Master's Programs</b>						
Psychology	115 (5.3)	142 (14.8)	79.94***	38 (4.0)	141 (14.7)	65.37***
Natural Sciences (physics, biology, chemistry)	155 (7.1)	72 (7.5)	0.13	43 (4.5)	72 (7.5)	25.99**
Social Sciences and Cultural Sciences	208 (9.6)	52 (5.4)	17.18***	114 (11.9)	52 (5.4)	34.31***
Agricultural Sciences, Nutritional Sciences and Environmental Management	255 (11.7)	150 (15.6)	0.40	124 (12.9)	150 (15.6)	0.34
<b>State Licensure Programs<sup>b</sup></b>						
Medicine	150 (6.9)	54 (5.6)	1.77	51 (5.3)	54 (5.6)	0.09
Veterinary Medicine	176 (8.1)	150 (15.6)	40.564***	78 (8.1)	150 (15.6)	5.53*
Teacher Training	413 (19.0)	147 (15.3)	6.13*	186 (19.4)	147 (15.3)	5.53*
<b>Housing situation, <i>N</i> (%)</b>						
<b>Student accommodation</b>						
Shared apartment	167 (7.7)	43 (4.5)	10.91**	69 (7.2)	43 (4.5)	9.25**
Own apartment (with/without partner)	673 (30.9)	274 (28.5)	1.82	295 (30.8)	274 (28.5)	2.23
Living with parents	773 (35.5)	345 (35.9)	0.50	340 (35.5)	345 (35.9)	0.08
Living with parents	562 (25.8)	298 (31.0)	9.06**	255 (26.6)	297 (31.0)	8.08**
<b>Sources of funding<sup>c</sup>, <i>N</i> (%)</b>						
Parents/partner	1,588 (73.0)	714 (74.4)	0.64	679 (70.8)	713 (74.3)	3.03
Job	1,083 (49.8)	482 (50.2)	0.05	530 (55.3)	482 (50.3)	4.82*
Loan	585 (26.9)	195 (20.3)	15.45***	269 (28.1)	195 (20.3)	15.57***
Own savings/legacy	487 (22.4)	233 (24.3)	1.33	195 (20.3)	233 (24.3)	4.34*
Time needed for studying (hours), <i>M</i> ( <i>SD</i> )	14.83 (10.94)	26.81 (15.62)	−21.40***	9.48 (8.43)	26.84 (15.68)	−30.09***
<b>Study-related objective demands</b>						
<b>Written coursework, <i>N</i> (%)</b>						
“None”	855 (39.3)	282 (29.4)	27.53***	329 (34.5)	261 (27.6)	10.35**
“1–2”	770 (35.4)	393 (40.9)	8.75**	358 (37.5)	388 (41.1)	2.54
“3–4”	359 (16.5)	131 (13.6)	4.13*	186 (19.5)	131 (13.9)	10.77**
“5–6”	95 (4.4)	60 (6.3)	5.02*	35 (3.7)	60 (6.3)	7.21**
“7 and more”	96 (4.4)	94 (9.8)	33.83***	36 (3.8)	93 (9.8)	27.67***
<b>Oral presentations, <i>N</i> (%)</b>						
“None”	779 (35.8)	344 (35.8)	0.00	318 (33.2)	344 (35.8)	3.09
“1–2”	809 (37.2)	344 (35.8)	0.53	369 (38.5)	344 (35.8)	1.51
“3–4”	447 (20.6)	209 (21.9)	0.60	214 (22.3)	208 (21.7)	1.07
“5–6”	107 (4.9)	49 (5.1)	0.05	45 (4.7)	49 (5.1)	0.04
“7 and more”	33 (1.5)	14 (1.4)	0.02	13 (1.4)	14 (1.4)	0.16
<b>Written examinations, <i>N</i> (%)</b>						
“None”	156 (7.2)	86 (9.0)	2.98	82 (8.6)	85 (9.0)	0.10
“1–2”	452 (20.8)	197 (20.5)	0.28	205 (21.5)	194 (20.5)	0.25
“3–4”	716 (32.9)	400 (41.7)	22.23***	318 (33.3)	397 (42.0)	15.36***
“5–6”	673 (30.9)	213 (22.2)	25.18***	281 (29.4)	209 (22.1)	13.25***
“7 and more”	178 (8.2)	64 (6.7)	2.15	69 (7.2)	60 (6.3)	0.58
<b>Oral examinations, <i>N</i> (%)</b>						
“None”	1,524 (70.1)	681 (70.9)	0.24	677 (70.9)	671 (71.0)	0.00
“1–2”	461 (21.2)	240 (25.0)	5.55*	203 (21.3)	237 (25.1)	3.90

(continued)

Table 1. (continued)

	Before matching			After matching		
	Pre-COVID ( <i>N</i> = 2,175)	COVID ( <i>N</i> = 959)	Group differences ( <i>t</i> -test or $\chi^2$ )	Pre-COVID ( <i>N</i> = 959)	COVID ( <i>N</i> = 959)	Group differences ( <i>t</i> -test or $\chi^2$ )
"3–4"	126 (5.8)	33 (3.4)	7.68**	49 (5.1)	32 (3.4)	3.54
"5–6"	37 (1.7)	2 (0.2)	12.08***	14 (1.5)	2 (0.2)	8.95**
"7 and more"	27 (1.2)	4 (0.4)	4.63*	12 (1.3)	3 (0.3)	5.35*

<sup>a</sup>Bachelor's and Master's Programs each have a duration of 6 and 4 semesters.

