Evidence analysis on technostress, factors, significance, and mitigation strategies in health students.

Análisis de evidencia sobre tecnoestrés, factores, trascendencia y estrategias de mitigación en estudiantes de salud.

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Summary: Technology has been widely integrated into health sciences teaching, especially during the pandemic, fostering digital learning. However, studies reveal challenges such as limited technological skills, technostress, and difficulty performing critical tasks. Factors such as age, gender, and motivation influence the use of mobile devices for learning. Technostress, with negative effects on academic performance, requires strategies to mitigate its impact, especially among health sciences students. The objective was to analyze the available evidence associated with technostress, its triggers, and mitigation strategies. A search was conducted in the literature published between 2019 and 2024, available in English and Spanish. The databases Scopus, PubMed, EBSCO, and ERIC were consulted, and a free search was also added. Eight articles were included in this integrative review. The methodological assessment criteria suggested by the Equator network were followed. Technostress, present in health sciences students, arises from the excessive use and poor management of technology. Technological overload, complexity, and expectations of constant availability intensify this problem, affecting well-being, academic performance, and mental health. To address this, it is recommended to strengthen computer self-efficacy, implement institutional support, and adopt personal strategies such as digital disconnection, relaxation, and balanced management of technology use. Appropriate strategies can transform the challenge into academic growth, and a comprehensive approach that includes institutional support, digital training, teacher adaptation, and healthy habits can mitigate the impact and promote student resilience.

Keywords: Technostress, digital literacy; information and communication technologies; medical education.

Abstract: Technology has been widely integrated into health sciences education, especially during the pandemic, fostering digital learning. However, studies reveal challenges such as limited technological skills, technological stress, and difficulties in critical tasks. Factors such as age, gender, and motivation influence the use of mobile devices for learning. Technostress, with its negative effects on academic performance, requires strategies to mitigate its impact, particularly among health students. The objective was to analyze the available evidence on technostress, its triggers, and mitigation strategies. A literature search was conducted for publications between 2019 and 2024, available in English and Spanish. The databases consulted included Scopus, PubMed, EBSCO, and ERIC, along with an additional free search. A total of eight articles were included in this integrative review. The methodological assessment criteria suggested by the Equator Network were followed. Technostress, present among health sciences students, arises from excessive use and poor management of technology. Overload, technological complexity, and constant availability expectations intensify it, affecting well-being, academic performance, and mental health. To address it, strengthening computer self-efficacy, implementing institutional support, and adopting personal strategies such as digital disconnection, relaxation, and balanced technology use management are recommended. Proper strategies can turn this challenge into academic growth, and a comprehensive approach that includes institutional support, digital training, teacher adaptation, and healthy habits can mitigate the impact and promote student resilience.

1. Introduction

In health sciences programs, the use of technology has become more strongly incorporated as a teaching and learning tool. The recent COVID-19 pandemic and the need to ensure the availability of training resources in medical education forced the migration towards teaching focused on the use and interaction of digital technology as a pillar of the teaching and learning process for both teachers and students (1). In this sense, examples of this are the use of screens, interaction through virtual platforms, simulation and online assessments, which allow for technology-mediated and assisted learning (2). Indeed, the results and conclusions of some studies have been heterogeneous in demonstrating and estimating digital literacy in health sciences students (3). Although some studies indicate that students feel competent with the use of technology, they recognize having few skills and show a problematic use of technology to perform tasks such as accessing, using, managing and generating information (4). Other research indicates that, although students develop informal digital learning practices and experiment with technology, they fail to integrate it into their study programs or into the disciplinary training of their health-related careers (5).

In the approach to understanding this evidence, an example derives from the use of the model centered on the unified theory of acceptance and use of technology (UTAUT-2) to understand the behavioral intentions of students who use the mobile device as a learning tool. A recent study revealed that the intention to use of students called digital natives was influenced by the expectation of effort, hedonic motivation and habit, acting on these variables age and gender as moderating agents (6). Along with this, it has been observed that students find it difficult to perform tasks that require critical thinking, solve problems, manage the search for information, creation of resources using technology (7). This use of technology in the academic context that turns out to be problematic is finally expressed in information overload, difficulty adapting to demands, lack of digital skills, and constant connectivity, elements that manifest as technostress (8).

