Association of Positive and Negative Feelings with Anxiety and Depression Symptoms among Computer Science Students during the COVID-19 Pandemic

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ABSTRACT

The global COVID-19 pandemic has had a significant impact not just on physical health, but also on mental health. Previous studies have demonstrated that Computer Science (CS) students are particularly vulnerable to mental illness. This paper presents a study describing the changes in CS students' positive and negative feelings during the pandemic and social isolation, as well as activities used to cope with this new situation. Our evaluation shows that 81.0% of students reported that their well-being had been negatively affected by the pandemic, with the most reported concerns including social isolation, delay in their academic progress, risk of contamination, and death of loved ones, with discouragement, uncertainty, and stress being the negative feelings that increased the most. Our study also showed that these negative feelings correlated with a higher prevalence of anxiety and depression symptoms, and that the impact was more pronounced in female students than in male students.

CCS CONCEPTS

• **Social and professional topics** → **Computing education**.

KEYWORDS

mental health; positive feeling; negative feeling; anxiety; depression; well-being; students; Computer Science; COVID-19

1 INTRODUCTION

The World Health Organization declared the Coronavirus Disease 2019 (COVID-19) as a pandemic on March 11, 2020 [7]. According to [19], the outbreak of COVID-19 pandemic is impacting both global physical health and mental health, including problems such as stress, anxiety, depression, insomnia, denial, anger and fear.

A call to action for further research examining the impact of COVID-19 on student mental health is suggested in [9]. Studies about the psychological impact of the COVID-19 epidemic on college and university students have been conducted around the world [5, 10–12, 14, 15]. In [12], the authors assessed the impact of COVID-19 on medical students' mental health and well-being, and determined the activities that students used to cope with the situation.

Discussions about the mental health of Computer Science (CS) students in particular have become increasingly important. Previous work has shown that CS students are particularly vulnerable to mental illness and have higher prevalence of anxiety and depression symptoms compared to the general population and medical students [18]. It is reasonable to assume that these issues may have become worse during these unprecedented times.

The present study aims to measure the impact of the COVID-19 pandemic on CS students' well-being by investigating the following questions:

- What factors have most affected CS students' well-being during the COVID-19 pandemic social isolation?
- Which positive and negative feelings have increased in CS students the most during this time?
- To what extent do these feelings correlate with symptoms of anxiety and depression in CS students?
- How have CS students modified their daily activities to cope with this new situation, and how effective are those changes?

To answer these questions, we conducted a study of CS undergraduate students at a public university in the state of Rio de Janeiro, Brazil.

This paper is organized as follows. In section 2, the methods used in this study are presented. The results are shown in section 3. A discussion is presented in section 4. Finally, the last section concludes this work with a short summary, an assessment of the presented study and an outlook on possible future studies.

2 METHODS

This study was approved by the Ethics Committee on Human Research at the lead author's institution under the protocol number 1270/18, amendment number 1/2020 and conformed to the principles outlined in the Declaration of Helsinki. Only the CS students who signed the consent form participated in this study.

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The present study considers only the regular students in the undergraduate CS program at a public university in the state of Rio de Janeiro, Brazil. This population size was 315 students. All the students were invited to participate by a call for participation sent by email and published on social media. In total, 174 ($n = 174$) students participated in the study, answering a sociodemographic questionnaire as well as the Beck Anxiety [2] and Depression [4] Inventories, which are described below. We adopted a confidence level of 95% and a margin of error of 5%.

The data were collected online and anonymously, via Google Forms, from June 9 to June 23, 2020. The data collection started 88 days after the start of social isolation in the state of Rio de Janeiro. It is important to highlight that the CS students were neither attending traditional classroom nor remote/online classes since March 2020, when classes were suspended at the university.