<sup>b</sup>The state licensure programs range in terms of duration from 9 (law) to 11 (medicine) semesters.

<sup>c</sup>Multiple answers possible.

\*\*\* $p < 0.001$ ;

\*\* $p \leq 0.01$ ;

\* $p < 0.05$ .

allowed to rest."), high need for achievement ("I want to be the best."), and perfectionism ("I must not make mistakes."). Internal consistency was good in the pre-COVID and COVID cohort (Cronbach's  $\alpha = 0.74$  for both cohorts). For more information, see Supplementary Materials (Table S3).

**Perceived demands related to online-only teaching.** At the time of the data collection for the COVID cohort, statewide lockdowns were in place in Germany. Universities switched to online-only teaching with very rare exceptions for lab courses in natural sciences or medical school. The format of such online-only classes included live interactive seminars and lectures as well as pre-recorded lectures made available to students. Four items were constructed to capture the demands related to online-only teaching: Item 1 – "I feel self-organized learning at home is currently more difficult than before COVID." Item 2 – "I feel the teaching staff successfully switched to online-only learning." Item 3 – "I feel the study demands have increased due to online-only teaching." Item 4 – "I feel the teaching staff is supportive with respect to the change to online-only teaching (e.g., being available to students via email, video conferencing...)." Participants rated the extent to which they agreed on a five-point Likert scale (0 = *I disagree* to 4 = *I agree*). For descriptive statistics, see Supplementary Materials (Table S2). Items were interpreted individually.

### Procedure

As part of the advertising emails, participating university students received a survey link. For data collection, Unipark software (Questback GmbH, 2020) was used. Students of the Department of Psychology and Sports Science received course credit for participation. All participants automatically participated in a lottery of various vouchers (25 euros).

### Data analysis

In order to control for confounding variables, participants in both cohorts were matched on their propensity score using Austin's (2007, 2011) four-step procedure. First, we specified the propensity score model. Second, we constructed the propensity-score-matched sample using R-studio (v.4.3.2, RCore Team, 2023) and the library packages *Match-it* (Ho, Imai, King & Stuart, 2011) and *Cobalt* (Greifer, 2023). We used nearest neighbor matching without replacement with a caliper of width 0.2. Third, we assessed whether the propensity score model was adequately specified. Fourth, we investigated cohort differences with the matched sample using SPSS software 27 (IBM Corp., 2021). For all questionnaires, outlier analysis was carried out (absolute *z*-scores  $> 3.29$  were excluded from analysis).

Differences between the pre- and COVID sample with regard to perceived stress and the potential predictor variables were tested using independent *t*-tests (two-sided) with Bonferroni correction (i.e.,  $p \leq 0.004$ ) to limit alpha inflation. In case of heterogeneity of variance, the degrees of

freedom were adjusted, yet nominal degrees of freedom are reported. Differences with respect to categorical baseline characteristics were investigated with Pearson's  $\chi^2$  tests. Zero-order correlations between perceived stress and potential predictor variables were computed with the significance level set at  $p \leq 0.01$  to limit alpha inflation.

A forward stepwise linear regression was used to identify possible predictors of perceived stress (PSS-10) in the COVID cohort by entering the following variables as identified by Dickhäuser *et al.* (2022): age, gender, semester, depressive symptoms (i.e., PHQ-9), anxiety symptoms (i.e., GAD-7), stress-enhancing beliefs, general self-efficacy (i.e., GSE), academic procrastination (i.e., state procrastination, fear of failure, aversion), study-related resources, and perceived demands (i.e., perceived study-related demands, distress due to housing, and distress due to funding). In addition, perceived demands related to online-only teaching were included (i.e., self-organized learning at home, successful switch to online-only by teaching staff, perceived increased study demands, support by teaching staff). At each step, variables were added based on the probability threshold of *F*-entry  $p \leq 0.002$ .<sup>1</sup>

Prior to carrying out the regression analysis, assumptions were checked (cf., Fox, 2016). Predictors displayed normally distributed errors, and there was no sign of heteroscedasticity. A linear relationship of predictors with the outcome was examined with Component-Plus-Residual-Plots; for discrete data the "lack of fit"-test was used. Predictors exhibited a linear relationship with the outcome variable (PSS-10). Tolerances were greater than 0.50, and VIFs were less than 2.00, indicating that there was no evidence for multicollinearity.

De-identified data along with a codebook and analysis scripts are posted at <https://doi.org/10.5281/zenodo.10731829>.