It is possible to think that this phenomenon may affect satisfaction with learning and academic performance, mainly linked to fatigue, cognitive exhaustion, distrust, and considering its use as ineffective (9-10). In this matter, a recent study in Alicante (Spain) that included 451 students, revealed moderate levels of technostress in the majority of students, greater technostress compared to the normative population, and a negative effect on academic performance (11). A similar experience in Peru in a study that considered 251 students reported that 49.4% and 21.91% of students presented moderate and high technostress respectively, and the level of technostress had a significant and inverse influence on the academic performance of the students participating in the study (12). Although there is some evidence that relates the harmful effect of technostress on teachers, there is little information available on students of health careers.

Therefore, this study aims to analyze the available evidence regarding technostress, its triggers, implications, and mitigation strategies in health science students.

2. Methods

This scoping work is based on evidence from previous studies and the following stages were used for its implementation: a) formulation of the research question, b) literature review, c) data collection, d) critical analysis of the included studies, e) summary of main results and d) presentation of the scoping review.

The research question that guided the search was: What is the effect of technostress on learning in health science students? The researchers used the PICO method (P: patient/problem, I: intervention, C: comparison, O: outcomes) to search for articles in the databases.
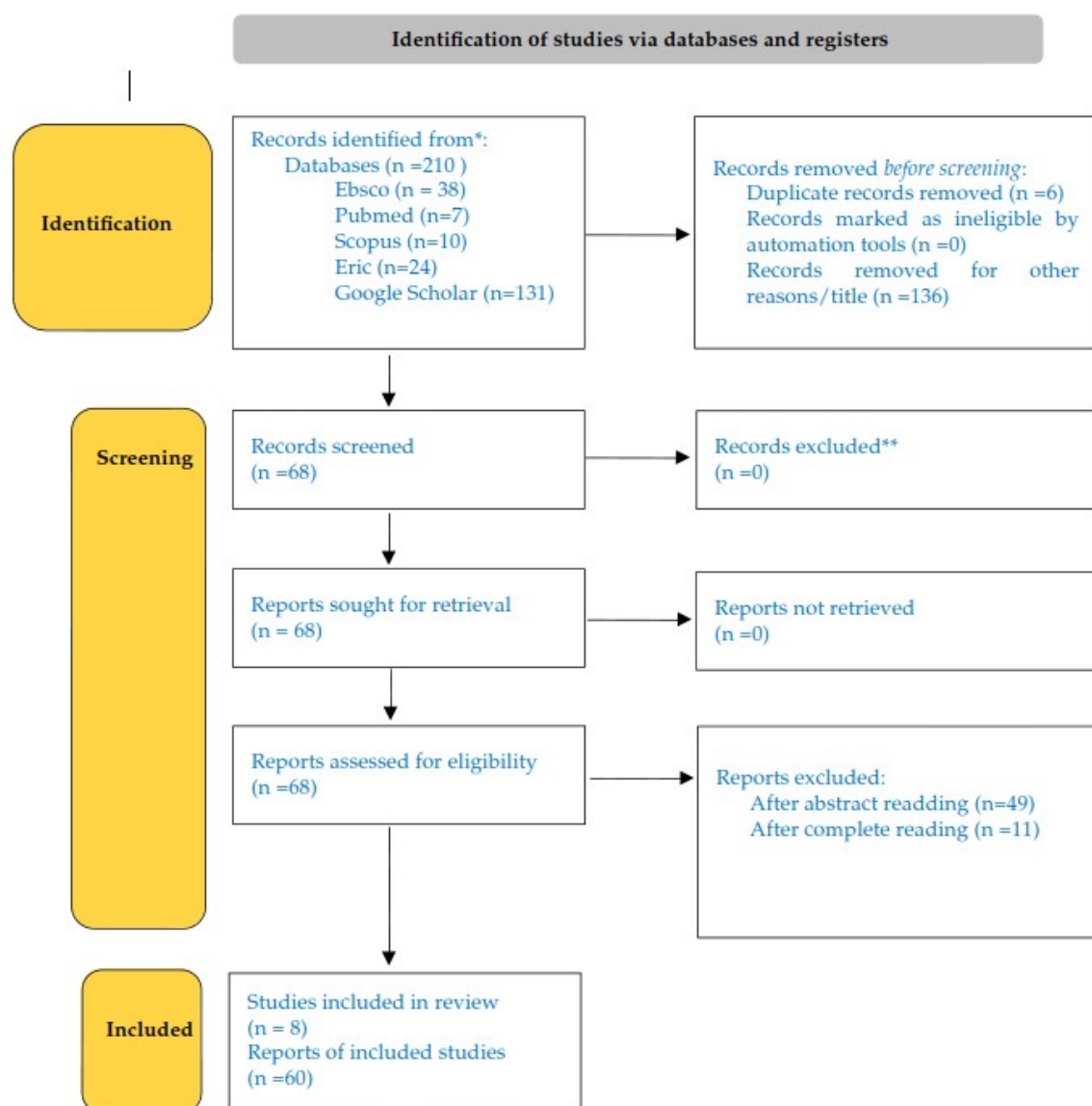
Identification of studies via databases and registers