The following questions were presented in the sociodemographic questionnaire:

- age;
- sex;
- monthly household income, in Brazilian Real (BRL), and number of people in the household;
- "For how many semesters have you been matriculated in the CS program?";
- "Do you feel that the COVID-19 pandemic is affecting your well-being in any way? (yes, I believe that the following are determining factors: (risk of contamination, social isolation, fear of death, death of loved ones, unemployment, financial difficulties, delay in academic progress, others), no)";
- "Do you notice an increase in any of these feelings during the COVID-19 pandemic? (happiness, tranquility, trust, security, hope, faith/ spirituality/ religiosity)";
- "Do you notice an increase in any of these feelings during the COVID-19 pandemic? (guilt, hurt, anguish, fear/panic, stress, sadness/melancholy, hate/anger, excessive worry, hopelessness, insecurity, uncertainty, loneliness, despair, discouragement, impatience)";
- "During the COVID-19 pandemic, are you including in your routine any activity to improve your well-being? (yes, I am including the following activities: (meditation, reading, dance, yoga, prayers, listening to music, physical exercise, remote chat/conferences with friends/family, relaxation exercises, watching movies/TV/lectures, playing video games, others), no)".

The Beck Anxiety Inventory (BAI) [2] and Beck Depression Inventory (BDI) [4] were used to measure the levels of anxiety and depression symptoms, respectively, among the CS students during the COVID-19 pandemic social isolation. These inventories were adopted due to their reliability, validity and broad scientific use.

The Beck Anxiety Inventory (BAI) [2] is a 21-question multiple-choice self-report inventory used for measuring the severity of anxiety symptoms that the subject has had during the past week. The following items are rated: numbness or tingling, feeling hot, wobbliness in legs, unable to relax, fear of the worst happening, feeling dizzy or lightheaded, heart pounding or racing, unsteady, terrified, nervous, feelings of choking, hands trembling, shaky, fear of losing control, difficulty breathing, fear of dying, scared, indigestion or discomfort in abdomen, faint, face flushed and sweating (not due to heat). The possible answers for each item are: absent: not at all; mild: it did not bother me much; moderate: it was very unpleasant, but I could stand it; severe: I could barely stand it. The scale ranges from 0 to 3 (absent, mild, moderate and severe). The total score is given by the sum of each individual item and ranges from 0 to 63. The BAI-16 cut-off presented in [1] – ≤ 16 *non-clinically significant anxiety*; > 16 *clinically significant anxiety* – was adopted for comparisons of BAI with sociodemographic variables, due to its clinical classification.

The Beck Depression Inventory (BDI) [4] is a 21-question multiple-choice self-report inventory used for measuring the severity of depression symptoms that the subject has had during the past week. The answers for each question comprise scores ranging from 0 to 3 (absent, mildly, moderately and severely). The minimum score is 0 and the maximum score is 63. It is a psychometric test that discriminates sub-types of depression and differentiates depression from anxiety [3]. The symptom-attitude categories are as follows: mood, pessimism, sense of failure, lack of satisfaction, guilty feeling, sense of punishment, self-hate, self accusations, self punitive wishes, crying spells, irritability, social withdrawal, indecisiveness, body image, work inhibition, sleep disturbance, fatigability, loss of appetite, weight loss, somatic preoccupation and, finally, loss of libido. Many BDI cut-offs are proposed in the literature. For comparisons of BDI with sociodemographic variables, we adopted the BDI-16 cut-off recently suggested in [6], with the following classification: ≤ 16 *non-clinically significant depression*; > 16 *clinically significant depression*.

2.1 Data Analysis

The data were analyzed using the TIBCO Statistica™ software (version 13.5). The quantitative variables were compared between groups using a Mann-Whitney U test by groups (2 groups). Chi-Square tests (for k samples) were used to verify associations between nominal or categorical variables when the expected cell sizes were ≥ 5. Odds Ratio (OR), with a 95% Confidence Interval (CI), was calculated by binary logistic regression analysis. Spearman's Rank correlation tests were used to summarize the strength and direction (negative or positive) of a relationship between two quantitative variables. The level of significance adopted was $p < 0.05$.

3 RESULTS

Considering that the data were collected during the COVID-19 pandemic social isolation, Table 1 shows the mean, minimum, maximum and standard deviation (SD) for the number of daily deaths by COVID-19, the number of daily new cases of COVID-19, and the social isolation rate (SIR) in the state of Rio de Janeiro (RJ) and in all of Brazil, from June 2 to June 23, 2020; note that the BAI and BDI inventories consider symptoms during the past week, and the data were collected from June 9 to June 23, 2020. In total, 174 CS students participated in the present study, answering the sociodemographic questionnaire and the BDI and BAI inventories.

