**The impact of lockdown stress and loneliness during the COVID-19 pandemic on
mental health among university students in Germany**

*Antonia M. Werner, PhD⁽¹⁾; Ana N. Tibubos, PhD⁽¹⁾; Lina M. Mülder, MSc⁽²⁾; Jennifer L. Reichel, MSc⁽³⁾; Markus Schäfer, PhD⁽⁴⁾; Sebastian Heller MSc⁽³⁾; Daniel Pfirrmann, PhD⁽⁵⁾; Dennis Edelmann MEd⁽⁵⁾; Pavel Dietz, PhD⁽³⁾; Prof. Thomas Rigotti, PhD^{(2);(6)}; Prof. Manfred E. Beutel, PhD, MD⁽¹⁾

(1) Department of Psychosomatic Medicine and Psychotherapy, University Medical Center Mainz, Germany

(2) Department of Work and Organizational Psychology, Johannes Gutenberg University Mainz

(3) Institute of Occupational, Social and Environmental Medicine, University Medical Center Mainz, Germany

(4) Department of Communication, Johannes Gutenberg University Mainz, Germany

(5) Institute for Sport Science, Sports Medicine, Rehabilitation and Disease Prevention, Johannes Gutenberg University Mainz, Germany

(6) Leibniz Institute for Resilience Research, Mainz, Germany

***Corresponding author:**

Dr. Antonia M. Werner

Department of Psychosomatic Medicine and Psychotherapy

University Medical Center of the Johannes Gutenberg-University Mainz

Untere Zahlbacher Str.8, 55131 Mainz

Phone: +49 (0) 6131 17-7648

E-mail: Antonia.Werner@unimedizin-mainz.de

Word Count (not including Abstract, Tables, References and Figure Legends): 4365

Abstract

The COVID-19 pandemic led to a shutdown of universities in Germany. In a longitudinal design, we compared mental health (depression, anxiety, somatic complaints) of university students in Germany before (June to August 2019) and in the course of the COVID-19 pandemic (June 2020) with two online surveys. Additionally, we determined the impact of lockdown stress and loneliness on students' mental health.

Among 443 participants (mean age 22.8 years), there were 77% female, and 10.4% medical students. Elevated levels of depression were reported more often during than before the pandemic (38.5% vs. 27.7%). Likewise, symptoms of anxiety (35.8% vs. 29.8%) and somatic complaints (32.3% vs. 27.5%) were more present in the course of the pandemic. A small increase of depression mean scores was observed, no significant changes of anxiety and somatic complaints became evident. Current loneliness and pre-pandemic distress represented the strongest associations with mental health during the pandemic. Pandemic-related psychosocial stress contributed indirectly to mental health through loneliness.

The results imply increased levels of loneliness as the most substantial consequence of the pandemic. Given their high levels of pre-pandemic distress and pandemic-specific stress, university students represent a risk group for social and economic long-term ramifications of the pandemic.

Keywords:

Mental health, loneliness, COVID-19 pandemic, young adulthood, students

Introduction

Since the infectious disease COVID-19 have been declared a *pandemic* in March 2020, the consequences on mental health have got increasing attention. Emerging evidence has pointed out a stress-related increase of levels of anxiety and depression, and of other symptoms of mental distress. Young adults are considered a low risk group for COVID-19 hospitalization and mortality¹. However, in online surveys, younger age²⁻⁴ and student status⁵ turned out as risk factors for heightened distress during the pandemic, along with female gender⁵⁻⁷.

In young adulthood, affiliating with peers in schools, universities and training programs, and attending large-scale leisure-time activities such as visiting parties, concerts, bars or fitness studios, are of pivotal importance. Those social activities were intercepted by the pandemic containment measures. Lockdown regulations (e.g. staying at home, physical distancing) may thwart important means for socializing, finding a partner or engaging in leisure time activities. Thus, social isolation, reduced peer support and loneliness may contribute to depressive symptoms in young adults during the pandemic^{2,8}. Already before the COVID-19 pandemic, a strongly increasing prevalence of mental disorders among young adults between 18 and 25 years has been reported in Germany⁹ and other countries¹⁰ over the past years. Therefore, there is a need to look more closely at this age group, as the majority of mental disorders manifest in the second and third decade of life.

In the specific case of university students, closing of universities during the COVID-19 pandemic, led to abrupt loss of personal contacts with peers and faculty, postponement of curricula, research, practical work, and exchange programs¹¹, which might result in concerns about the future academic performance and professional career. The abrupt and often ill-prepared switch into online learning may additionally evoke stress¹². Furthermore, loss of temporary jobs (gastronomy, student or teaching aides) could have compounded financial uncertainties¹³.

Recent studies indicated high levels of mental distress among university students in the beginning of the COVID-19 pandemic: in an online survey in the USA³, 48.1% of university

students reported increased scores of depression, respectively 38.5% of anxiety. In a large online survey among Chinese college students (N=89,588), 41.1% reported increased anxiety¹⁴. Similar figures were reported from university students from hot spot areas for COVID-19, like reports of students in New Jersey with a distress rate of almost 50%⁶ and a prevalence of PTSD of 16.3% among students in Wuhan¹⁵. Similar numbers were published in an online survey among French university students: 43% suffered from depression and 39% from anxiety¹³.

Certain faculties may have been hit harder by closing the universities than others. Medical faculties were at the forefront of efforts to contain and treat the pandemic. Medical students in China perceived the health threat of COVID-19 as more serious, but also reported less anxiety and depression than non-medical students¹⁶. A systematic review mostly based on studies of Chinese university students, found a prevalence of anxiety of 28% among medical students who were assumed to be particularly burdened¹⁷. To date, studies on university students' mental health during COVID-19 have mostly relied on convenience samples with a cross-sectional design. As an exception, Li et al. (2021) studied a sample of university students twice, during the COVID-19 outbreak and its remission. While acute stress symptoms decreased, anxiety and depression increased¹⁸.

Study Objectives

Due to limitations in study design (mostly cross-sectional), scope (focus on depression and anxiety symptoms), and region of origin (mostly Asian, particularly Chinese, few European studies), there is little knowledge on the specific mental health burden of university students in Europe, and more specifically in Germany. Therefore, the current study investigated the following questions:

- 1) What is the symptom load of depression, anxiety, and somatic complaints (mental health) before and during the COVID-19 pandemic among university students in Germany?