Records identified from*:
Databases (n =210)
   Ebsco (n = 38)
   Pubmed (n=7)
   Scopus (n=10)
   Eric (n=24)
   Google Scholar (n=131)

Records removed *before screening*:
   Duplicate records removed (n =6)
   Records marked as ineligible by automation tools (n =0)
   Records removed for other reasons/title (n =136)

Identification

Records screened (n =68)

Records excluded** (n =0)

Screening

Reports sought for retrieval (n = 68)

Reports not retrieved (n =0)

Reports assessed for eligibility (n =68)

Reports excluded:
   After abstract reading (n=49)
   After complete reading (n =11)

Included

Studies included in review (n = 8)
Reports of included studies (n =60)

Figure 1. Flowchart of the PRISMA methodology.

Identification and selection of studies

The search was conducted in the databases EBSCO, PubMed, Scopus, Eric, and freely between 2014 and 2024 in Spanish and English. The search was conducted using MeSH terms and the Boolean operators AND and OR. The terms included were: "technostress," "learning," "health," "students," and "academic stress." Filters were also applied, including subject selection, and the type of study was limited to publications. Original studies and systematic reviews published between 2019 and 2024, available in Spanish and English, and with full texts were considered. According to the exclusion criteria, works in languages other than English or Spanish were excluded. Studies in which only the abstract was available and those from only one conference were also excluded. The second stage consisted of selecting the articles. Researchers were required to review the titles and abstracts of each paper to limit the number of discrepancies between authors. After reading the articles in full using PRISMA guidelines (13) (Figure 1), eight were included in this review.

Data extraction

A summary table was created, compiling the most relevant information from each study included in this review, including title, author, description of sample type, associated intervention/assessment, results, and main suggestions. Since all studies had a cross-sectional design, the STROBE statement was used to assess communication and methodological quality. A

score of 1 was assigned to all STROBE statement criteria present in each article, and a score of 0 was assigned when a criterion was not met (Table 1, 14).

3. Results

To understand technostress and its effects on health science students, it is necessary for teaching professionals to integrate the available institutional knowledge, as well as how higher education institutions are seeking to develop and implement tools to mitigate the deleterious effects of technostress on students' academic performance and well-being. It is also important to study and explore the factors that influence and trigger technostress, its main implications, consequences, and possible coping strategies as mitigation measures (Table 3).

On the conceptualization of technostress

Although most sources assume a basic understanding of "technostress," some offer definitions or conceptualizations that provide a clearer framework (15) and define technostress as "any unhealthy condition caused by attempting to cope with modern technology in various unhealthy ways, such as addiction and stress." This definition emphasizes the detrimental nature of interacting with technology when not properly managed. Similarly, other studies describe technostress as "physical and psychological" problems resulting from "excessive use or misuse" of technology, highlighting the potential risks for long-term occupational exposure (16). Another aspect relates to the definition of technostress as "a form of occupational stress associated with information and communication technologies" based on the notions declared by the American Psychological Association in which it is recognized as a lack of person-environment (PE) fit and is therefore associated with a problem in the work and occupational context (17).

