Revista Brasileira de Informática na Educação – RBIE
Brazilian Journal of Computers in Education
(ISSN online: 2317-6121; print: 1414-5685)
http://br-ie.org/pub/index.php/rbie

Submission: 29/Aug/2022; 1st round notif.: 11/Apr/2023;
Camera ready: 18/Jul/2023; Edition review: 06/Sep/2023; Available online: 06/Sep/2023; Published: 06/Sep/2023;

Mental Health of Computer Science Students during the COVID-19 Pandemic Social Isolation

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Abstract

The global COVID-19 pandemic has had impact not just on physical health, but also on mental health, particularly among undergraduate students. Previous studies have demonstrated that Computer Science students in particular already exhibit more symptoms of anxiety and depression than the general population and students in other fields. The study aimed to measure the impact of COVID-19 on Computer Science students' mental health, by assessing the prevalence and associated factors of anxiety and depression symptoms, and the factors that most affected their well-being. An online cross-sectional survey focused on concerns and impacts of COVID-19 was designed. The Beck Anxiety and Depression Inventories were used to measure the anxiety and depression symptoms. The data were anonymously collected, and analyzed using the TIBCO Statistica™ software, by non-parametric tests. 174 students (135 males; age= 21.07 ± 2.47 years) participated in the study. The prevalence of symptoms was 36.7% for anxiety and 60.3% for depression. 81% of students reported that their well-being had been negatively affected by the pandemic, with the most reported concerns including social isolation and delay in academic progress. Correlations between anxiety and depression symptoms, strong social relationships, regular practice of physical exercise, and students' level of satisfaction with their academic program were found. This paper sheds light on the impact of the COVID-19 pandemic on CS students' mental health, suggests ways in which Computer Science students may be able to reduce symptoms of anxiety and depression, and improve their mental health during and after the pandemic.

Keywords: *Computer Science; Students; Mental Health; Anxiety; Depression; Well-being; COVID-19.*

Cite as: Soares Passos, L.M., Murphy, C., Chen, R. Z., Santana, M. G. & Passos, G. S. (2023). Mental Health of Computer Science Students during the COVID-19 Pandemic Social Isolation. Revista Brasileira de Informática na Educação – RBIE, 31, 553-574. DOI: 10.5753/rbie.2023.2855.

1 Introduction

The World Health Organization declared the Coronavirus Disease 2019 (COVID-19) as a pandemic on March 11, 2020 (dos Santos, 2020). According to Torales, O'Higgins, Castaldelli-Maia, and Ventriglio (2020), the outbreak of the COVID-19 pandemic is impacting global health and mental health, including problems such as stress, anxiety, depression, insomnia, denial, anger and fear. Naser et al. (2020) aimed to explore the prevalence of anxiety and depression during the COVID-19 outbreak among the general population, health care professionals, and university students in order to identify key populations who might need psychological intervention. The study shows that anxiety and depression were most prevalent across university students, followed by healthcare professionals, and the general population.

A call to action for further research examining the impact of COVID-19 on student mental health specifically is suggested by Grubic, Badovinac, and Johri (2020). Studies about the psychological impact of the COVID-19 epidemic on college and university students have been conducted around the world (Cao et al., 2020; Odriozola-Gonzalez, Planchuelo-Gomez, Irurtia, & de Luis-Garcia, 2020; Kaparounaki et al., 2020; Husky, Kovess-Masfety, & Swendsen, 2020; Patsali et al., 2020; Lyons, Wilcox, Leung, & Dearsley, 2020). A study about the psychological impact of the pandemic on medical students in China was presented by Cao et al. (2020). Results indicated that 0.9% of the respondents were experiencing severe anxiety, 2.7% moderate anxiety, and 21.3% mild anxiety. The aim of the study presented by Odriozola-Gonzalez et al. (2020) was to analyze the psychological impact of COVID-19 on a Spanish university community during the first weeks of confinement. Moderate to extremely severe scores of anxiety and depression were reported by 21.34% and 34.19% of the respondents, respectively. They found that students from Arts & Humanities and Social Sciences & Law showed higher scores related to anxiety, depression, stress and impact of the event with respect than students from Engineering & Architecture. Kaparounaki et al. (2020) reported the results from the analysis of the responses to an online survey, from the first 1000 university students from Greece, concerning the impact of the lockdown on their mental health. The study considered university students in general. Overall, they found an increase in the scores for anxiety, depression and suicidal thoughts. Husky et al. (2020) considered in their study French first-year university students from the Social Sciences, Health Sciences, Technology (32.6%) and Law and Economics, and two-thirds of the students reported increase in anxiety during the COVID-19 mandatory confinement in France. Despite also considering students of Technology, the data were not stratified by field. The study presented by Patsali et al. (2020) considered university students of Law, Literature, Pedagogy, Political Sciences and related studies, and two-thirds of these students reported an increase in anxiety and one-third reported an increase in depressive feelings. Lyons et al. (2020) 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. Deterioration in mental health since the COVID-19 onset was reported by 68% of these students. Although all of these studies are concerned with university students, none of them assessed the impacts of COVID-19 on Computer Science (CS) students' mental health.