## RESULTS

### Propensity score matching

Baseline test statistics (see Table 1) yielded significant group differences with respect to semester and gender. Consistent with Dickhäuser *et al.*'s (Dickhäuser, Koddebusch & Hermann, 2022) regression model, which controlled for semester, gender, and age, we used these three covariates for propensity score matching. Second, we constructed the propensity-score-matched sample, which consisted of 959 matched pairs (100% of the COVID cohort were successfully matched to a student from the pre-COVID cohort with a similar value of the propensity score). The distribution of the propensity scores in the unmatched and matched samples and the propensity scores overlapping using mirrored histogram can be seen in Fig. 1. The baseline characteristics of the matched sample are described in Table 1.<sup>2</sup>

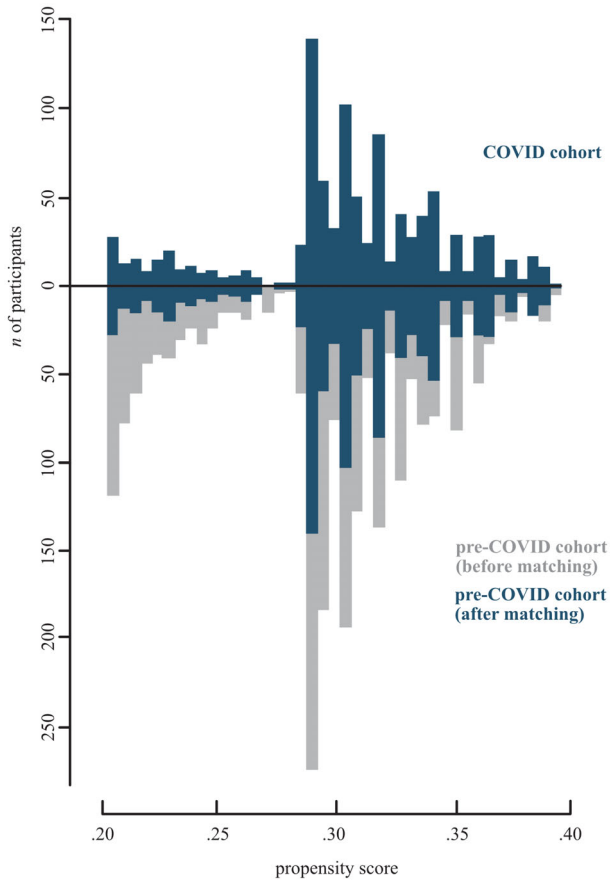


Fig. 1. Mirrored histogram of propensity scores showing the propensity score distribution and overlapping in unmatched (gray) and matched (blue) samples with COVID cohort (top) and pre-COVID cohort (bottom).

Third, systematic differences were investigated using empirical cumulative distribution plots, distribution balances, and the quantile-quantile plots for the three covariates (see Supplementary Materials, Figs. S4 and S5). The standardized mean differences for covariates after matching ranged from  $-0.011$  to  $0.030$  (see Fig. 2), and variance ratios ranged from 1.019 to 1.199, indicating a good balance. Thus, the propensity score model appears to have been adequately specified: After matching on the estimated propensity score, there were no systematic differences between the COVID and pre-COVID cohorts on all three covariates.

*Comparison of the propensity-score-matched pre-COVID and COVID cohorts*

Compared with the propensity-matched pre-COVID cohort, participants in the COVID cohort reported significantly more stress, more depressive and anxiety symptoms, more procrastination due to fear of failure, more stress-enhancing beliefs, increased perceived study-related distress, and more distress due to housing. Effect sizes were small to medium (Cohen’s  $d$  ranging from 0.15 to 0.45; see Table 2; corresponding bar graphs can be seen in Supplementary Materials, Figure S6). There were no significant group differences regarding general self-efficacy, study-related resources, state procrastination, procrastination due to lack of motivation, or distress due to funding. Compared with the pre-COVID cohort (16.0%), significantly more participants in the COVID cohort (30.1%) reported severely elevated perceived stress levels (i.e.,  $PSS-10 \geq 27$ :  $\chi^2(1) = 54.38, p < 0.001$ ). Similarly, compared with the pre-COVID cohort (39.1%), significantly more participants in the COVID cohort (44.0%) met the clinical cutoff for depression symptoms (i.e.,  $PHQ-9 \geq 10$ :  $\chi^2(1) = 4.74, p = 0.03$ ).