- 2) What is the contribution of pandemic-related stress (concerns, psychosocial stress situations, preventive behavior) as well as loneliness during the pandemic beyond pre-pandemic conditions (mental distress, gender, field of study) on university students' mental health during the COVID-19 pandemic?

The study was performed by an ongoing student health initiative at the Johannes Gutenberg University (JGU), Mainz, Germany ("Healthy Campus Mainz"). The JGU is a full university covering the whole range of study programs (e.g. Social and Life Sciences, Humanities, Medicine, Teaching, Law and Economy, Science, Mathematics, and Informatics) with twelve faculties and around 32,000 students. The current study analyzed data from two online surveys, the first conducted before the pandemic (between June and August of 2019) and the second during the pandemic in June 2020.

We expected depression, anxiety, and somatic complaints to increase during the pandemic, particularly in female vs. male students⁷ and in non-medical vs. medical students¹⁷. Pandemic-related concerns, psychosocial stress, and loneliness were expected to contribute to mental distress during the pandemic after adjustment for pre-pandemic distress.

Methods

Data Collection

Data were gathered in two online surveys conducted among the students of the Johannes Gutenberg University (JGU) Mainz, Germany. The first survey took place between June and August in 2019, the second in June 2020. Both surveys followed the same data collection procedure, with an e-mail invitation to all students through the central mailing list, and scheduled reminders. The questionnaires covered information about sociodemographic data (e.g. gender, age), mental health screeners, health behavior, and social support. In the second survey, specific questions on COVID-19 have been added (pandemic-related concerns and psychosocial stress, adherence to preventive behavior in order to contain the pandemic). Participation was voluntarily and informed consent was obtained in advance to participation.

Study approval was obtained by the ethical committees of the Medical Association of Rhineland-Palatinate (No. 2019-14336) and the Institute of Psychology of the JGU (No. 2020-JGU-psychEK-S008). Both studies were performed in accordance with the *Code of Ethics of the World Medical Association* (Declaration of Helsinki) for experiments involving humans and the *Ethical Principles and Guidelines for the Protection of Human Subjects of Research* by the American Psychological Association (APA).

Study Design

In 2019, an online survey was designed in order to investigate the university students' health and to develop corresponding health promotion interventions. With the COVID-19 pandemic, another online survey based on the first one was created in March and April 2020, which was adapted to the pandemic situation and included additional questions on pandemic-related concerns, psychosocial stress, and preventive behavior. A matching code was used since the first survey in order to identify those participants who would take part in follow-up surveys.

The individual scores of the main outcome variable mental health (depression, anxiety, somatic complaints), and also of loneliness, self-perceived employability, and subjective general health of the two time points of measurement (before and during the pandemic) were compared in a longitudinal study design, considering also different subgroups with regard to gender (male vs. female) and field of study (medical vs. non-medical). Additionally, the role of pre-pandemic and concurrent pandemic determinants of mental health was investigated.

Measures

Regarding sociodemographic information, age was assessed in years. Participants indicated their *gender* as "male"=1, "female"=2, or "diverse"=3 and their *field of study*. Answers were assigned as "non-medical"=0 or "medical"=1, including medicine and dentistry. Furthermore, participants were asked about their relationship status during the pandemic. Based on this, a binominal variable was built ("Single"=0, "in a relationship"=1).

The Patient Health Questionnaire 9 [PHQ-9]¹⁹ assessed nine symptoms (e.g. loss of interest, sleep disturbances, suicidal ideation) of Major Depression over the last 14 days on a scale

between “not at all”=0, “on single days”=1, “on more than half of the days”=2, and “almost every day”=3. A sum score ≥ 10 indicates at least a moderate depressive disorder. ‘The *Generalized Anxiety Disorder-2* [GAD-2]²⁰ assessed feelings of worry and nervousness based on the same answer options as in the PHQ-9. A sum score ≥ 3 indicates increased *generalized anxiety*. The Somatic Symptom Scale 8 [SSS-8]²¹ assessed eight somatic symptoms (e.g. back pain, headaches, dizziness) on five-point Likert-scales from “not at all”=0, “a little bit”=1, “somewhat”=2, “quite a bit”=3 to “very much”=4. Scores ≥ 12 indicate a clinically relevant burden of *somatic complaints* (sum score between 0 and 32). *Loneliness* was measured by the German version of the three-item UCLA (University of California, Los Angeles) loneliness scale²²: “how often do you... (1) ...feel a lack of companionship?; (2) ...feel isolated from others?; (3) ...feel left out?”. Responses were scored on a five-point Likert scale from “never”=0 to “very often”=4 (sum scores 0 to 12). Participants rated their *subjective health status* from “worst”=0 to “best conceivable state of health”=10. Positive outlook regarding the professional career after graduation was assessed as *self-perceived employability*: “How do you assess your future chances on the labor market?” (“very bad”=0 to “very good”=5).

Participants rated *pandemic-related concerns*, about their own health, the health of a close person infected with the coronavirus, isolation/quarantine, supply shortages, and the economic impact of the pandemic on a seven-level scale from “no fear at all”=1, “neutral”=4, and “very strong fear”=7. The answers were aggregated to a total score between 5 and 35. In an additional categorical variable, answers between 1 and 4 were assigned to “no agreement”=0, and answers between 5 and 7 “agreement”=1.

Participants rated their *pandemic-related psychosocial stress* answering how much they feel stressed by not seeing family and friends, not pursuing hobbies, cancelled medical appointments, and if they needed psychological support (“not at all”=1, “hardly”=2, “somewhat”=3, “quite”=4, and “very”=5). A sum score representing overall pandemic-related psychosocial stress was calculated (range 5-25). Furthermore, a categorical variable was build with answer options 1 and 2 indicating no or little and answers from 3 to 5 at least moderate perceived stress.

In order to examine how participants were committed to recommended *pandemic-related preventive behavior*, they indicated, if they have followed a list of 10 behaviors during the last 7 days (e.g. “I have kept my distance to other people (at least 1.5 meters).”). The total number of behaviors endorsed was used to estimate pandemic-related preventive behavior (values between 0 and 10).