Discussions about the mental health of CS students have become increasingly important, and a study prior to the COVID-19 pandemic demonstrated that CS undergraduate students were particularly vulnerable to mental illness, and that the prevalence of anxiety and depression symptoms was a higher compared to the general population and medical students (Soares Passos, Murphy,

Chen, Santana, & Passos, 2020). However, no study has considered the mental health of CS students during the COVID-19 pandemic social isolation. Therefore, this is the first study aimed to measure the impact of the COVID-19 pandemic on CS students' mental health, by investigating the following questions:

- What is the prevalence and associated factors of anxiety and depression symptoms among CS students during the COVID-19 pandemic social isolation?
- 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 cross-sectional study considering CS undergraduate students at a public university in Brazil.

2 Materials and Methods

The present 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.

2.1 Data Collection

This cross-sectional study considered only the regular students in the undergraduate CS program at a large, Brazilian public university. The 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. The sample size calculation was based on a confidence level of 95% and a margin of error of 5%. In total, 174 ($n = 174$) students participated in the study, answering a sociodemographic questionnaire as well as the Beck Anxiety (Beck, Epstein, Brown, & Steer, 1988) and Depression (Beck, Ward, Mendelson, Mock, & Erbaugh, 1961) Inventories, which are described below.

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 Brazil. It is important to highlight that the CS students were neither attending traditional classes nor remote/online classes since March 2020, when classes were suspended and social isolation started.

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;
- “Have you ever had treatment for anxiety and/or depression? (yes, no)”;
- “Are you being treated for anxiety and/or depression? (yes, no)”;
- “Do you participate in leisure activities such as music, dance, cinema, etc.? (always, sporadically, rarely)”;
- “Do you do physical exercise regularly? (yes, I exercise: ($\geq$ 150 min/week or $<$ 150 min/week), no)”;
- “How would you rate your degree of satisfaction with the CS program? (terrible, bad, reasonable, good, excellent)”;
- “How do you rate the quality of your sleep? (0=very bad, 10=very good (Likert scale))”;
- “Do you consider yourself a person with strong social relationships? (yes, no)”;
- “How many close friends do you have?”;
- “Have you been diagnosed with COVID-19? (yes, no)”;
- “Has anyone else in your family been diagnosed with COVID-19? (yes, no)”;
- “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, other), no)”;
- “Do you notice an increase in any of these feelings during the COVID-19 pandemic? (happiness, tranquility, trust, security, hope, faith/ spirituality/ religiosity, others, absence of increased positive feelings)”;
- “Do you notice an increase in any of these feelings during the COVID-19 pandemic? (guilt, anguish, fear/panic, stress, sadness/melancholy, hate/anger, excessive worry, hopelessness, insecurity, uncertainty, loneliness, despair, discouragement, impatience, others, absence of increased negative feelings)”;
- “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, other), no)”.

The Beck Anxiety Inventory (BAI) (Beck, Epstein, et al., 1988) and Beck Depression Inventory (BDI) (Beck et al., 1961) were used, respectively, to measure the levels of anxiety and depression symptoms among the CS students during the COVID-19 pandemic social isolation. These inventories are widely used to measure anxiety and depression levels with general and specific populations, such as students. Furthermore, they are well established and validated instruments.

The BAI 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 (Beck, Epstein, et al., 1988). 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 cut-offs presented by Tabalipa et al. (2015), in the context of undergraduate students, were adopted in the present study for measuring the prevalence of anxiety symptoms: 0-10 = *minimal* anxiety; 11-19 = *mild* anxiety; 20-30 = *moderate* anxiety and 31-63 = *severe* anxiety. The BAI-16 cut-off presented by Bardhoshi, Duncan, and Erford (2016) – ≤ 16 *non-clinically significant anxiety*; > 16 *clinically significant anxiety* – was adopted for comparisons of BAI with sociodemographic variables, due to its clinical classification.

The BDI (Beck et al., 1961) has been translated into many languages and validated in many countries. In 1982 it was translated into Portuguese and was validated for Brazilian university students by (Gorenstein, Pompéia, & Andrade, 1995). The BDI 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 a score range 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 (Beck, Steer, & Carbin, 1988). 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. The BDI cut-offs presented by Tabalipa et al. (2015) were adopted in the present study for measuring the prevalence of depression symptoms: 0-9 *minor or no* symptoms; 10-18 *mild* symptoms; 19-29 *moderate* symptoms; and 30-63 *severe* symptoms. For comparisons of BDI with sociodemographic variables, we adopted the BDI-16 cut-off recently suggested by Choi, Shim, Jeong, and Jo (2020), with the following classification: ≤ 16 *non-clinically significant depression*; > 16 *clinically significant depression*.