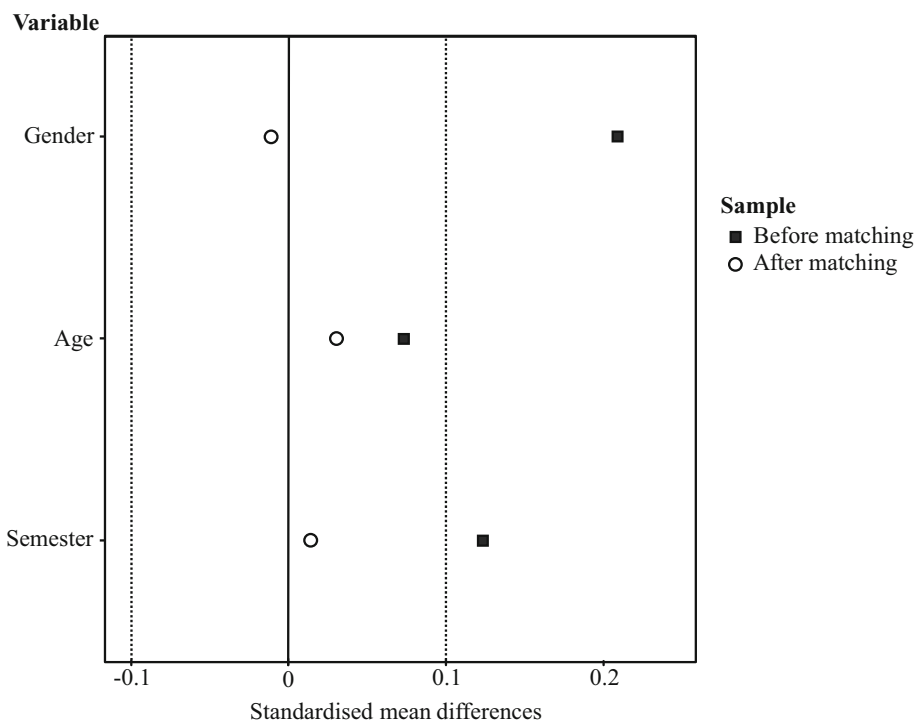


Fig. 2. Covariance balance plot for gender, age, and semester before (rectangle) and after matching (circle).

Table 2. Descriptive statistics (*M*, *SD*) and group differences in the propensity-score-matched sample for the dependent and predictor variables

	Pre-COVID ( <i>N</i> = 959) <i>M</i> ( <i>SD</i> )	COVID ( <i>N</i> = 959) <i>M</i> ( <i>SD</i> )	<i>t</i> -value   ( <i>df</i> 1916)	Cohen's <i>d</i>   [CI 95%]
Outcome variable				
Perceived stress (PSS-10)	19.59 (6.86)	22.63 (6.56)	9.93*	0.45 [0.36 0.54]
Potential predictor variables				
Depressive symptoms (PHQ-9)	8.79 (5.29)	9.56 (5.32)	3.15*	0.15 [0.06 0.24]
Anxiety symptoms (GAD-7)	7.08 (2.79)	7.61 (2.86)	3.68*	0.19 [0.09 0.29]
General self-efficacy (GSE)	27.16 (4.60)	27.06 (4.59)	0.46	0.02 [−0.07 0.11]
Stress-enhancing beliefs	15.84 (5.00)	17.52 (5.05)	7.11*	0.34 [0.24 0.43]
Study-related resources	3.25 (0.87)	3.32 (0.83)	1.64	0.08 [−0.02 0.17]
State procrastination (APSI)	3.03 (0.68)	3.06 (0.73)	0.83	0.04 [−0.06 0.13]
Fear of failure (APSI)	2.66 (0.83)	2.94 (0.84)	7.03*	0.33 [0.24 0.43]
Lack of motivation (APSI)	2.53 (0.86)	2.55 (0.90)	0.55	0.03 [−0.07 0.12]
Perceived study-related demands	2.64 (0.94)	2.93 (0.93)	6.54*	0.31 [0.22 0.40]
Distress due to funding	2.40 (1.20)	2.27 (1.20)	2.34	0.11 [0.02 0.20]
Distress due to housing	1.84 (0.95)	2.05 (1.20)	4.63*	0.21 [0.12 0.30]

Note: \*two-sided *p*-value significant with Bonferroni correction ( $\alpha = [0.05]/12 = 0.004$ ); due to missing values, sample sizes ranged from  $n = 1,544$  to  $n = 1,918$ .

**Study-related objective demands.** The COVID cohort reported significantly fewer written exams (Mann–Whitney *U*-test;  $z = -2.08$ ,  $p = 0.04$ ): there was a significant pre- to COVID frequency increase in the category “3–4 exams” (33.3% vs. 42.0%;  $\chi^2[1, N = 1900] = 15.36$ ,  $p < 0.001$ ) and a decrease in “5–6 exams” (29.4% vs. 22.1%;  $\chi^2[1, N = 1900] = 13.25$ ,  $p < 0.001$ ). The COVID cohort reported significantly more written coursework (Mann–Whitney *U*-test;  $z = -3.65$ ,  $p < 0.001$ ): There was a significant pre- to COVID frequency decrease in the category “no coursework” (34.5% vs. 27.46%;  $\chi^2[1, N = 1900] = 10.35$ ,  $p = 0.001$ ) and “3–4 coursework” (19.5% vs. 13.9%;  $\chi^2[1, N = 1900] = 10.77$ ,  $p = 0.001$ ). By contrast, in the COVID cohort participants endorsed more frequently the category of “5–6 coursework” (6.3% vs. 3.7%;  $\chi^2[1, N = 1900] = 7.21$ ,  $p = 0.007$ ) and “7 and more coursework” (9.8% vs. 3.8%;  $\chi^2[1, N = 1900] = 27.67$ ,  $p < 0.001$ ). Participants in the COVID cohort ( $M = 26.84$  h,  $SD = 15.68$  h) reported spending significantly more time preparing for university courses than the pre-COVID cohort ( $M = 9.48$  h,  $SD = 8.43$  h;  $t[1899] = -30.09$ ,  $p < 0.001$ ; Cohen's  $d = -1.38$ ). For more information, see Table 1.