The mean and standard deviation (SD) for the variables age, BAI and BDI scores are shown in Table 2. Table 2 also shows the count and frequencies for the CS students' sociodemographic variables:

Table 1: COVID-19 Basic Statistics during Data Collection.

Variable	Mean	Min	Max	SD
Daily deaths				
RJ State	167.77	51	324	86.33
Brazil	1032.18	525	1473	299.6
Daily new cases				
RJ State	2118.59	354	6061	1264.48
Brazil	28157.23	15654	54771	8877.98
SIR*				
RJ State	41.78%	36.16%	50.72%	3.62%
Brazil	40.17%	34.7%	48.9%	3.71%

* *SIR = Social Isolation Rate.*

sex, if the COVID-19 pandemic is affecting the student's well-being, and, finally, if any activity was included by the student to improve their well-being during the COVID-19 pandemic social isolation. The factors that affected the CS students' well-being during the COVID-19 pandemic social isolation are detailed in Table 3. The activities included by CS students in their routine to improve their well-being are detailed in Table 4; the numbers in this table exclude students who said they were not doing any new activities to improve their well-being. Finally, the counts and frequencies for the increase in CS students' positive and negative feelings during the COVID-19 pandemic social isolation are shown in Tables 5 and 6, respectively.

Table 2: CS Students' Basic Statistics.

Variable	*n* (%)	Mean ± SD
Age (years)		21.07 ± 2.47
BAI (score)		10.51 ± 9.28
BDI (score)		13.09 ± 8.91
Sex		
Male	135 (77.6%)	
Female	39 (22.4%)	
COVID-19 Pandemic is Affecting Well-being		
Yes	141 (81.0%)	
No	33 (19.0%)	
Including Activities to Improve Well-being		
Yes	113 (64.9%)	
No	61 (35.1%)	

Table 3: Factors that Affected CS Students' Well-being during the COVID-19 Pandemic Social Isolation.

Variable	n (%)	Variable	n (%)
Risk of Contamination		***Social Isolation***	
Yes	100 (70.9%)	*Yes*	120 (85.1%)
No	41 (29.1%)	*No*	21 (14.9%)
Death of Loved Ones		***Fear of Death***	
Yes	73 (51.8%)	*Yes*	41 (29.1%)
No	68 (48.2%)	*No*	100 (70.9%)
Unemployment		***Delay in Academic Progress***	
Yes	30 (21.3%)	*Yes*	102 (72.3%)
No	111 (78.7%)	*No*	39 (27.7%)
Financial Difficulties		***Other Factors***	
Yes	62 (44.0%)	*Yes*	18 (12.8%)
No	79 (56.0%)	*No*	123 (87.2%)

Table 4: Activities Included by CS Students in their Routine to Improve their Well-being during the COVID-19 Pandemic Social Isolation.

Variable	n (%)	Variable	n (%)
Listening to Music		***Meditation***	
Yes	86 (76.1%)	*Yes*	13 (11.5%)
No	27 (23.9%)	*No*	100 (88.5%)
Reading		***Physical Exercises***	
Yes	55 (48.7%)	*Yes*	53 (46.9%)
No	58 (51.3%)	*No*	60 (53.1%)
Dance		***Yoga***	
Yes	6 (5.3%)	*Yes*	7 (6.2%)
No	107 (94.7%)	*No*	106 (93.8%)
Prayers		***Relaxation Exercises***	
Yes	24 (21.2%)	*Yes*	4 (3.5%)
No	89 (78.8%)	*No*	109 (96.5%)
Other Activities		***To Play Virtual Games***	
Yes	16 (14.2%)	*Yes*	29 (25.7%)
No	97 (85.8%)	*No*	84 (74.3%)
To Watch Movies/TV/ Lectures		***Remote Chat/Conferences with Friends/Family***	
Yes	95 (84.1%)	*Yes*	60 (53.1%)
No	18 (15.9%)	*No*	53 (46.9%)