2.2 Data Analysis

The data were analyzed using the TIBCO Statistica™ software (version 13.5). As the data do not follow a normal distribution, the quantitative variables were compared between groups using a

Mann-Whitney U test by groups (2 groups) or by analysis of variance Kruskal-Wallis tests (≥ 3 groups). Chi-Square tests (for k samples) were used to verify associations of 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 in 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.

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

Variable	**Mean**	**Min**	**Max**	**SD**
Daily Deaths	1032.18	525	1473	299.6
Daily New Cases	28157.23	15654	54771	8877.98
Social Isolation Rate	40.17%	34.7%	48.9%	3.71%

In total, 174 CS students participated in the present study, answering the sociodemographic questionnaire and the BDI and BAI inventories. The prevalence of anxiety symptoms among the CS students was 36.7% with the following distribution: 22.4% *mild*, 10.3% *moderate* and 4.0% *severe*. The prevalence of depression symptoms among the CS students was 60.3%, with the following distribution: 35.6% *mild*, 18.4% *moderate* and 6.3% *severe*.

Table 2 shows the mean and standard deviation (SD) for the variables age, monthly household income, monthly average household income, BDI and BAI scores, sleep quality and close friends. The count and frequencies for the following CS students' sociodemographic variables are also shown in Table 2: sex, if the student ever had treatment for anxiety and/or depression, if the student is being treated for anxiety and/or depression, how often the student has leisure activities, if the student does physical exercise regularly – if yes, less than 150 minutes per week or more (or equal) than 150 minutes per week –, how the student rates their degree of satisfaction with their CS program, if the student considers themselves to have strong social relationships, if the student or a family member had been diagnosed with COVID-19, 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 numbers in this table exclude students who said their well-being was not being affected by the COVID-19 pandemic social isolation.

The activities included by CS students in their routine to improve their well-being are presented in Table 4; the numbers in this table exclude students who said they were not doing any new activities to improve their well-being.

Table 2: CS Students' Basic Statistics.

Variable	*n* (%)	Mean±SD
Age (years)		21.07 ± 2.47
Household Income[a](BRL)		$4,702.20 \pm 3,985.97$
Average Household Income[a] (BRL)		$1,445.39 \pm 1,375.67$
BDI (score)		13.09 ± 8.91
BAI (score)		10.51 ± 9.28
Sleep Quality		6.29 ± 2.1
Close Friends		5.23 ± 3.53
Sex		
Male	135 (77.6%)	
Female	39 (22.4%)	
Had Treatment		
Yes	50 (28.7%)	
No	124 (71.3%)	
In Treatment		
Yes	21 (12.1%)	
No	153 (87.9%)	
Has Leisure Activities		
Always	55 (31.6%)	
Sporadically	73 (42.0%)	
Rarely	46 (26.4%)	
Does Physical Exercise Regularly		
Yes	48 (27.6%)	
<150min/week	16 (9.2%)	
>=150min/week	32 (18.4%)	
No	126 (72.4%)	
Degree of Satisfaction with the CS Program		
Terrible	3 (1.7%)	
Bad	4 (2.3%)	
Reasonable	52 (29.9%)	
Good	86 (49.4%)	
Excellent	29 (16.7%)	
Strong Social Relationships		
Yes	98 (56.3%)	
No	76 (43.7%)	
Student Diagnosed with COVID-19		
Yes	7 (4.0%)	
No	167 (96.0%)	
Family Member Diagnosed with COVID-19		
Yes	63 (36.2%)	
No	111 (63.8%)	
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%)	

[a]Monthly .

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 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%)
Remote Chat/Conferences with Friends/Family		***To Play Virtual Games***	
Yes	60 (53.1%)	*Yes*	29 (25.7%)
No	53 (46.9%)	*No*	84 (74.3%)
To Watch Movies/TV/ Lectures		***Other Activities***	
Yes	95 (84.1%)	*Yes*	16 (14.2%)
No	18 (15.9%)	*No*	97 (85.8%)

The mean BAI and BDI scores were compared considering the following sociodemographic variables: ***sex***, ***strong social relationships***, ***regular practice of physical exercise***, *student or* ***family member diagnosed with COVID-19***, ***COVID-19 pandemic is affecting well-being*** and, finally, ***including activities to improve well-being***. Statistically significant differences were found for the variables in bold. The detailed results are shown in Table 7. The mean BAI and BDI scores were also compared considering how long the students practice physical exercise ($<$ 150min/week or $\geq$ 150min/week) and no significant difference was found (BAI $p = 0.66$; BDI $p = 0.71$).