#### Relationship between perceived stress and potential predictors in the COVID cohort

Zero-order correlations between perceived stress and demographic variables were significant only for gender ( $r = 0.12$ ) in the COVID cohort. In line with findings by Dickhäuser, Koddebusch, and Hermann (2022), study-related objective demands (i.e., written coursework, oral presentations, oral exams, and written exams) were not significantly correlated with perceived stress. Accordingly, they were not included as predictors in the subsequent regression analysis. All other potential predictor variables were significantly related to perceived stress: Particularly large correlations were observed for depressive symptoms ( $r = 0.65$ ), procrastination due to fear of failure ( $r = 0.64$ ), study-behavior problems ( $r = 0.56$ ), and general self-efficacy ( $r = -0.50$ ; see Table 3 for details).

Table 3. Pearson's correlations between perceived stress (PSS-10) and potential predictors in both cohorts

Potential predictors	Pre-COVID ( <i>N</i> = 959)	COVID ( <i>N</i> = 959)
Demographics		
Age	0.13**	0.02
Gender	0.16**	0.12**
Semester	0.06	−0.03
Study-related objective demands		
Written coursework	0.07	0.05
Oral presentations	0.07	−0.05
Written exams	−0.04	0.03
Oral exams	0.06	0.08
Depression and anxiety		
Depressive symptoms (PHQ-9)	0.69**	0.65**
Anxiety symptoms (PHQ-7)	0.56**	0.52**
Beliefs and resources		
General Self-Efficacy	−0.55**	−0.50**
Stress-enhancing beliefs	0.39**	0.38**
Study-related resources	−0.23**	−0.32**
APSI – State procrastination	0.40**	0.38**
APSI – Fear of failure	0.65**	0.64**
APSI – Lack of motivation	0.43**	0.47**
Perceived demands		
Perceived study-related demands	0.57**	0.56**
Distress due to housing situation	0.29**	0.34**
Distress due to funding situation	0.36**	0.30**
Demands related to online-only teaching <sup>a</sup>		
Difficulties with self-organized learning at home	– <sup>b</sup>	0.38**
Successful switch to online-only (teaching staff)	–	0.23**
Increased study demands	–	0.35**
Supported by teaching staff	–	0.30**

Note: Due to missing values, sample sizes ranged from  $n = 1,544$  to  $n = 1,918$ .

<sup>a</sup>Single items measuring perceived additional demands due to COVID situation.

<sup>b</sup>Not available.

\*\* $p < 0.01$ .

### Regression analysis with perceived stress as dependent variable in the COVID cohort

A stepwise regression analysis was carried out with perceived stress (PSS-10) as dependent variable initially entering 18 variables that might account for students' stress level. The analysis identified seven significant predictor variables. Results of the regression analysis are presented in Table 3. The Durbin-Watson statistic was 1.886, indicating the absence of auto-correlations in the residuals of the last model. The total model accounted for 52% of variance. At each step, the amount of accounted variance increased significantly (step 1: 37%; step 2: 7%; step 3: 3%; step 4: 2%; step 5: 1%; step 6: 1%; step 7: 1%). In the final model, predictors were depressive symptoms

( $\beta = 0.30$ ), procrastination due to fear of failure ( $\beta = 0.20$ ), general self-efficacy ( $\beta = -0.18$ ), perceived difficulties with self-organized learning ( $\beta = 0.12$ ), perceived difficulties due to increased study demands ( $\beta = 0.12$ ), distress due to housing ( $\beta = 0.10$ ), and stress-enhancing beliefs ( $\beta = 0.09$ ). See Table 4 for details.

### DISCUSSION

This study investigated potential contributing factors to students' elevated stress as related to the COVID pandemic in a cross-sectional design. To this end, we compared a COVID cohort with a pre-COVID cohort from the same university, with regard to

Table 4. Multiple regression analysis with PSS-10 as outcome variable in the COVID cohort ( $N = 719$ )