Statistical Analysis Plan

We investigated elevated mental distress before and during the pandemic by comparing which proportions of participants exceeded the cut-offs for depression, anxiety, and somatic complaints with χ^2 -tests. For the main analysis, we conducted six *Analyses of Variance* (ANOVA) with a mixed design, separately for each variable of interest (PHQ-9 score, GAD-2 score, SSS-8 score, loneliness score, subjective health, and self-perceived employability). The scores before and during the pandemic represented the within-subject factor. As between-subject factors, *gender* and *field of study* were included in order to determine if male vs. female and non-medical vs. medical students were affected by the pandemic in similar ways. The effect size was estimated by partial eta² (η_p^2); with $\eta_p^2 \geq .01$ indicating a small, $\eta_p^2 \geq .06$ a medium, and $\eta_p^2 \geq .14$ a large effect.

To answer the second study question, we describe relative frequencies separately for each item by the categorical variables as well as the overall sum scores of pandemic-related concerns, and psychosocial stress, as well as for the total number of followed preventive behaviors, for the total sample as well as separately for gender (male vs. female), and field of study (medical vs. non-medical), respectively. Multiple regression analyses identified determinants of mental health (depression, anxiety, somatic complaints) during the pandemic. In Model 1, we took into account pre-pandemic characteristics (pre-pandemic levels of mental health, gender, field of study), and we added as further variables relationship status (during the pandemic), loneliness during the pandemic, overall pandemic-related concerns and psychosocial stress, and number of preventive behaviors followed in Model 2.

In order to understand the role of loneliness during the pandemic, another multiple regression analysis was conducted for loneliness during the pandemic as outcome with pre-pandemic loneliness, gender, and field of study as predictors (Model 1). In a second step, we considered additionally relationship status during the pandemic, and the specific pandemic variables pandemic-related concerns, psychosocial stress, and preventive behavior (Model 2). All statistical analyses were performed with IBM SPSS, version 26.

Results

A total number of 443 university students answered both surveys, out of 4,351 students who took part in the first and 3,066 students from the second survey corresponding to 10 or 14%, respectively. Their mean age was 22.8 years at baseline ($SD=3.3$ years); 77% were female, and 10.4% were medical students. During the pandemic, 53% reported to be in a relationship (Supplementary Table 1).

Mental Health Before and in the Course of the COVID-19 Pandemic

Elevated scores of depression were reported by 38.5% (vs. 27.7% pre-pandemic; $\chi^2(1)=86.80$, $p \leq .001$), 36% indicated increased anxiety (vs. 29.8%; $\chi^2(1)=61.00$, $p \leq .001$), and 33% suffered from elevated somatic complaints (vs. 27.5% $\chi^2(1)=77.46$, $p \leq .001$).

Table 1 presents the mean scores and standard deviations for depression, anxiety, somatic complaints, loneliness, self-perceived employability, and subjective general health with regard to the within-subject factor *time of the survey* (before vs. during the pandemic), and the two between-subject factors *gender* (male vs. female) and *field of study* (non-medical vs. medical). In the ANOVAs, there was a significant increase of depression (small effect size), while no significant increase was found for both anxiety and somatic complaints. Loneliness increased over time (medium effect size). No significant differences were found for subjective general health and self-perceived employability.

Table 1 about here

Table 1. Means, Standard Deviations, and Analyses of Variance in Depression, General Anxiety, Somatic Symptoms, Loneliness, Self-Perceived Employability, and Subjective Health by Time of Survey (Pre-Pandemic vs. During The Pandemic), Gender (Male vs. Female), and Field of Study (Medical vs. Other).

	Before the Pandemic					During the Pandemic													
	Gender		Field of study			Gender		Field of study											
	All	male	female	med	no med	All	male	female	med	no med	Time (within-subject factor)			Gender (between-subject factor)			Field of study (between-subject factor)		
	<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)	<i>F</i> (<i>df</i>)	<i>p</i>	η^2	<i>F</i> (<i>df</i>)	<i>p</i>	η^2	<i>F</i> (<i>df</i>)	<i>p</i>	η^2
Depression (PHQ-9), <i>N</i> =424	7.49 (4.87)	6.91 (4.76)	7.66 (4.90)	6.62 (5.33)	7.60 (4.82)	8.49 (5.31)	7.82 (5.39)	8.69 (5.27)	7.20 (5.57)	8.64 (5.26)	5.21 (1, 420)	.023	.012	4.51 (1, 420)	.034	.011	5.11 (1, 420)	.024	.012
Anxiety (GAD-2), <i>N</i> =425	2.06 (1.57)	1.60 (1.53)	2.20 (1.56)	1.82 (1.51)	2.09 (1.57)	2.12 (1.73)	1.78 (1.75)	2.22 (1.72)	1.76 (1.54)	2.16 (1.75)	1.88 (1, 421)	.171	.004	5.92 (1, 421)	.015	.014	2.80 (1, 421)	.095	.007
Somatic complaints (SSS-8), <i>N</i> =425	8.92 (4.89)	6.89 (4.35)	9.52 (4.89)	7.78 (4.97)	9.06 (4.87)	9.48 (5.52)	6.96 (5.03)	10.22 (5.44)	8.04 (5.27)	9.65 (5.53)	0.29 (1, 421)	.592	.001	13.73 (1, 421)	<.001	.032	3.97 (1, 421)	.047	.009
Subjective Health, <i>N</i> =428	7.53 (1.59)	7.59 (1.46)	7.52 (1.63)	7.56 (1.88)	7.53 (1.63)	7.40 (1.66)	7.53 (1.66)	7.36 (1.66)	7.36 (1.90)	7.40 (1.63)	0.23 (1, 424)	.630	.001	4.17 (1, 424)	.042	.010	1.30 (1, 424)	.255	.003
Loneliness, <i>N</i> =427	3.89 (2.73)	4.08 (2.89)	3.83 (2.68)	3.51 (2.64)	3.93 (2.74)	5.89 (2.69)	5.49 (2.85)	6.01 (2.63)	5.18 (2.20)	5.98 (2.73)	30.56 (1, 423)	<.001	.067	1.95 (1, 423)	.163	.005	4.75 (1, 423)	.030	.011
Self-perceived employability <i>N</i> =398	4.90 (1.29)	5.17 (1.36)	4.82 (1.26)	6.33 (0.78)	4.73 (1.23)	4.82 (1.41)	4.95 (1.55)	4.79 (1.37)	6.26 (1.36)	4.65 (1.31)	0.64 (1, 394)	.424	.002	4.99 (1, 394)	.013	>.001	64.45 (1, 394)	<.001	.141

Note. med = medical students; no med = non-medical students; PHQ-9 = Patient Health Questionnaire-9; GAD-2 = Generalized Anxiety Disorder-2; SSS-8 = Somatic Symptoms Scale-8.