We also compared the mean BAI and BDI scores considering the following sociodemographic variables: *leisure activities* (BAI $p = 0.21$; BDI $p = 0.0159$); and *degree of satisfaction with the CS program* (BAI $p = 0.0354$; BDI $p = 0.0005$). A significant difference was ob-

Table 5: CS Students' Increased Positive Feelings during the COVID-19 Pandemic Social Isolation and the Comparison of BAI and BDI Scores Considering these Feelings.

		BAI Score		**BDI Score**	
Variable	**n (%)**	**Mean±SD**	**p-value**	**Mean±SD**	**p-value**
Happiness			0.0242		0.34
Yes	11 (6.3%)	4.82 ± 3.19		9.64 ± 4.67	
No	163 (93.7%)	10.89 ± 9.43		13.33 ± 9.08	
Tranquility			0.0024		0.0012
Yes	46 (26.4%)	6.80 ± 5.40		9.46 ± 7.02	
No	128 (73.6%)	11.84 ± 10.00		14.40 ± 9.17	
Trust			0.65		0.21
Yes	19 (10.9%)	8.53 ± 6.51		10.21 ± 6.47	
No	155 (89.1%)	10.75 ± 9.55		13.45 ± 9.11	
Hope			0.29		0.14
Yes	64 (36.8%)	10.03 ± 10.04		11.95 ± 8.63	
No	110 (63.2%)	10.78 ± 8.84		13.75 ± 9.03	
Security			0.07		0.0269
Yes	19 (10.9%)	6.68 ± 5.13		8.89 ± 6.91	
No	155 (89.1%)	10.97 ± 9.57		13.61 ± 9.00	
Faith/Spirituality/Religiosity			0.25		0.52
Yes	52 (29.9%)	11.46 ± 9.64		12.19 ± 8.05	
No	122 (70.1%)	10.10 ± 9.13		13.48 ± 9.25	
Other Positive Feelings			0.41		0.37
Yes	5 (2.9%)	6.80 ± 4.71		9.80 ± 6.65	
No	169 (97.1%)	10.62 ± 9.36		13.19 ± 8.96	
Absence of Increased Positive Feelings			0.0127		0.0104
Yes	39 (22.4%)	13.10 ± 9.48		16.41 ± 9.91	
No	135 (77.6%)	9.76 ± 9.11		12.13 ± 8.39	

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

served in the BDI score of different categories of ***leisure activities*** – always, sporadically, rarely – (Kruskal-Wallis test $p = 0.0159$). Multiple comparisons of p values (2-tailed), by Bonferroni correction, showed a significant difference between the *always* and *rarely* groups ($p = 0.0124$), such that ***rarely*** $>$ ***always***. A significant difference was also observed in the BAI (Kruskal-Wallis test $p = 0.0354$) and BDI (Kruskal-Wallis test $p = 0.0005$) scores of different categories of ***degree of satisfaction with the CS program*** – terrible, bad, reasonable, good, excellent. Multiple comparisons of p values (2-tailed), by Bonferroni correction, showed no significant differences among these groups when considering the BAI score; however, when considering the BDI score, it showed a significant difference between the *excellent* and *terrible* groups ($p = 0.0131$), such that ***terrible*** $>$ ***excellent***, as well as a significant difference between the *excellent* and *reasonable* groups ($p = 0.0247$), such that ***reasonable*** $>$ ***excellent***.

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. A statistically significant difference was found only for the variable ***fear of death*** (**BAI** $p = 0.0012$: Yes[Mean $\pm$ SD=15.73$\pm$10.02] /No[Mean $\pm$ SD= 10.39$\pm$8.98]; **BDI** $p = 0.0162$: Yes[Mean $\pm$ SD= 17.61$\pm$9.66] /No[Mean $\pm$ SD= 13.19$\pm$8.11]).

We also compared the mean BAI and BDI scores with the activities most included by CS students in their daily routines to improve their well-being during the COVID-19 pandemic social

Table 6: CS Students' Increased Negative Feelings during the COVID-19 Pandemic Social Isolation and the Comparison of BAI and BDI Scores Considering these Feelings.