Predictors	<i>B</i>	<i>SE</i>	$\beta$	<i>t</i> -value	$R^2$	$R^2$ adj.	$\Delta R^2$
Model 1					0.37	0.37***	
(Constant)	16.52	0.39		42.09***			
<i>PHQ-9</i>	0.70	0.03	0.61	20.66***			
Model 2					0.44	0.44***	0.07***
(Constant)	11.23	0.68		16.59***			
PHQ-9	0.47	0.04	0.41	11.77***			
<i>APSI Fear of Failure</i>	2.49	0.27	0.33	9.32***			
Model 3					0.47	0.47***	0.03***
(Constant)	20.05	1.48		13.56***			
PHQ-9	0.43	0.04	0.37	10.81***			
<i>APSI Fear of Failure</i>	2.08	0.27	0.27	7.80***			
<i>GSE</i>	-0.27	0.04	-0.20	-6.66***			
Model 4					0.50	0.49***	0.02***
(Constant)	19.13	1.46		13.12***			
PHQ-9	0.40	0.04	0.35	10.20***			
<i>APSI Fear of Failure</i>	1.86	0.26	0.24	7.03***			
<i>GSE</i>	-0.27	0.04	-0.20	-6.91***			
<i>Increased study demands<sup>a</sup></i>	0.80	0.16	0.15	5.51***			
Model 5					0.51	0.50***	0.01***
(Constant)	18.47	1.45		12.74***			
PHQ-9	0.38	0.04	0.33	9.84***			
<i>APSI Fear of Failure</i>	1.74	0.26	0.23	6.65***			
<i>GSE</i>	-0.26	0.04	-0.20	-6.70***			
<i>Increased study demands<sup>a</sup></i>	0.65	0.15	0.13	4.41***			
<i>Distress due to housing<sup>a</sup></i>	0.54	0.13	0.12	4.19***			
Model 6					0.52	0.51***	0.01***
(Constant)	17.38	1.47		11.87***			
PHQ-9	0.36	0.04	0.32	9.38***			
<i>APSI Fear of Failure</i>	1.70	0.26	0.22	6.53***			
<i>GSE</i>	-0.25	0.04	-0.18	-6.35***			
<i>Increased study demands<sup>a</sup></i>	0.62	0.15	0.12	4.25***			
<i>Distress due to housing<sup>a</sup></i>	0.49	0.13	0.11	3.84***			
<i>Difficulties w. self-organized learning<sup>a</sup></i>	0.58	0.15	0.11	3.82***			
Model 7					0.52	0.52***	0.01***
(Constant)	15.80	1.53		10.34***			
PHQ-9	0.35	0.04	0.30	8.91***			
<i>APSI Fear of Failure</i>	1.50	0.27	0.20	5.66***			
<i>GSE</i>	-0.24	0.04	-0.18	-6.32***			
<i>Increased study demands<sup>a</sup></i>	0.63	0.15	0.12	4.32***			
<i>Distress due to housing<sup>a</sup></i>	0.54	0.13	0.12	4.20***			
<i>Difficulties w. self-organized learning<sup>a</sup></i>	0.56	0.15	0.10	3.69***			
<i>Stress-enhancing beliefs</i>	0.12	0.04	0.09	3.35***			

PHQ-9 = Patient-Health-Questionnaire (Subscale for Depression); GSE = General Self-Efficacy Scale; APSI = Academic Procrastination State Inventory. Newly included variables in italic.

<sup>a</sup>Single item.

\*\*\* $p < 0.001$ .

perceived burden (i.e., perceived stress, depressive and anxiety symptoms, stress-enhancing beliefs) and study-related behaviors and challenges (i.e., academic procrastination, perceived study-related demands, study-related resources). To control for sampling differences, both cohorts were matched based on their propensity score of the covariates age, gender, and currently enrolled semester. We then explored potential predictors of perceived stress in the COVID cohort. To our knowledge, this is the first cohort study investigating COVID-related changes in both students' perceived burden and study-related challenges.

### Cohort differences

One year after the outbreak, after a second nationwide lockdown (in December 2020), a federal emergency law ("*Bundesnotbremse*") was initiated during the third COVID wave from April through June 2021 (Benke, Autenrieth, Asselmann & Pané-Farré, 2022). This included curfews, limitations on gathering, and university closures in districts exceeding incident thresholds. Our study captured students' experiences during this time (i.e., March to June 2021). Compared with the pre-COVID cohort, students in the COVID cohort reported elevated stress levels and increased depressive and anxiety symptoms. Results are in line with previous longitudinal and cross-sectional studies (Charles, Strong, Burns, Bullerjahn & Serafine, 2021; Keyserlingk, Yamaguchi-Pedroza, Arum & Eccles, 2022; Sivertsen, Knapstad, Petrie, O'Connor, Lønning & Hysing, 2022). Interestingly, students in our COVID cohort reported more distress due to their housing situation, possibly because they were living again with their parents. We further assessed whether objective demands might have changed due to the COVID pandemic. In fact, while there were no changes in either the number of oral presentations or oral exams, there was a pre- to COVID shift from written exams toward written coursework. Since meeting restrictions for larger groups were one nationwide strategy to combat the spread of the virus, written examinations were often not possible. Consequently, many lecturers switched from written exams to written coursework. Indeed, students in the COVID cohort reported a significantly higher amount of written coursework. Hence, students were confronted with a great number of written assignments with different due times resulting in a continuous level of study demands. This is reflected by the higher number of study-related working hours, which almost doubled from pre- to COVID.

The pre- to COVID increase in procrastination due to fear of failure might have three sources. First, the COVID-related increase of students' stress might have been associated not only with heightened anxiety in general but also fear of negative performance in particular, leading students to avoid negative performance feedback (Flett, Blankstein, Hewitt & Koledin, 1992; Schraw, Wadkins & Olafson, 2007; Solomon & Rothblum, 1984), thus increasing procrastination tendencies. Second, students had fewer opportunities to gauge their achievements with their peers due to the lack of classroom and informal interaction. According to Bandura (1991), activities such as studying, which do not have an absolute measure of adequacy, require social referencing. Because of the pandemic-related changes in students' lives and study environment, social references were lacking, even though

they are invaluable for establishing realistic standards. Third, pre- to COVID increases in depressive symptoms may have contributed to difficulties with self-organized learning. Depressive symptoms are known to impair executive functions such as attention, learning, memory, and decision-making (Chrousos, 2009; Lupien, Maheu, Tu, Fiocco & Schramek, 2007; Snyder, 2013) and heighten negative self-referential thinking (Pyszczynski & Greenberg, 1987; Shestyuk & Deldin, 2010) and rumination (McLaughlin & Nolen-Hoeksema, 2011). This, in turn, may also result in procrastination due to fear of failure (Steel, 2007) and explain higher scores in the COVID cohort.