The mean BAI and BDI scores were compared considering the variables: *COVID-19 pandemic is affecting well-being* and *including activities to improve well-being*. The results are shown in Table 7. The mean BAI and BDI scores were also compared with the factors that affected the CS students' well-being during the COVID-19 pandemic social isolation. For significant differences, the [*mean* ± *SD*] are shown: risk of contamination (BAI $p = 0.36$; BDI $p = 0.55$); social isolation (BAI $p = 0.91$; BDI $p = 0.84$); **fear of death** (**BAI** $p = 0.0012$: Yes[15.73 ± 10.02] /No[10.39 ± 8.98]; **BDI** $p = 0.0162$: Yes[17.61 ± 9.66] /No[13.19 ± 8.11]); death of loved ones (BAI $p = 0.36$; BDI $p = 0.32$); unemployment (BAI $p = 0.18$; BDI $p = 0.12$); financial difficulties (BAI $p = 0.95$; BDI $p = 0.35$); delay in academic progress (BAI $p = 0.88$; BDI $p = 0.62$); and, finally, other declared factors (BAI $p = 0.57$; BDI $p = 0.10$).

We also compared the mean BAI and BDI scores with the activities included by CS students in their daily routines to improve their well-being during the COVID-19 pandemic social isolation, presented in Table 4: listening to music (BAI $p = 0.61$; BDI $p = 0.54$); reading (BAI $p = 0.93$; BDI $p = 0.83$); dance (BAI $p = 0.47$; BDI $p = 0.66$); prayers (BAI $p = 0.064$;; BDI $p = 0.78$); watching movies/TV/lectures (BAI $p = 0.46$; BDI $p = 0.51$); meditation (BAI $p = 0.17$; BDI $p = 0.58$); physical exercise (BAI $p = 0.39$; BDI $p = 0.81$); yoga (BAI $p = 0.33$; BDI $p = 0.52$); relaxation exercises (BAI $p = 0.97$; BDI $p = 0.98$); to play virtual games (BAI $p = 0.99$;

Table 5: CS Students' Increased Positive Feelings during the COVID-19 Pandemic Social Isolation.

Variable	n (%)	Variable	n (%)
Happiness		***Tranquility***	
Yes	11 (6.3%)	*Yes*	46 (26.4%)
No	163 (93.7%)	*No*	128 (73.6%)
Trust		***Faith/Spirituality/Religiosity***	
Yes	19 (10.9%)	*Yes*	52 (29.9%)
No	155 (89.1%)	*No*	122 (70.1%)
Hope		***Security***	
Yes	64 (36.8%)	*Yes*	19 (10.9%)
No	110 (63.2%)	*No*	155 (89.1%)
Other Positive Feelings		***Absence of Increased Positive Feelings***	
Yes	5 (2.9%)	*Yes*	39 (22.4%)
No	169 (97.1%)	*No*	135 (77.6%)

Table 6: CS Students' Increased Negative Feelings during the COVID-19 Pandemic Social Isolation.

Variable	n (%)	Variable	n (%)
Guilt		***Hurt***	
Yes	39 (22.4%)	*Yes*	19 (10.9%)
No	135 (77.6%)	*No*	155 (89.1%)
Anguish		***Fear/Panic***	
Yes	85 (48.9%)	*Yes*	43 (24.7%)
No	89 (51.1%)	*No*	131 (75.3%)
Stress		***Sadness/melancholy***	
Yes	95 (54.6%)	*Yes*	81 (46.6%)
No	79 (45.4%)	*No*	93 (53.4%)
Hate/Anger		***Excessive worry***	
Yes	31 (17.8%)	*Yes*	87 (50.0%)
No	143 (82.2%)	*No*	87 (50.0%)
Hopelessness		***Insecurity***	
Yes	41 (23.6%)	*Yes*	75 (43.1%)
No	133 (76.4%)	*No*	99 (56.9%)
Uncertainty		***Loneliness***	
Yes	107 (61.5%)	*Yes*	71 (40.8%)
No	67 (38.5%)	*No*	103 (59.2%)
Despair		***Discouragement***	
Yes	22 (12.6%)	*Yes*	123 (70.7%)
No	152 (87.4%)	*No*	51 (29.3%)
Impatience		***Other Negative Feelings***	
Yes	73 (42.0%)	*Yes*	3 (1.7%)
No	101 (58.0%)	*No*	171 (98.3%)
Absence of Increased Negative Feelings			
Yes	5 (2.9%)		
No	169 (97.1%)		

BDI $p = 0.59$); remote chat/conferences with friends/family (BAI $p = 0.40$; BDI $p = 0.51$); and, finally, other activities (BAI $p = 0.30$; BDI $p = 0.14$). No statistically significant differences were found related to the increase of any single activity.