			BAI Score		BDI Score	
Variable		**n (%)**	**Mean±SD**	**p-value**	**Mean±SD**	**p-value**
Guilt				0.015		0.001
	Yes	39 (22.4%)	13.74 ± 11.38		17.56 ± 9.85	
	No	135 (77.6%)	9.57 ± 8.39		11.80 ± 8.21	
Anguish				< 0.001		< 0.001
	Yes	85 (48.9%)	15.14 ± 10.43		17.64 ± 8.77	
	No	89 (51.1%)	6.08 ± 4.97		8.75 ± 6.59	
Fear/Panic				< 0.001		< 0.001
	Yes	43 (24.7%)	18.56 ± 11.57		18.79 ± 9.20	
	No	131 (75.3%)	7.86 ± 6.54		11.22 ± 8.00	
Stress				< 0.001		< 0.001
	Yes	95 (54.6%)	14.06 ± 10.27		16.91 ± 9.04	
	No	79 (45.4%)	6.23 ± 5.45		8.51 ± 6.19	
Sadness/melancholy				< 0.001		< 0.001
	Yes	81 (46.6%)	15.59 ± 10.40		18.74 ± 8.33	
	No	93 (53.4%)	6.08 ± 5.01		8.17 ± 5.36	
Hate/Anger				< 0.001		< 0.001
	Yes	31 (17.8%)	20.23 ± 11.64		19.71 ± 10.07	
	No	143 (82.2%)	8.40 ± 7.15		11.66 ± 7.97	
Excessive worry				< 0.001		< 0.001
	Yes	87 (50.0%)	13.99 ± 10.44		16.15 ± 9.04	
	No	87 (50.0%)	7.02 ± 6.30		10.03 ± 7.68	
Hopelessness				0.010		< 0.001
	Yes	41 (23.6%)	13.56 ± 10.36		18.34 ± 10.15	
	No	133 (76.4%)	9.56 ± 8.74		11.47 ± 7.84	
Insecurity				< 0.001		< 0.001
	Yes	75 (43.1%)	15.05 ± 10.49		17.53 ± 8.92	
	No	99 (56.9%)	7.06 ± 6.40		9.73 ± 7.31	
Uncertainty				< 0.001		< 0.001
	Yes	107 (61.5%)	12.47 ± 10.34		15.50 ± 9.59	
	No	67 (38.5%)	7.37 ± 6.13		9.25 ± 5.99	
Loneliness				< 0.001		< 0.001
	Yes	71 (40.8%)	13.99 ± 10.47		17.82 ± 9.22	
	No	103 (59.2%)	8.11 ± 7.52		9.83 ± 7.06	
Despair				< 0.001		< 0.001
	Yes	22 (12.6%)	22.36 ± 11.49		22.50 ± 8.03	
	No	152 (87.4%)	8.79 ± 7.53		11.73 ± 8.19	
Discouragement				< 0.001		< 0.001
	Yes	123 (70.7%)	12.68 ± 9.86		15.35 ± 9.22	
	No	51 (29.3%)	5.25 ± 4.54		7.65 ± 4.90	
Impatience				0.001		< 0.001
	Yes	73 (42.0%)	13.36 ± 10.77		15.71 ± 9.22	
	No	101 (58.0%)	8.45 ± 7.43		11.20 ± 8.20	
Absence of Increased Negative Feelings				0.001		0.014
	Yes	5 (2.9%)	1.20 ± 1.64		4.40 ± 5.03	
	No	169 (97.1%)	10.78 ± 9.27		13.35 ± 8.87	

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

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

	BAI Score			BDI Score		
Variables	**Mean**	**SD**	**p-value**	**Mean**	**SD**	**p-value**
Sex			< 0.0001			< 0.0001
Male	9.19	9.17		11.67	8.49	
Female	15.05	8.25		18.00	8.66	
Strong Social Relationships			< 0.01			< 0.01
Yes	9.35	9.09		11.40	8.40	
No	12.00	9.36		15.28	9.12	
Does Physical Exercise Regularly			< 0.01			< 0.01
Yes	7.98	8.72		10.25	8.31	
No	11.47	9.33		14.17	8.92	
Student Diagnosed with COVID-19			0.1348			0.6481
Yes	18.57	15.09		15.00	10.74	
No	10.17	8.86		13.01	8.85	
Family Member Diagnosed with COVID-19			0.0350			0.4843
Yes	12.19	9.50		13.97	9.38	
No	9.55	9.05		12.59	8.63	
COVID-19 is Affecting Well-being			< 0.0001			< 0.0001
Yes	11.94	9.57		14.48	8.79	
No	4.36	4.02		7.18	6.78	
Including Activities to improve Well-being			0.0649			< 0.001
Yes	9.57	8.59		11.52	8.66	
No	12.25	10.27		16.00	8.68	

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

isolation. No statistically significant differences were found related to the increase of any single activity.

The mean BAI and BDI scores were also compared with the students' increased positive feelings during the COVID-19 pandemic social isolation. Statistically significant differences were found for the following variables: ***happiness***; ***tranquility***; ***security***; and ***absence of increased positive feelings***. Detailed results are presented in Table 5.

Finally, the mean BAI and BDI scores were compared with the students' increased negative feelings during the COVID-19 pandemic social isolation. Statistically significant differences were found for all the negative feelings, such that mean BAI and BDI scores were always higher for those who had a negative feeling increased. On the other hand, we found lower mean BAI and BDI scores when considering the ***absence of increased negative feelings***. Detailed results are shown in Table 6.