Indeed, participants in the COVID cohort endorsed more perceived study-related difficulties. Hence, our data suggest that the previously reported deterioration in students' academic performance during the pandemic (Freyhofer, Ziegler, de Jong & Schippers, 2021) might be related to inadequate study behavior. The increase of perceived stress was associated with a pre- to COVID difference in stress-enhancing beliefs. In accordance with the transtheoretical model of stress (Lazarus & Folkman, 1984), students imposing unrealistically high demands on themselves and having the need to be in control might have experienced the pandemic-related changes of university and personal life as particularly serious threats, while at the same time feeling more helpless.

Interestingly, there was no difference regarding general self-efficacy beliefs between the pre- and COVID cohort. This supports the notion that self-efficacy beliefs are a rather stable trait that is not easily altered by an external event that affected countries all over the world. Possibly, the support students received might also have helped to sustain their general self-efficacy beliefs. For example, many lecturers at our university decided against demanding examinations and offered coursework or less demanding online exams instead, which could have bolstered students' self-efficacy beliefs in dealing with these challenges, while at the same time resulting in an increase in work hours.

### Predictors of stress in the COVID cohort

The main aim of the study was to identify potential factors that contributed to students' stress in the COVID cohort. To this end, a stepwise regression analysis was computed. First, zero-order correlates were obtained in order to identify potential predictors. Consistent with Dickhäuser, Koddebusch, and Hermann (2022), objective demands did not correlate significantly with perceived stress and, therefore, were not further considered. The regression model identified seven significant predictors of perceived stress.

Consistent with previous findings by Dickhäuser, Koddebusch, and Hermann (2022), depressive symptoms, low general self-efficacy, and personal stressors (i.e., distress due to housing but not funding) were replicated as predictors of perceived stress among students, with depressive symptoms as the strongest predictor. In addition, procrastination due to fear of failure and stress-enhancing beliefs emerged as significant predictors. As noted earlier, both procrastination due to fear of failure and stress-enhancing beliefs were higher in the COVID cohort, thus possibly shifting the relative contribution of the predictor variables in accounting for the perceived stress level.

In line with the transactional stress model (Lazarus & Folkman, 1987), students' dysfunctional beliefs about themselves may fuel their stress. The increased COVID-related demands may trigger previously inactive dysfunctional attitudes in vulnerable students (Beck, Rush, Shaw & Emery, 1979; Scher, Ingram & Segal, 2005), explaining both the pre- to COVID increase as well as newly emerged potential predictive capabilities of stress-enhancing beliefs in explaining increased stress levels during but not prior to the COVID pandemic.

We were also interested in determining whether, specifically, the switch to online-only teaching and potentially associated difficulties in self-organized learning at home and perceived increase of study demands due to online-only teaching might have contributed to the perceived level of stress. It has been shown that online study environments constitute major challenges to students (Aguilera-Hermida, 2020; Alhazbi & Hasan, 2021; Tichavsky, Hunt, Driscoll & Jicha, 2015). First, online-only education requires students to organize their studying with few external cues and nudges (e.g., class schedule, peers; Goetz, 2013; Zimmerman, 1998). Yet not all students have high levels of self-regulated learning skills. Hence, online learning and online study activities might have been a challenge especially for those with low self-regulated learning skills and, possibly, already low general self-efficacy. Second, the perceived increase of study demands is in line with findings that the online format might be more demanding than face-to-face instruction. It may be more cognitively demanding due to enhanced cognitive load (Aguilera-Hermida, 2020; Ellianawati, Subali, Khotimah, Cholila & Darmahastuti, 2021; Schindler, Polujanski & Rothhoff, 2021). In addition, participants might face technical problems, may be unfamiliar with the new study environment, and might have difficulties in communicating with other students and lecturers (Aguilera-Hermida, 2020). Consistent with these considerations, students in the COVID cohort reported online learning as more challenging compared with pre-COVID cohorts (Schindler, Polujanski & Rothhoff, 2021).

### Limitations

A few limitations should be noted. First, even though the two cohorts were matched based on their propensity score, there were some sociodemographic differences after matching with regard to study program and being in a relationship: however, as noted earlier, these differences could not account for higher self-reported stress levels in students of the COVID cohort compared with the pre-COVID cohort. The only exception was psychology students in the COVID cohort, who were less stressed than non-psychology students. However, given that the COVID as compared with the pre-COVID cohort included a higher proportion of psychology students, the stress level reported by the students in the COVID cohort should actually be considered a quite conservative estimate.

Second, given the cohort design of this study, no causal relationships can be inferred. Yet, the identified predictors of stress in the COVID cohort were consistent with those observed in a previous study (Dickhäuser, Koddebusch & Hermann, 2022). Indeed, this allowed us to identify those factors that might have been particularly crucial in accounting for the students'

heightened stress level due to the pandemic situation. Clearly, due to the stepwise procedure of the regression analysis, identified potential predictors should be replicated in future studies.

### Implications and future research

This study investigated potential contributing factors to elevated student stress as related to the COVID pandemic. Compared with the pre-COVID cohort, university students in the COVID cohort reported more experienced burden and higher study-related challenges. In the COVID cohort, several potential predictors of perceived stress were identified that were quite consistent with previous findings. Yet, we were also able to identify specific factors that led to heightened perceived stress, specifically procrastination due to fear of failure, perceived difficulties with self-organized learning, and stress-enhancing beliefs.