Table 7: Comparison of BAI and BDI Scores Considering Sociodemographic Variables.

	Score		
Variables	**Mean**	**SD**	**p-value**
	BAI Score		
COVID-19 is Affecting Well-being			< 0.0001
Yes	11.94	9.57	
No	4.36	4.02	
Including Activities to improve Well-being			0.0649
Yes	9.57	8.59	
No	12.25	10.27	
	BDI Score		
COVID-19 is Affecting Well-being			< 0.0001
Yes	14.48	8.79	
No	7.18	6.78	
Including Activities to improve Well-being			< 0.001
Yes	11.52	8.66	
No	16.00	8.68	

Mann-Whitney U Test (w/ continuity correction).

The mean BAI and BDI scores were also compared with the students' increased positive feelings during the COVID-19 pandemic social isolation. For significant differences, the [*mean* ± *SD*] are shown: **happiness** (**BAI** $p = 0.0242$: Yes[4.82 ± 3.19] /No[10.89 ± 9.43]; BDI $p = 0.34$); **tranquility** (**BAI** $p = 0.0024$: Yes[6.80 ± 5.40] /No[11.84 ± 10.00]; **BDI** $p = 0.0012$: Yes[9.46 ± 7.02] /No[14.40 ± 9.17]); trust (BAI $p = 0.65$; BDI $p = 0.21$); **security** (BAI $p = 0.07$; **BDI** $p = 0.0269$: Yes[8.89 ± 6.91] /No[13.61 ± 9.00]); hope (BAI $p = 0.29$; BDI $p = 0.14$); faith/spirituality/religiosity (BAI $p = 0.25$; BDI $p = 0.52$); other positive feelings (BAI $p = 0.41$; BDI $p = 0.37$); and, finally, **absence of increased positive feelings** (**BAI** $p = 0.0127$: Yes[13.10 ± 9.48] /No[9.76 ± 9.11]; **BDI** $p = 0.0104$: Yes[16.41 ± 9.91] /No[12.13 ± 8.39]).

Finally, the mean BAI and BDI scores were compared with the students' increased negative feelings during the COVID-19 pandemic social isolation. For significant differences, the [*mean* ± *SD*] are shown: **guilt** (**BAI** $p = 0.015$: Yes[13.74 ± 11.38] /No[9.57 ± 8.39]; **BDI** $p = 0.001$: Yes[17.56 ± 9.85] /No[11.80 ± 8.21]); **hurt** (**BAI** $p < 0.001$: Yes[21.42 ± 12.23] /No[9.17 ± 7.92]; **BDI** $p < 0.001$: Yes[21.00 ± 8.33] /No[12.12 ± 8.50]); **anguish** (**BAI** $p < 0.001$: Yes[15.14 ± 10.43] /No[6.08 ± 4.97]; **BDI** $p < 0.001$: Yes[17.64 ± 8.77] /No[8.75 ± 6.59]); **fear/panic** (**BAI** $p < 0.001$: Yes[18.56 ± 11.57] /No[7.86 ± 6.54]; **BDI** $p < 0.001$: Yes[18.79 ± 9.20] /No[11.22 ± 8.00]); **stress** (**BAI** $p < 0.001$: Yes[14.06 ± 10.27] /No[6.23 ± 5.45]; **BDI** $p < 0.001$: Yes[16.91±9.04] /No[8.51±6.19]); **sadness/melancholy** (**BAI** $p < 0.001$: Yes[15.59 ± 10.40] /No[6.08 ± 5.01]; **BDI** $p < 0.001$: Yes[18.74 ± 8.83] /No[8.17 ± 5.36]); **hate/anger** (**BAI** $p < 0.001$: Yes[20.23±11.64] /No[8.40±7.15]; **BDI** $p < 0.001$): Yes[19.71±10.07]