The following variables were compared considering the BAI-16 and BDI-16 cut-offs groups: ***numbers of positive*** and ***negative feelings increased during the COVID-19 pandemic social isolation***; ***number of activities included in the students' routine to improve their well-being during the COVID-19 pandemic social isolation***; ***sleep quality***; and, finally, ***number of close friends***.

Statistically significant differences were found for variables in bold. The detailed results are shown in Table 8. The monthly average household income was also compared considering the BAI-16 and BDI-16 cut-offs (Mann-Whitney U Test, with continuity correction: $p = 0.237$ and $p = 0.094$, respectively), and they were not statistically significantly different.

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	
	Number of activities included in the students' routine		
BAI-16			0.82
Non-clinical Anxiety	2.63	2.31	
Clinical Anxiety	2.47	2.33	
BDI-16			0.0013
Non-clinical Depression	2.94	2.27	
Clinical Depression	1.68	2.18	
	Sleep Quality		
BAI-16			< 0.001
Non-clinical Anxiety	6.54	2.02	
Clinical Anxiety	5.19	2.15	
BDI-16			< 0.00001
Non-clinical Depression	6.78	1.89	
Clinical Depression	4.96	2.10	
	Number of Close Friends		
BAI-16			0.13
Non-clinical Anxiety	5.47	3.73	
Clinical Anxiety	4.16	2.20	
BDI-16			0.0175
Non-clinical Depression	5.63	3.70	
Clinical Depression	4.15	2.78	

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

The BAI-16 and BDI-16 cut-offs were associated with the following sociodemographic variables: ***sex***, *strong social relationships*, ***regular practice of physical exercise***, *student or family member diagnosed with COVID-19*, and, finally, ***including activities to improve well-being***. Statistically significant differences were found for the variables in bold. The detailed results for these variables are shown in Tables 9 and 10.

Table 9: Association of BAI-16 and BDI-16 Cut-offs and Students' Sex.

	Sex					
	Male		**Female**		**Total**	
	(*n*)	(%)	(*n*)	(%)	(*n*)	(%)
BAI-16 *($p = 0.02$; OR=2.56 (95% CI[1.11, 5.86]))*						
Non-clinical Anxiety	115	85.2	27	69.2	142	81.6
Clinical Anxiety	20	14.8	12	30.8	32	18.4
BDI-16 ($p = 0.0005$; OR=3.63 (95% CI[1.71, 7.71]))						
Non-clinical Depression	107	79.3	20	51.3	127	73.0
Clinical Depression	28	20.7	19	48.7	47	27.0

Pearson Chi-square test.

Table 10: Association of BAI-16 and BDI-16 Cut-offs with the Inclusion of Activities to Improve Well-being and the Regular Practice of Physical Exercise.

	Variable					
	Yes		**No**		**Total**	
	(*n*)	(%)	(*n*)	(%)	(*n*)	(%)
	Including Activities?					
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
	Regular Practice of Physical Exercise?					
BAI-16 *($p = 0.0346$; OR=3.14 (95% CI[1.04, 9.50]))*						
Non-clinical Anxiety	44	31.0	98	69.0	142	81.6
Clinical Anxiety	4	12.5	28	87.5	32	18.4
BDI-16 ($p = 0.0227$; OR=2.72 (95% CI[1.12, 6.60]))						
Non-clinical Depression	41	32.3	86	67.7	127	73.0
Clinical Depression	7	14.9	40	85.1	47	27.0

Pearson Chi-square test.

The following variables were compared with the students' sex (for significant differences (variables in bold), the [$mean \pm SD$] are shown): ***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 also considered in a descriptive analysis to identify the count and percentages of students that are and are not in treatment for anxiety and/or depression. The results are shown in Table 11.

Table 11: Description of BAI-16 and BDI-16 Cut-offs Considering the Students who are and are not in Treatment for Anxiety and/or Depression.

	Cut-offs					
	Non-Clinical		**Clinical**		**Total**	
	n	**(%)**	*n*	**(%)**	(*n*)	**(%)**
	BAI-16 (Anxiety)					
In treatment	12	8.4	9	28.1	21	12.1
Not in treatment	130	91.6	23	71.9	153	87.9
	BDI-16 (Depression)					
In treatment	12	9.5	9	19.2	21	12.1
Not in treatment	115	90.5	38	80.8	153	87.9

We also found the following statistically significant correlations: higher sleep quality with lower BAI ($r_s = -0.31$) and BDI ($r_s = -0.46$) scores; 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; and, finally, higher BDI score with higher BAI score ($r_s = 0.79$), an expected high positive correlation.