Looking at between-subject effects, female students reported in average higher symptom loads of depression, anxiety, somatic complaints, and lower subjective general health and self-perceived employability compared to male students (Table 1). There were no significant gender differences in loneliness.

Regarding field of study, non-medical students reported more symptoms of depression, loneliness, and somatic complaints than medical students. The strongest difference became evident regarding self-perceived employability, which medical students described as higher than non-medical students. There were no differences with regard to anxiety, and subjective general health.

Interaction effects for gender or field of study became evident only for anxiety: male students reported an increase of anxiety symptoms during the pandemic, while female students reported rather constant levels ($F(1,421)=5.03$, $p=.025$, small effect, Figure 1). Second order interactions could not be analyzed due to small group size.

Figure 1 about here

Figure 1. Anxiety predicted by time (before vs. during pandemic) and gender (male vs. female)

Note. $F(1,421)=5.03$, $p=.025$, small effect size

Pandemic-Related Concerns, Psychosocial Stress, and Preventive Behavior during the COVID-19 Pandemic

Almost two thirds articulated concerns over the economic impact (64%), while one third was concerned about isolation or quarantine (36%), followed by concerns about one's own or the health of an infected person (24%, resp. 21%). Fear for shortage of supply was comparably rare (11%). Female students were by far more concerned for isolation/quarantine than male students (41% vs. 22%, $\chi^2 = 11.46$, $p = .001$), otherwise there were no significant association between gender and pandemic-related concerns (Figure 2). Likewise, there were no differences with regard to field of study, contrasting medical vs. non-medical students.

Figure 2 about here

Figure 2. *Pandemic-related concerns during the COVID-19 pandemic reported by university students in June 2020 (N=443).*

Note. Participants were asked to indicate on a seven-level response scale whether they did not feel the concern at all (1), neutral (4) or very strongly (7). Answers between 1 and 4 were assigned as 0 = “no agreement”, and answers between 5 and 7 as 1 = “agreement”. Here we see the relative frequencies of “agreement”.

The great majority felt stressed by no longer meeting friends (91%) or family members (74%) and not pursuing hobbies (80%). 26% had to postpone medical treatments, and 25% desired psychological support in overcoming the crisis (Figure 3). Compared to male students, female students were more significantly more stressed by not seeing important family members (65% vs. 77%, $\chi^2 = 5.27$, $p = .022$), not pursuing interests/hobbies (68% vs. 83%, $\chi^2 = 11.21$, $p = .001$), and by cancelled medical treatments (15% vs. 29%, $\chi^2 = 7.94$, $p = .005$). There were no further gender differences. Furthermore, medical and non-medical students were affected to a comparably high amount by the pandemic-related psychosocial stress situations.

Figure 3 about here

Figure 3. *Pandemic-related psychosocial stress during the COVID-19 pandemic reported by university students in June 2020 (N=443).*

Note. Participants answered five questions on pandemic-related psychosocial stress. Answer options “not at all”=1, “hardly”=2 indicated no or few stress; answer options “somewhat”=3, “quite”=4, and “very”=5 indicated at least a little degree of perceived stress.

Almost all participants (98%) reported that they have worn masks and maintained physical distance (94%) over the last seven days. Personal meetings had been reduced by 88% of the sample. They adapted their study or work (87%), avoided busy places (84%), and practiced more hand-washing (84%). Male students reported more often than female students to have put themselves into quarantine even though they had no symptoms (17.0% vs. 10%, $\chi^2 = 4.36$, $p = .037$). There were no other gender differences (Figure 4). Medical students did not differ from non-medical students regarding the reported preventive behaviors.

Figures 4 about here

Figure 4. *Pandemic-related preventive behavior during the COVID-19 pandemic reported by university students in June 2020 (N=443).*

Looking at the overall scores, the participants had a total score of pandemic-related concerns of $M = 16.41$ ($SD = 4.74$), a psychosocial stress score of $M = 14.15$ ($SD = 3.65$), and followed averagely 6.32 preventive behaviors ($SD = 1.31$). Female students reported in average a higher load of pandemic-related concerns ($M_{female} = 16.78$ vs. $M_{male} = 15.14$; $t = 3.06$, $df = 435$, $p = .002$) and more psychosocial stress than male students ($M_{female} = 14.50$ vs. $M_{male} = 12.86$; $t = 4.02$, $df = 437$, $p \leq .001$); there was no gender difference regarding pandemic-related preventive behavior ($M_{female} = 6.32$ vs. $M_{male} = 6.31$; $t = 0.09$, $df = 435$, $p = .928$). There were no differences of medical and non-medical students regarding these overall scores in the three pandemic-related measures.

Determinants of Mental Health

Table 2 shows the multiple linear regression models for the main outcome mental health (depression, anxiety, and somatic complaints). Depression during the pandemic was predicted most strongly by pre-pandemic depression (Model 1, $R^2 = .39$). Including loneliness (during the pandemic), pandemic-related concerns, psychosocial stress, and preventive behaviors, Model 2 explained 51% of variance with loneliness, and psychosocial stress as additional significant predictors.

Variance of anxiety was explained by pre-pandemic anxiety in Model 1 with 22%. In Model 2, 29% of variance in anxiety levels were explained and loneliness was a significant predictor.

Somatic symptoms were associated with pre-pandemic somatic symptom load and additionally with gender (Model 1, $R^2 = .43$). In Model 2, also loneliness and pandemic-related psychosocial stress significantly contributed to explained variance of somatic symptoms (Model 2, $R^2 = .50$).

Table 2 about here

Table 2. Linear Regressions of Associations Between Depression, Anxiety, and Somatic Symptoms with Gender, Field of Study, Relationship Status (Model 1), and Loneliness, Pandemic-Related Concerns, Psychosocial Stress, and Preventive Behaviors (Model 2).