/No[11.66 ± 7.97]; **excessive worry** (**BAI** $p < 0.001$: Yes[13.99 ± 10.44] /No[7.02±6.30]; **BDI** $p < 0.001$: Yes[16.15±9.04] /No[10.03± 7.68]); **hopelessness** (**BAI** $p = 0.010$: Yes[13.56 ± 10.36] /No[9.56 ± 8.74]; **BDI** $p < 0.001$: Yes[18.34 ± 10.15] /No[11.47 ± 7.84]); **insecurity** (**BAI** $p < 0.001$: Yes[15.05 ± 10.49] /No[7.06 ± 6.40]; **BDI** $p < 0.001$: Yes[17.53 ± 8.92] /No[9.73 ± 7.31]); **uncertainty** (**BAI** $p < 0.001$: Yes[12.47 ± 10.34] /No[7.37 ± 6.13]; **BDI** $p < 0.001$: Yes[15.50 ± 9.59] /No[9.25 ± 5.99]); **loneliness** (**BAI** $p < 0.001$: Yes[13.99±10.47] /No[8.11±7.52]; **BDI** $p < 0.001$: Yes[17.82±9.22] /No[9.83 ± 7.06]); **despair** (**BAI** $p < 0.001$: Yes[22.36 ± 11.49] /No[8.79±7.53]; **BDI** $p < 0.001$: Yes[22.50±8.03] /No[11.73±8.19]); **discouragement** (**BAI** $p < 0.001$: Yes[12.68±9.86] /No[5.25±4.54]; **BDI** $p < 0.001$: Yes[15.35 ± 9.22] /No[7.65 ± 4.90]); **impatience** (**BAI** $p = 0.001$: Yes[13.36 ± 10.77] /No[8.45 ± 7.43]; **BDI** $p < 0.001$: Yes[15.71 ± 9.22] /No[11.20 ± 8.20]); and, finally, **absence of increased negative feelings** (**BAI** $p = 0.001$: Yes[1.20 ± 1.64] /No[10.78±9.27]; **BDI** $p = 0.014$: Yes[4.40±5.03] /No[13.35±8.87]).

The numbers of positive and negative feelings increased during the COVID-19 pandemic social isolation were compared considering the BAI-16 and BDI-16 cut-offs. The results are shown in Table 8.

Table 8: Comparisons Considering BAI-16 and BDI-16 Cut-offs.

	Variable		
Cut-offs	**Mean**	**SD**	**p-value**
Number of increased positive feelings			
BAI-16			0.0014
Non-clinical Anxiety	1.36	1.07	
Clinical Anxiety	0.72	0.63	
BDI-16			< 0.001
Non-clinical Depression	1.40	1.09	
Clinical Depression	0.81	0.68	
Number of increased negative feelings			
BAI-16			< 0.0001
Non-clinical Anxiety	4.77	3.17	
Clinical Anxiety	9.94	2.63	
BDI-16			< 0.0001
Non-clinical Depression	4.39	2.99	
Clinical Depression	9.30	2.88	

Mann-Whitney U Test (w/ continuity correction).

The number of activities included in the students' routine to improve their well-being during the COVID-19 pandemic social isolation was compared with the BAI-16 ($p = 0.82$) and BDI-16 ($p = 0.0013$) cut-offs. A significant difference was found when considering the non-clinical ([2.94 ± 2.27]) and the clinical depression ([1.68 ± 2.18]) groups.

The following variables were compared with the students' sex: number of factors that affected the CS students' well-being during the COVID-19 pandemic social isolation ($p < 0.001$: Female[4.26 ± 1.87]/Male[2.84 ± 1.97]); number of positive feelings increased during the COVID-19 pandemic social isolation ($p = 0.29$); number of negative feelings increased during the COVID-19 pandemic social isolation ($p < 0.001$: Female[7.54±2.90]/ Male[5.19±3.71]); number of activities included in the students' routines to improve well-being during the COVID-19 pandemic social isolation ($p = 0.44$).