4 Discussion

The aim of this study was to verify the prevalence and associated factors of anxiety and depression symptoms among CS students during the COVID-19 pandemic social isolation. It also aimed 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 a prevalence of anxiety symptoms of 36.7% and a prevalence of depression symptoms of 60.3% among CS students during the COVID-19 pandemic social isolation. In a previous study with CS students, the prevalence of anxiety and depression was, respectively, 51.9% and 64.9% (Soares Passos et al., 2020). The down variation in the rates before and during the COVID-19 pandemic are corroborated by Brunoni et al. (2021). In the context of the prevalence of psychiatric symptoms before and during the COVID-19 pandemic, Brunoni et al. (2021) shown that in 2117 Brazilian participants, rates of depressive disorders did not significantly change over time, whereas a slight decrease in anxiety disorders was found. Furthermore, the

down variation in the percentage before and during the COVID-19 pandemic could be explained by CS students' ability to adapt more easily to a more digital and isolated life. A previous study showed that Engineering & Architecture students had lower scores related to anxiety and depression compared to Arts & Humanities and Social Sciences & Law students during the COVID-19 pandemic (Odriozola-Gonzalez et al., 2020). We could hypothesize that students in STEM-related fields could better cope with these new conditions imposed by the COVID-19 pandemic, or that STEM courses are better suited to individual learning, whereas humanities courses require more conversation and discussion. Future work would be required to investigate it in more detail.

The present study also 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 by Lyons et al. (2020) corroborates these findings, indicating that a decrease of well-being was reported by 68% of medical students and 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 did 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. On the other hand, 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. We also found a positive correlation of the number of negative feelings increased during the COVID-19 pandemic social isolation with BAI and BDI scores.

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%). According to Lyons et al. (2020), video chats and social media apps were the most commonly reported strategies – 87.5% and 62%, respectively – adopted by medical students. Those 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. We also found that only 17.7% of 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.

4.2 Correlations

There is a consensus in the general literature that anxiety and depression disorders are more common among females than males, and the study presented by Soares Passos et al. (2020) corroborates these findings in the context of CS students. The present study also shows that female CS students had higher BAI and BDI scores than male CS students during the COVID-19 pandemic. Considering the BAI-16 and BDI-16 cut-offs, 14.8% of male students and 30.8% of female students are in the *Clinical Anxiety* group, and 20.7% of male and 48.7% of female students are in the *Clinical Depression* group. Furthermore, the female CS students were 2.56 times more likely to be in the *Clinical Anxiety* group and were 3.63 times more likely to be in the *Clinical Depression* group than the male CS students. This mirrors the results of a study conducted during the COVID-19 lockdown in Greece that showed that female students were at a double risk to develop depression in comparison to male students (Patsali et al., 2020). The present study also 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.

We also found that those CS students who declared themselves as a person with strong social relationships had lower BAI and BDI scores than those who declared the opposite. A comparison among BAI-16 and BDI-16 cut-off groups according to the number of close friends has shown statistical differences between the *Non-clinical Depression* and *Clinical Depression* groups, i.e. those students in the *Non-Clinical Depression* group have higher mean number of close friends than those in the *Clinical Depression* group. The effects of social relationships on health have long been investigated (House, Landis, & Umberson, 1988), particularly among students. In the context of Chinese medical students, for instance, previous findings show that social support was significantly negatively associated with depression and anxiety symptoms (Sun et al., 2011). According to Cao et al. (2020), the social support was also negatively correlated with the anxiety of Chinese college students during the COVID-19 pandemic.

Another interesting result of this study is related to the regular practice of physical exercise among the investigated students during the COVID-19 social isolation. Consistent with the results presented by Soares Passos et al. (2020), the present study found lower BAI and BDI scores among CS students who exercise regularly compared to those who do not. Furthermore, the students who do not regularly practice physical exercise were 3.14 times more likely to be in the *Clinical Anxiety* group and were 2.72 times more likely to be in the *Clinical Depression* group than those who regularly practice physical exercise. The positive effects of regular exercise on reduction of anxiety and depression were already described in previous studies (Carek, Laibstain, & Carek, 2011; Stubbs et al., 2017). A study conducted during the COVID-19 pandemic showed that people who exercise are less likely to present depression and anxiety symptoms, and those reporting higher levels of sedentary behavior are more likely to present prevalent depression symptoms (Schuch et al., 2020).

The present study also shows that those CS students who had a family member diagnosed

with COVID-19 had higher BAI scores than those who had not. No difference was found when considering the BDI score and a family member diagnosed with COVID-19. These findings are corroborated by the study presented by Cao et al. (2020), which showed that having relatives or acquaintances infected with COVID-19 was a risk factor for increasing the anxiety of Chinese college students.