	Depression (PHQ-9)						General Anxiety (GAD-2)						Somatic Symptoms (SSS-8)					
	Model 1 ($R^2=.39^{***}$)						Model 1 ($R^2=.22^{***}$)						Model 1 ($R^2=.43^{***}$)					
	<i>B</i>	<i>SE</i>	95% CI L	95% CI U	<i>t</i>	<i>p</i>	<i>B</i>	<i>SE</i>	95% CI L	95% CI U	<i>T</i>	<i>p</i>	<i>B</i>	<i>SE</i>	95% CI L	95% CI U	<i>t</i>	<i>p</i>
Pre-pandemic distress ¹	0.67	0.04	0.59	0.75	16.11	>.001	0.51	0.05	0.42	0.61	10.57	>.001	0.69	0.04	0.61	0.78	16.04	>.001
Gender	0.32	0.48	-0.63	1.27	0.67	.504	0.13	0.18	-0.22	0.49	0.73	.466	1.46	0.50	0.47	2.45	2.91	.004
Field of study	-1.04	0.67	-2.33	0.28	-1.56	.121	-0.33	0.25	-0.82	0.16	-1.34	.182	-0.92	0.68	-2.26	0.41	-1.36	.176

	Depression (PHQ-9)						General Anxiety (GAD-2)						Somatic Symptoms (SSS-8)					
	Model 2 ($R^2=.51^{***}$)						Model 2 ($R^2=.29^{***}$)						Model 2 ($R^2=.50^{***}$)					
	<i>B</i>	<i>SE</i>	95% CI L	95% CI U	<i>t</i>	<i>p</i>	<i>B</i>	<i>SE</i>	95% CI L	95% CI U	<i>t</i>	<i>p</i>	<i>B</i>	<i>SE</i>	95% CI L	95% CI U	<i>t</i>	<i>p</i>
Pre-pandemic distress ¹	0.55	0.04	0.48	0.63	14.10	>.001	0.43	0.05	0.34	0.53	8.99	>.001	0.61	0.04	0.53	0.70	14.50	>.001
Gender	-0.18	0.45	-1.51	0.70	-0.41	.684	0.03	0.18	-0.32	0.37	0.15	.883	1.00	0.48	0.05	1.95	2.08	.039
Field of study	-0.63	0.61	-1.82	0.56	-1.05	.295	-0.24	0.24	-0.71	0.23	-0.99	.322	-0.71	0.65	-1.98	0.56	-1.10	.270
Relationship status	-0.24	0.38	-0.99	0.50	-0.65	.519	0.08	0.15	-0.22	0.37	0.56	.599	-0.01	0.40	-0.80	0.78	-0.04	.972
Loneliness	0.55	0.08	0.39	0.72	6.57	>.001	0.16	0.03	0.10	0.23	4.90	>.001	0.24	0.09	0.06	0.41	2.67	.008
Concerns	0.07	0.04	-0.02	0.15	1.56	.119	0.02	0.02	-0.02	0.05	0.88	.380	0.09	0.05	-0.00	0.18	1.90	.058
Psychosocial Stress	0.14	0.06	0.02	0.26	2.21	.028	0.02	0.03	-0.03	0.07	0.78	.438	0.26	0.07	0.13	0.39	3.93	>.001
Preventive Behavior	-0.05	0.14	-0.34	0.23	-0.36	.722	-0.01	0.06	-0.12	0.11	-0.13	.901	-0.07	0.15	-0.37	0.23	-0.44	.659

Note: ¹ in the corresponding outcome variable (PHQ-9, GAD-2, SSS-8, respectively); CI = Confidence interval; PHQ-9 = Patient Health Questionnaire-9; GAD-2 = Generalized Anxiety Disorder-2; SSS-8 = Somatic Symptoms Scale-8.

With regard to loneliness during the pandemic, pre-pandemic loneliness and female gender were relevant predictors in Model 1 with 16% explained variance. In Model 2, it became evident that not having a relationship during the pandemic, more pandemic-related concerns, higher psychosocial stress, and a lower number of preventive behaviors explained 43% of variance in pandemic loneliness scores (Table 3).

Table 3 about here

Table 3. Linear Regressions of Associations Between Loneliness and Gender, Field of Study, Relationship Status (Model 1), and Pandemic-Related Concerns, Psychosocial Stress, and Preventive Behaviors (Model 2).

Outcome: Loneliness	Model 1 ($R^2=.16^{***}$)					
	<i>B</i>	<i>SE</i>	95% CI L	95% CI U	<i>t</i>	<i>p</i>
Pre-pandemic loneliness	0.39	0.05	0.30	0.48	8.72	>.001
Gender	0.61	0.29	0.05	1.17	2.22	.034
Field of study	-0.62	0.40	-1.41	0.16	-1.57	.118
	Model 2 ($R^2=.43^{***}$)					
	<i>B</i>	<i>SE</i>	95% CI L	95% CI U	<i>t</i>	<i>p</i>
Pre-pandemic loneliness	0.32	0.04	0.25	0.39	8.50	>.001
Gender	0.02	0.24	-0.46	0.50	0.09	.933
Field of study	-0.39	0.33	-1.04	0.27	-1.16	.247
Relationship status	-0.52	0.21	-0.93	-0.12	-2.53	.012
Concerns	0.07	0.02	0.03	0.12	3.13	.002
Psychosocial Stress	0.34	0.03	0.28	0.40	11.16	>.001
Preventive Behavior	-0.17	0.08	-0.32	-0.01	-2.11	.035

Discussion

In the context of a university-based health promotion program, we investigated, first, mental health before and in the early course of the COVID-19 pandemic, and second, the role of pandemic-related concerns, psychosocial stress, and preventive behavior in this regard. During the pandemic, proportions of high scorers in depression increased from 27.7 to 38.8%. Similarly, increased anxiety was reported by 35.8% (vs. 29.8% before the pandemic), and elevated levels of somatic complaints were reported by 32.3% (vs. 27.5%).

Proportions of elevated levels in scores for depression, anxiety, and somatic complaints among university students were high, by far exceeding numbers reported in the general population²³. In the current study, the proportion of elevated depression scores were slightly lower compared to other online surveys among university students in the USA³ and in France¹³, respectively, while the proportion of elevated anxiety scores was comparable. Associating these numbers with the ongoing stressful experience of the pandemic, authors of cross-sectional studies attributed the high figures of mental distress to the consequences of the ongoing pandemic.