The BAI-16 and BDI-16 cut-offs were associated with the inclusion of activities by CS students to improve their well-being during the COVID-19 pandemic social isolation. Table 9 shows the results.

Table 9: Association of BAI-16 and BDI-16 Cut-offs with the Inclusion of Activities to Improve Well-being.

	Including Activities?					
	Yes		No		Total	
	(*n*)	(%)	(*n*)	(%)	(*n*)	(%)
BAI-16 *($p = 0.46$)*						
Non-clinical Anxiety	94	83.2	48	78.7	142	81.6
Clinical Anxiety	19	16.8	13	21.3	32	18.4
BDI-16 ($p < 0.001$; OR=3.69 (95% CI[1.84, 7.43]))						
Non-clinical Depression	93	82.3	34	55.7	127	73.0
Clinical Depression	20	17.7	27	44.3	47	27.0

Pearson Chi-square test.

We also found the following statistically significant correlations: higher number of factors that affected the CS students' well-being with higher number of increased negative feelings ($r_s = 0.53$); higher number of factors that affected the CS students' well-being with higher BAI ($r_s = 0.36$) and BDI ($r_s = 0.41$) scores; higher number of positive feelings with lower number of negative feelings increased during the COVID-19 pandemic social isolation ($r_s = -0.30$); higher number of positive feelings increased during the COVID-19 pandemic social isolation with lower BAI ($r_s = -0.22$) and BDI ($r_s = -0.30$) scores; higher number of negative feelings increased during the COVID-19 pandemic social isolation with higher BAI ($r_s = 0.69$) and BDI ($r_s = 0.74$) scores; higher number of activities included by CS students to improve well-being with higher number of increased positive feelings ($r_s = 0.28$); higher number of activities included by CS students to improve well-being with lower BDI ($r_s = -0.24$) score.

4 DISCUSSION

The aim of this study was to verify the impact of the COVID-19 pandemic social isolation on CS students' well-being, their most perceived positive and negative feelings, the most included activities to improve their well-being, and, finally, the associations between the CS students' behavior, positive and negative feelings, and symptoms of anxiety or depression.

4.1 Findings

The present study shows that 81.0% of CS students reported that their well-being had been affected by the COVID-19 pandemic. The most reported factors were *social isolation* (85.1%), *delay in academic progress* (72.3%), the *risk of contamination* (70.9%) and, finally, the *death of loved ones* (51.8%). The study presented in [12], which sought to assess the impact of COVID-19 on medical students' mental health and well-being, corroborates these findings, indicating that a decrease of well-being was reported by 68% of medical students and that their main concern was the impact on

their academic studies (81% of medical students). Another finding of the present study is that those students who declared that the COVID-19 pandemic is affecting their well-being had higher BAI and BDI scores than those who declared the opposite.

The CS students most perceived the increase of the following positive feelings during the COVID-19 pandemic social isolation: *hope* (36.8%), *faith/spirituality/religiosity* (29.9%), and *tranquility* (26.4%). The absence of increased positive feelings was reported for 22.4% of CS students.

The CS students who perceived the increase of *happiness* or *tranquility* had lower BAI scores than those who declared the opposite. Those students who perceived the increase of *tranquility* or *security* had lower BDI scores than those who do not perceive this increase. The absence of increased positive feelings is associated with higher BAI and BDI scores among CS students.

The increase of negative feelings during the COVID-19 pandemic social isolation was reported by 97.1% of the students. The most increased negative feelings were *discouragement* (70.7%), *uncertainty* (61.5%), *stress* (54.6%), *excessive worry*, (50%), and, finally, *anguish* (48.9%). Each one of the negative feelings perceived by CS students is associated with higher BAI and BDI scores. The absence of increased negative feelings is associated with lower BAI and BDI scores. We also observed that the students in *Non-Clinical Anxiety* and *Non-Clinical Depression* groups had higher mean number of increased positive feelings and lower mean of increased negative feelings than those in the clinical groups.

This study also shows that 64.9% of CS students included in their routine some activity to improve their well-being during the COVID-19 pandemic social isolation. The most included activities were *watching movies, TV or lectures* (84.1%), *listening to music* (76.1%), *remote chats or conferences with friends or family members* (53.1%), *reading* (48.7%), and, finally, *physical exercise* (46.9%). In [12], video chats and social media apps were the most commonly reported strategies – 87.5% and 62%, respectively – adopted by medical students to help with the pandemic situation.