Another finding of this study is related to the frequency of participation in leisure activities. We found statistical differences in the BDI score of the groups *always* and *rarely*, such that the CS students who rarely have leisure activities had higher mean BDI score than those who always have this kind of activity. This differs from the prior results presented by Soares Passos et al. (2020), in which no relationship was found.

Additionally, a comparison among BAI-16 and BDI-16 cut-offs considering the quality of sleep shows that the students in the *Non-Clinical Anxiety* and *Non-Clinical Depression* groups have higher mean of quality of sleep than those in the *Clinical Anxiety* and *Clinical Depression* groups.

We also found a significant difference in the BDI score when considering the degree of satisfaction with the CS program. The CS students whose degree of satisfaction is *terrible* or *reasonable* have higher BDI scores than those whose degree of satisfaction is *excellent*.

Finally, when considering the BAI-16 and BDI-16 cut-off groups, 71.9% of students in the *Clinical Anxiety* group and 80.8% of the students in the *Clinical Depression* group are not in treatment for anxiety or depression. The study presented by Soares Passos et al. (2020) corroborates these findings, showing that most students with high BAI and BDI scores were not in treatment for anxiety or depression. A study presented by Tjia, Givens, and Shea (2005) shows that only 26.5% of depressed medical students reported treatment.

4.3 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. Therefore, students should be encouraged to include leisure and healthy activities in their routines to help them cope with symptoms of depression and increased negative feelings, such as remote video chats with friends and family, reading for fun, and physical exercise, which, along with increased quality of sleep, has previously been shown to correlate with decreased anxiety and depression symptoms in CS students (Soares Passos et al., 2020).

As this study has demonstrated that students who exercise regularly show fewer symptoms of anxiety and depression, and those who engage in leisure activities show fewer symptoms of depression, CS students should also be encouraged and even incentivized to find time for these, without neglecting security issues inherent in a pandemic, while it lasts. Of course, some students may need to work part-time jobs, spend time supporting their families, or require more time to study and complete assignments, but in those cases CS instructors should try to find ways to help students make time for more restful activities.

Additionally, this study also demonstrates that students who say they have strong social relationships exhibit fewer symptoms of both anxiety and depression. CS instructors can also help their students in this manner by incorporating more opportunities for collaboration and community building in their courses, e.g. through small group activities, pair programming, group projects, etc.

In the context of positive and negative feelings, others have also investigated the efficacy of numerous positive activities on improving well-being and ameliorating depression symptoms (Sin & Lyubomirsky, 2009). Lyubomirsky and Layous (2013) points out that people can increase their happiness through simple intentional positive activities, such as expressing gratitude or practicing kindness. More specifically, Seligman, Steen, Park, and Peterson (2005) 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 (Seligman et al., 2005). 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.

Finally, according to Yamaguchi et al. (2020), the psychological crisis we are facing due to the COVID-19 pandemic can prove to be a turning point for looking back at what is most important to us and discovering new aspects about ourselves, and 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. CS students should be encouraged and incentivized by their CS instructors to find time to reflect on these and to use this experience as an opportunity for growth and improvement.

4.4 Limitations and Future Work

One limitation of this study comes 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.

As the CS students were not attending traditional nor remote classes during the data collection, and the found prevalence of anxiety and depression symptoms had a down variation compared to previous work, new questions should be investigated: are CS students coping well with the effects of social isolation, and could this be due to their ability to better adapt to a more digital life? Or is it the case that, as 81% of students reported that they felt that the pandemic affected their well-being, the impact on mental health will only be perceived later in the long run? Did the fact that students were out of classes reduce the impact of the pandemic on their mental health? All of these issues should be investigated in new studies into CS students' mental health during and post COVID-19 pandemic social isolation, particularly during online classes, considering that,

according to Araujo, Lima, Cidade, Nobre, and Neto (2020), by discussing online and distance education, the COVID-19 pandemic opens an important and urgent issue that affects mental health – these are virtually unexplored topics, and their results have not been validated yet.

5 Conclusion

The present study shows a prevalence of anxiety symptoms of 36.7% and a prevalence of depression symptoms of 60.3% among CS students during the COVID-19 pandemic social isolation.

This paper also 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.

Finally, some suggestions to improve the mental health and well-being of CS students during and after the COVID-19 pandemic were given.

New studies should be conducted to assess the CS students' mental health during and post COVID-19 pandemic, and we hope that the present study motivates similar studies considering CS students from other universities and countries to enable a deeper understanding of the impact of COVID-19 on CS students' mental health and well-being.

Acknowledgements

The authors would like to thank FAPERJ for scholarship.

Extended Award-Winning Article

This publication is an extended version of an award-winning article at 2nd Symposium on Computing Education (EduComp 2022), entitled "Association of Positive and Negative Feelings with Anxiety and Depression Symptoms among Computer Science Students during the COVID-19 Pandemic", DOI: https://doi.org/10.5753/educomp.2022.19198.

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