However, our longitudinal findings provide a more differentiated picture: in line with the hypotheses, the mean scores of depression increased during the pandemic compared to pre-pandemic scores. Yet, contrary to the hypotheses, no significant increase was found for anxiety and somatic complaints, respectively. Likewise, no significant change neither in self-perceived employability nor subjective general health was observed. Loneliness on the other hand increased the most with a medium effect size.

Female vs. male and also non-medical vs. medical students reported more mental health issues (depression, anxiety, somatic complaints), consistent with previous findings regarding gender⁵⁻⁷ and field of study¹⁷. Previous findings comparing medical and non-medical students regarding depression have been inconclusive²⁴, and it must be considered that medical students may become socialized to disclaim mental health problems during their training²⁵. On the other side, there was only one interaction effect, which was between anxiety and gender: while male students' anxiety scores increased during the pandemic, female students' scores remained at the same level (small effect). Altogether, contrary to previous studies^{7,17} and to our hypotheses, the absence of interactions indicated that neither the mental distress of female nor non-medical students increased more than male or medical students' distress. The interaction between anxiety and gender even indicated the opposite effect, namely that male students' anxiety increased more than female students' anxiety during the pandemic.

The second study question focused on pandemic-related concerns, psychosocial stress, and the adherence to preventive behavior during the pandemic. Almost two thirds of participants were concerned about the economic impact, almost a third about quarantine, one's own and an infected person's health, while concern about supply shortages was comparably rare. Psychosocial stress of no longer meeting friends or family and not pursuing interests affected over 90%, 80% could not pursue hobbies, and three in four participants felt stressed by not meeting their families.

Gender differences were observed regarding concerns about quarantine, which affected female almost twice as often as male students. Likewise, they suffered more by not meeting family, not pursuing hobbies, and by cancelled medical treatments than male students. Both articulated comparably often the need for psychological support.

The great majority of the participants reported following the recommendations for preventive behavior during the pandemic, especially by wearing masks, keeping physical distance, and reducing personal meetings. They reported more handwashing, avoiding busy places and using disinfectants. More than that, about one in ten persons had undergone quarantine (most of them without symptoms), with male students reporting more often than female students that they went voluntarily in quarantine. There were no differences in preventive behaviors between medical and non-medical students. These results imply a high compliance with the recommended containment measures among university students.

The linear regression analyses demonstrated that pre-pandemic mental health scores were the strongest predictors for depression, anxiety, and somatic complaints, respectively. Loneliness during the pandemic represented the second strongest association with mental health issues after that. Gender was only associated with somatic symptoms, where female students were more affected. Higher levels of pandemic-related psychosocial stress were associated with depression, and somatic complaints, but not with anxiety. Pandemic-related concerns and preventive behaviors were no relevant predictors in any of these models.

The major public policy strategy has aimed at containing the spread of COVID-19 by implementing physical distancing (along with hygiene measures such as wearing facial masks), avoiding close social contacts beyond the immediate household. Indeed, almost all of the participating university students reported following rules, even if they also reported not meeting friends as the preeminent stressor, followed by not pursuing hobbies and reduced family contact due to lockdown measures. Therefore, it is not surprising that loneliness has been identified as the strongest pandemic-related factor promoting mental health issues of depression, anxiety and somatic symptoms. Researchers on loneliness already expected that loneliness and social isolation are of highest relevance for mental health issues during the pandemic²⁶.

Interestingly, loneliness during the pandemic was only predicted to a comparably small degree by pre-pandemic loneliness. Unlike depression, anxiety, and somatic complaints, the degree of reported loneliness has been most influenced by pandemic factors with an increasing explained variance from 16% to 43%. Therefore, it can be concluded that pandemic-related concerns, psychosocial stress, and preventive behaviors had hardly any direct association with depression, anxiety, and somatic complaints, but contributed indirectly through loneliness to distress during the pandemic. The observation that following a higher number of preventive behavior recommendations was associated with less loneliness may seem counterintuitive at first. Yet, in a study among Japanese adults, engaging in preventive behavior and loneliness were negatively associated as well²⁷. Taking social responsibility, feeling part of the society and making a social contribution in order to fight the pandemic may counteract feelings of loneliness. Alternatively, those who are more socially connected may have undertaken more measures in order to keep at least some personal contact (such as balancing potentially risky contacts by self-chosen quarantine and utilizing digital contact possibilities)²⁸.

Unlike most published studies on university students' mental health, which are based on cross-sectional data, we analyzed two measurement points of two samples from the same total population conducted at the same time of each year, with the same recruitment strategies. By a longitudinal design we could investigate intra- and inter-individual changes of mental health

from pre-pandemic conditions to the situation during the pandemic among university students. To the best of our knowledge, this study on university students' mental health during the COVID-19 pandemic is among the first differentiating field of study (medical vs. non-medical) and gender. We also extended analyses by including somatic complaints in addition to anxiety and depression as another important dimension of distress. Due to their high comorbidity²⁹, somatic complaints, anxiety, and depression are also termed as the *SAD triad*.

Yet, as the investigation was conducted only at one German university, generalization of the findings is limited. Regarding study design, selection bias might be present, preferentially reaching those who were strongly preoccupied by health topics in general, and the pandemic in particular. Differences between findings in university students in Germany compared to those in France¹³ and the USA³, could be due to the lower spread and mortality of the COVID-19 pandemic in Germany³⁰. Additionally, comparably more female than male students took part in the study, as female students seem to be more willing to participate in such surveys than male students³¹. While the overall response rate was comparable to other university student surveys with about 10% (2020) to 14% (2019)³, there was a further reduction in sample size by analyzing only those participating twice.

Increase of depression, anxiety, and somatic complaints was smaller than expected from cross-sectional observations. Loneliness was the most substantial consequence of the pandemic. Given their high levels of distress before and during the pandemic, and their pandemic-related concerns and psychosocial stress, however, university students represent a under-estimated risk group for the social and economic ramifications of the pandemic. This is underscored by one in four participants indicating a need for psychological support.

Future research should focus on the further development of mental health among university students in the course of the COVID-19 pandemic, as our investigation took part comparably early after the first general lockdown in Germany, and during the first semester of a university, largely closed for attendance.