Those CS students who declared that they are including activities in their routine to improve their well-being had lower BDI scores than those who declared the opposite. No difference was found when considering the BAI score and the inclusion of activities to promote well-being (Table 7).

Considering the BDI-16 cut-offs, only 17.7% of CS students who are including activities to improve their well-being are in the *Clinical Depression* group. Furthermore, the students who included activities to improve their well-being were 3.69 times more likely to be in the *Non-Clinical Depression* group than those who included no activity. The mean number of activities included in the routine to improve the well-being was higher in the *Non-Clinical Depression* group than in the clinical one.

Finally, when considering the students' sex, this study shows that female CS students have higher mean number of factors that affected their well-being during the COVID-19 pandemic than male CS students. The mean number of negative feelings increased during the COVID-19 pandemic was also higher among female than male CS students.

4.2 Suggestions

The improvement of student well-being should get attention in order to reduce any negative effects of the pandemic on CS students' mental health.

As mentioned above, our study shows that students who included activities in their daily routine to improve their well-being had lower mean BDI scores and are nearly four times more likely to be in the *Non-Clinical Depression* group than those who included no activity. Moreover, a systematic review and meta-analysis on meditation programs for psychological stress and well-being [8] has shown that mindfulness meditation programs had moderate evidence of improved anxiety and depression. Despite of that, only 11,5% of CS students included meditation in their daily routine. Therefore, students should be encouraged to include healthy activities in their routines to help them cope with symptoms of depression and increased negative feelings, such as mindfulness meditation, remote video chats with friends and family, reading for fun, and physical exercise, which, along with increased amounts of sleep, has previously been shown to correlate with decreased anxiety and depression symptoms in CS students [18].

Others have also investigated the efficacy of numerous positive activities on improving well-being and ameliorating depression symptoms [17]. In [13], the authors point out that people can increase their happiness through simple intentional positive activities, such as expressing gratitude or practicing kindness. More specifically, in [16], the authors show that *to cultivate self strengths* – using signature strengths in a new way every day for one week – and writing a *three good things list* – three things that went well each day and their causes every night for one week, providing a causal explanation for each good thing – increased happiness and decreased depressive symptoms for six months. The *gratitude visit* – to write and then deliver a letter of gratitude in person to someone who had been especially kind to them but had never been properly thanked – caused large positive changes for one month [16].

All of these practices are simple, self-administered, cost-free and can help CS students improve their well-being. CS educators should encourage and even incentivize their students to engage in these activities, even after the time of pandemic-related isolation has ended.

Furthermore, according to [20], the psychological crisis we are facing right now due to the COVID-19 pandemic can prove to be a turning point for looking back at what is most important to us and also discovering new aspects about ourselves. It may also serve as an opportunity to observe our experience of psychological well-being and to reflect on the purpose and meaning of our lives.

4.3 Limitations

The limitations of this study come from the online data collection and the calls for participation that were sent by email and published on social media, which could affect the opportunity that some students had to participate in the study, since the the sample was not randomly selected from the student population. Some students may have had problems accessing the Internet during data collection, calls for participation may have gone unnoticed, and some of the most anxious or depressed students may have felt unmotivated to answer the instruments of this research. However, there was no

other safe way to collect these data during COVID-19 pandemic social isolation.

5 CONCLUSION

This paper provided insights into the impact of COVID-19 on CS students' well-being, and addressed the factors that affected these students' well-being, the most perceived positive and negative feelings, and the most included activities to help students cope with this new situation. Additionally, the present study also provided an assessment about the association of the CS students' behavior and feelings with anxiety and depression symptoms.

We hope that this study motivates similar studies considering CS students from other universities, cities, states and countries to enable a deeper understanding of the impact of COVID-19 on CS students' mental health, and raises awareness of how the COVID-19 pandemic impacts CS students' well-being. Future work in this area could also monitor student well-being over time, as the effects of the pandemic endure and then after the pandemic has ended.

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