First, findings suggest that the switch to online-only education was burdensome to students. In addition to a demanding pre-COVID shift from written exams toward written coursework, students experienced the online-only study format as more demanding than face-to-face classes. Students were unfamiliar with such asynchronous learning and online courses, and this might have been particularly stressful for students with low self-regulated learning skills and low general self-efficacy (Flores, Barros, Simão *et al.*, 2022; Reichel, Dietz, Mülder *et al.*, 2023; Tichavsky, Hunt, Driscoll & Jicha, 2015). Hence, it would seem important to identify such students and provide targeted interventions. As a first step, online self-assessments could be made available, and awareness of factors contributing to stress should be raised. Students could also be educated about how best to organize and adjust their study behaviors to the specific demands of digital teaching. Given the efficacy of psychological online interventions (Wang, Zhang & An, 2023; Harrer, Adam, Baumeister *et al.*, 2018; Ma *et al.*, 2021), they might be an efficient and low-level way to provide help for many students (Griffiths, Lindenmeyer, Powell, Lowe & Thorogood, 2006; Kählke, Buntrock, Smit *et al.*, 2019).

Second, our findings also suggest that reduced social interactions may not only be detrimental in contributing to perceived stress and depressive symptoms but also affect study-related behaviors such as procrastination and stress-enhancing beliefs. Social disconnection can lead to a lack of both direct and indirect social feedback, which could lead to increased unrealistic personal beliefs (Bandura, 1991), which, in turn, could exacerbate procrastination behavior (Flett, Blankstein, Hewitt & Koledin, 1992; Steel, 2007). Therefore, in an online-education setting, student interactions should be maximized inside and outside the classroom so that students have the opportunity for getting explicit and implicit peer feedback. Such interactions could be fostered in online formats via online collaborative work, discussion boards, chat rooms (Rakes & Dunn, 2010), or exchanged within study groups (Engel, Zimmer, Lörz & Mayweg-Paus, 2023). This would engender cooperative learning, which is essential for learning success (Moore, 2018; Roick, Poethke & Richter, 2023) and may even prevent procrastination (Wang, Liu, He *et al.*, 2023). At the same time, such interactions would strengthen students' social support, which, in turn, might positively impact student motivation (Rakes & Dunn, 2010),

reduce stress-enhancing beliefs such as perfectionism (Dunkley, Blankstein, Halsall, Williams & Winkworth, 2000; Dunkley, Solomon-Krakus & Moroz, 2016), and improve procrastination tendencies (Feeney & Collins, 2015; Ferrari, Harriott & Zimmerman, 1998).

## CONCLUSION

University students have been identified as an at-risk population for developing psychopathologies, and measures taken to control the spread of COVID-19 have exacerbated this vulnerability (Sivertsen, Knapstad, Petrie, O'Connor, Lønning & Hysing, 2022; Stallman, 2010; Xiong, Lipsitz, Nasri *et al.*, 2020). Even though COVID-related increase of students' perceived stress has been well documented in previous cross-sectional studies, studies examining cohorts comparable on sociodemographic characteristics and taking into account objective and perceived study-related demands and resources have been rare. This study closes this gap by investigating a propensity-score-matched sample and extends what is known about the potential contributors of students' perceived stress when confronted with fundamental changes of the learning environment amid the pandemic situation. Notably, objective demands did not markedly increase pre- to COVID, although there was a shift from written exams to coursework. Rather, students' increased perceived stress was demonstrated to be attributed to depressive symptoms, procrastination due to fear of failure, low general self-efficacy, increased perceived study demands due to online-only education, low self-organized learning skills, and high stress-enhancing beliefs. Further, vastly reduced social interactions with peers seem to have negatively affected social referencing, thus promoting stress-enhancing beliefs and procrastination due to fear of failure. A better understanding of the determinants of students' stress is a first step to tailor psychological interventions.

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## CONFLICT OF INTEREST

None of the authors has any potential conflict of interest to declare.

## DATA AVAILABILITY STATEMENT

De-identified data for analyses with a codebook and the data analysis scripts are publicly posted at <https://doi.org/10.5281/zenodo.10731829>.

## ENDNOTES

- <sup>1</sup> Bonferroni correction with  $\alpha = [.05]/18 = 0.002$  to limit alpha inflation.
- <sup>2</sup> After matching, there were some sociodemographic differences in the matched sample: Compared with the pre-COVID cohort, there were fewer students in a relationship, fewer students of the social and cultural sciences and teacher training, but more students of psychology, the natural sciences, and veterinary medicine in the COVID cohort after

matching. When analyzed for each of the cohorts separately, there were no significant differences in the stress level between the students enrolled in one of these study programs compared with the remaining total sample. The only exception was psychology students in the COVID cohort: Non-psychology students were more stressed ( $M = 22.95$ ,  $SD = 6.62$ ) than psychology students ( $M = 20.74$ ,  $SD = 5.87$ ):  $t(957) = 3.715$ ,  $p < 0.001$ .

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#### SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article:

#### Data S1 Supporting Information.

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