Concerns and psychosocial stress of university students during the pandemic must be specifically identified (e.g. academic, social, mental health, financial), in order to offer the appropriate support. Given the limitations by on-going COVID-19 containment measures, and a presumable affinity for internet use, coordinated online support could be a suitable way to reduce loneliness among university students and their risk of mental disorders³².

Data Availability

The dataset generated during and/or analyzed during the current study is available in the Open Science Framework (osf) repository, doi: [10.17605/OSF.IO/Z7QSY](https://doi.org/10.17605/OSF.IO/Z7QSY)

References

- 1 Bialek, S. *et al.* Severe Outcomes Among Patients with Coronavirus Disease 2019 (COVID-19) - United States, February 12-March 16, 2020. *MMWR Morb Mortal Wkly Rep* **69**, 343-346, doi:10.15585/mmwr.mm6912e2 (2020).
- 2 Bu, F., Steptoe, A. & Fancourt, D. Who is lonely in lockdown? Cross-cohort analyses of predictors of loneliness before and during the COVID-19 pandemic. *Public Health* **186**, 31-34, doi:10.1016/j.puhe.2020.06.036 (2020).
- 3 Wang, X. *et al.* Investigating Mental Health of US College Students During the COVID-19 Pandemic: Cross-Sectional Survey Study. *J Med Internet Res* **22**, e22817, doi:10.2196/22817 (2020).
- 4 Petzold, M. B. *et al.* Risk, resilience, psychological distress, and anxiety at the beginning of the COVID-19 pandemic in Germany. *Brain Behav*, e01745, doi:10.1002/brb3.1745 (2020).
- 5 Haesebaert, F., Haesebaert, J., Zante, E. & Franck, N. Who maintains good mental health in a locked-down country? A French nationwide online survey of 11,391 participants. *Health Place* **66**, 102440, doi:10.1016/j.healthplace.2020.102440 (2020).
- 6 Kibbey, M. M., Fedorenko, E. J. & Farris, S. G. Anxiety, depression, and health anxiety in undergraduate students living in initial US outbreak "hotspot" during COVID-19 pandemic. *Cogn Behav Ther*, 1-13, doi:10.1080/16506073.2020.1853805 (2021).
- 7 Tibubos, A. N., Otten, D., Ernst, M. & Beutel, M. E. A systematic review on sex- and gender-sensitive approaches in public mental health to tackle COVID-19 crisis. doi:<https://doi.org/10.31234/osf.io/cbsj6> (submitted).
- 8 Sun, Y., Lin, S. Y. & Chung, K. K. H. University Students' Perceived Peer Support and Experienced Depressive Symptoms during the COVID-19 Pandemic: The

- Mediating Role of Emotional Well-Being. *Int J Environ Res Public Health* **17**, doi:10.3390/ijerph17249308 (2020).
- 9 Grobe, T., Steinmann, S. & Szecsenyi, J. *BARMER Arztreport 2018*. (Müller Verlagsservice e.K., 2018).
 - 10 Auerbach, R. P. *et al.* Mental disorders among college students in the World Health Organization World Mental Health Surveys. *Psychol Med* **46**, 2955-2970, doi:10.1017/S0033291716001665 (2016).
 - 11 Kim, S. M., Park, S. G., Jee, Y. K. & Song, I. H. Perception and attitudes of medical students on clinical clerkship in the era of the Coronavirus Disease 2019 pandemic. *Med Educ Online* **25**, 1809929, doi:10.1080/10872981.2020.1809929 (2020).
 - 12 Mheidly, N., Fares, M. Y. & Fares, J. Coping With Stress and Burnout Associated With Telecommunication and Online Learning. *Front Public Health* **8**, 574969, doi:10.3389/fpubh.2020.574969 (2020).
 - 13 Essadek, A. & Rabeyron, T. Mental health of French students during the COVID-19 pandemic. *J Affect Disord* **277**, 392-393, doi:10.1016/j.jad.2020.08.042 (2020).
 - 14 Fu, W. *et al.* Mental health of college students during the COVID-19 epidemic in China. *J Affect Disord* **280**, 7-10, doi:10.1016/j.jad.2020.11.032 (2021).
 - 15 Li, X., Fu, P., Fan, C., Zhu, M. & Li, M. COVID-19 Stress and Mental Health of Students in Locked-Down Colleges. *Int J Environ Res Public Health* **18**, doi:10.3390/ijerph18020771 (2021).
 - 16 Xie, L. *et al.* The immediate psychological effects of Coronavirus Disease 2019 on medical and non-medical students in China. *Int J Public Health* **65**, 1445-1453, doi:10.1007/s00038-020-01475-3 (2020).

- 17 Lasheras, I. *et al.* Prevalence of Anxiety in Medical Students during the COVID-19 Pandemic: A Rapid Systematic Review with Meta-Analysis. *Int J Environ Res Public Health* **17**, doi:10.3390/ijerph17186603 (2020).
- 18 Li, Y. *et al.* Mental Health Among College Students During the COVID-19 Pandemic in China: A 2-Wave Longitudinal Survey. *J Affect Disord* **281**, 597-604, doi:10.1016/j.jad.2020.11.109 (2021).
- 19 Löwe, B., Kroenke, K., Herzog, W. & Gräfe, K. Measuring depression outcome with a brief self-report instrument: sensitivity to change of the Patient Health Questionnaire (PHQ-9). *Journal of affective disorders* **81**, 61-66, doi:10.1016/s0165-0327(03)00198-8 (2004).
- 20 Löwe, B. *et al.* A 4-item measure of depression and anxiety: validation and standardization of the Patient Health Questionnaire-4 (PHQ-4) in the general population. *Journal of Affective Disorders* **122**, 86-95, doi:10.1016/j.jad.2009.06.019 (2010).
- 21 Gierk, B. *et al.* The somatic symptom scale-8 (SSS-8): a brief measure of somatic symptom burden. *JAMA internal medicine* **174**, 399-407, doi:10.1001/jamainternmed.2013.12179 (2014).
- 22 Luhmann, M. & Hawkley, L. C. Age differences in loneliness from late adolescence to oldest old age. *Dev Psychol* **52**, 943-959, doi:10.1037/dev0000117 (2016).
- 23 Wiltink, J. *et al.* Prevalence of distress, comorbid conditions and well being in the general population. *J Affect Disord* **130**, 429-437, doi:10.1016/j.jad.2010.10.041 (2011).
- 24 Puthran, R., Zhang, M. W., Tam, W. W. & Ho, R. C. Prevalence of depression amongst medical students: a meta-analysis. *Med Educ* **50**, 456-468, doi:10.1111/medu.12962 (2016).

- 25 Lien, Y. Y. *et al.* Challenging mental illness stigma in healthcare professionals and students: a systematic review and network meta-analysis. *Psychol Health*, 1-16, doi:10.1080/08870446.2020.1828413 (2020).
- 26 Smith, B. J. & Lim, M. H. How the COVID-19 pandemic is focusing attention on loneliness and social isolation. *Public Health Res Pract* **30**, doi:10.17061/phrp3022008 (2020).
- 27 Stickley, A., Matsubayashi, T. & Ueda, M. Loneliness and COVID-19 preventive behaviours among Japanese adults. *J Public Health (Oxf)*, doi:10.1093/pubmed/fdaa151 (2020).
- 28 Sommerlad, A. *et al.* Social relationships and depression during the COVID-19 lockdown: longitudinal analysis of the COVID-19 Social Study. *Psychol Med*, 1-10, doi:10.1017/S0033291721000039 (2021).
- 29 Kohlmann, S., Gierk, B., Hilbert, A., Brähler, E. & Löwe, B. The overlap of somatic, anxious and depressive syndromes: A population-based analysis. *J Psychosom Res* **90**, 51-56, doi:10.1016/j.jpsychores.2016.09.004 (2016).
- 30 Johns Hopkins University & Medicine. <https://coronavirus.jhu.edu/map.html>; retrieved on 23.11.20 (2020).
- 31 Sax, L. J., Gilmartin, S. K., Lee, J. J. & Hagedorn, L. S. Using Web Surveys to Reach Community College Students: An Analysis of Response Rates and Response Bias. *Community College Journal of Research and Practice* **32**, 712-729, doi:10.1080/10668920802000423 (2010).
- 32 Hadler, N. L., Bu, P., Winkler, A. & Alexander, A. W. College Student Perspectives of Telemental Health: a Review of the Recent Literature. *Curr Psychiatry Rep* **23**, 6, doi:10.1007/s11920-020-01215-7 (2021).

Author Contribution Statement

Conceptualization:	AMW, ANT, LMM, JLR, MS, SH, DP, DE, PD, TR, MB
Data curation:	AMW, ANT, LMM, JLR, SH, PD, TR
Formal analysis:	AMW, ANT
Funding acquisition:	PD, TR, MB
Investigation:	AMW, ANT, JLR, MS, SH, PD, TR
Methodology:	AMW, ANT, LMM, MS, PD, TR, MB
Project administration:	LMM, JLR, SH
Resources:	AMW, ANT, LMM, JLR, MS, SH, DP, DE, PD, TR, MB
Software:	AMW, ANT, TR, MB
Supervision:	ANT, TR, PD, MB
Validation:	AMW, ANT, LMM, JLR, MS, SH, DP, DE, PD, TR, MB
Visualization:	AMW
Writing – original draft:	AMW, ANT, MB
Writing – review & editing:	AMW, ANT, LMM, JLR, MS, SH, DP, DE, PD, TR, MB

The manuscript has been read and approved by all named authors.

Additional Information

Competing Interests Statement

All authors declare no competing interests.

Funding

The research derived from the project Healthy Campus Mainz, which is funded by BARMER health insurance, Johannes Gutenberg University (JGU) Mainz and the University Medical Center of the JGU Mainz.

Supplementary Information

Supplementary Table 1. Frequencies of Gender and Field of Study in the study sample before and during the pandemic.

	Survey 2019 (N=4,351)	Survey 2020 (N=3,066)	Longitudinal Survey (N=443)
<i>Gender</i>			
Women, No. (%)	3065 (70.4)	2225 (72.6)	341 (77.0)
Men, No. (%)	1246 (28.6)	821 (26.8)	100 (22.6)
Diverse, No. (%)	39 (0.9)	20 (0.7)	2 (0.5)
<i>Field of study</i>			
STEM ¹ , No. (%)	783 (18.0)	506 (16.5)	71 (16.0)
Social Sciences, No. (%)	774 (17.8)	493 (16.1)	94 (21.2)
Humanities, No. (%)	871 (20.1)	630 (20.5)	87 (19.6)
Medicine, No. (%)	582 (13.4)	341 (11.1)	46 (10.4)
Law and Economics, No. (%)	576 (13.3)	479 (15.6)	49 (11.1)
Teaching, No. (%)	665 (15.3)	510 (16.6)	92 (20.8)
Other, No. (%)	91 (2.1)	53 (1.7)	3 (0.7)
<i>Relationship status (during the pandemic)</i>			
Single, No. (%)	-	1349 (44.0)	193 (43.6)
In a relationship, No. (%)	-	1520 (49.6)	235 (53.0)
<i>Mental health</i>			
PHQ-9 ≥ 10, No. (valid %)	1249 (29.0)	1117 (38.9)	-
GAD-2 ≥ 3, No. (valid %)	1272 (29.7)	983 (34.2)	-
SSS-8 ≥ 12, No. (valid %)	1105 (25.5)	982 (34.0)	-
PHQ-9 score, <i>M</i> (<i>SD</i>)	7.41 (5.16)	8.93 (5.63)	-
GAD-2 score, <i>M</i> (<i>SD</i>)	1.97 (1.63)	2.11 (1.77)	-
SSS-8 score, <i>M</i> (<i>SD</i>)	8.43 (5.13)	9.67 (5.82)	-
Loneliness score, <i>M</i> (<i>SD</i>)	3.86 (2.69)	6.27 (2.88)	-
Subjective health, <i>M</i> (<i>SD</i>)	7.45 (1.73)	7.37 (1.76)	-
Self-perceived employability, <i>M</i> (<i>SD</i>)	4.93 (1.41)	4.75 (1.15)	-
<i>Covid-19</i>			
Concerns, <i>M</i> (<i>SD</i>)	-	17.20 (5.26)	16.41 (4.74)
Psychosocial Stress, <i>M</i> (<i>SD</i>)	-	14.57 (3.73)	14.15 (3.65)
Preventive Behaviors, <i>M</i> (<i>SD</i>)	-	6.24 (1.43)	6.32 (1.31)

Note:

¹ Science, Technology, Engineering, and Mathematics