On the triggers of technostress

Although there are various approaches to understanding the factors that cause or intensify technostress, the overload derived from word processing and the multitasking associated with communication and managing academic life can be tiring (18). Along with this challenge, the incorporation of technology, the difficulties in its beneficial use, its constant availability and the rapid pace of innovation can constitute a stressor for those students who have less technological experience and its use tends to be novice. In this sense, phenomena such as technological evolution, automation and the inclusion of artificial intelligence tools in professional fields create anxiety, linked to the threat they represent to the security and stability of some jobs (19). For example, Khlaif et al. highlight the unique challenges faced by academics in Palestine due to the difficulties imposed by the occupation (20). In the context of distance education, it is essential to have an adequate learning environment, including reliable internet access, appropriate technological devices and a dedicated study space that facilitates concentration and learning.

On the consequences of technostress

First, this study suggests a relationship between technostress, burnout, and academic performance (16), although this association is not entirely clear. While some research with nursing students has not consistently reported a significant relationship between technostress and academic performance, other studies have been emphatic in reporting that, in the presence of technostress, mental health problems such as anxiety and depression also increase (21). Following the previous line, prolonged exposure to technology has been associated with altered sleep patterns, increased isolation, and more irritable behavior. Therefore, when students perceive technology as a source of stress, they may reject the use of digital platforms or environments that use online learning methods, for example, in distance education programs (16, 19).

On coping strategies for technostress

The reviewed works suggest that developing skills that improve computer self-efficacy can prevent technostress and promote its self-management. This skill is recognized as the confidence accompanied by the capacity to use technology efficiently (19). On this point, educational institutions can play a key role in prevention by implementing training programs that guide students in the balanced and responsible use of ICTs for academic purposes, establishing clear limits and avoiding technological overexposure (22). In parallel, the promotion of personal strategies such as digital

disconnection, the creation of technology-free spaces, the practice of meditation exercises, and relaxation techniques have been effective tools that, when adopted regularly, allow for the reduction of anxiety and facilitate a more effective management of technostress both in the academic and personal spheres (20).

4. Discussion

From the analysis of the reviewed articles, it is observed that technostress, particularly in the context of the health pandemic, describes a multicausal and multifactorial origin. Likewise, the importance of offering a comprehensive response to this phenomenon is highlighted, one that considers and values the experience of institutions, faculty, and students, with the purpose of addressing its implications in an effective and contextualized manner (23).

A first aspect identified in the reviewed studies relates to the effects of technostress on students' health, reflected in symptoms such as fatigue and anxiety. These symptoms negatively impact their academic performance and their relationship with technology. In particular, a study conducted in Peru showed that communication and social overload significantly influences the development of technostress and burnout, affecting academic performance (19). This association has also been documented by Shi et al., who highlight social media overload as a relevant factor. However, some studies recognize that moderate levels of stress can, in certain contexts, encourage coping strategies and strengthen skills, which could even improve academic performance (24).

Second, the impact of stress generated by the abrupt transition to online education during the COVID-19 pandemic, often without the necessary preparation, is highlighted. This situation forced a high dependence on technology in a scenario marked by health uncertainty (16). In this context, it is emphasized that the lack of institutional support, both technical and psychological, contributed to intensifying student discomfort26. Individual factors, such as educational level, excessive use of technology in personal life, low computer self-efficacy, and a negative perception of distance education, have also been associated with higher levels of technostress (27).

Third, technostress can be understood as a consequence of a mismatch between the person and their environment (25). This phenomenon arises from the interaction of multiple factors, grouped into three dimensions. The first corresponds to technological factors, which include information overload, technological complexity and uncertainty, the low reliability of tools, and the expectation of permanent availability. The second dimension is related to the learning environment, highlighting aspects such as the lack of adequate physical spaces, the sudden transition to remote education, the decrease in social interaction, the increase in academic load, and the lack of institutional support. Finally, the third dimension considers personal factors, already mentioned previously, that also influence the experience of technostress (26).

A fourth element highlighted in the articles in this review is the relationship described between technostress and the technological tools available to medical students. This finding is crucial and reinforces the idea that institutions should provide training in digital skills and integrate them into the health sciences curriculum from the initial stages of training (17).

Finally, research agrees on the need to adopt a multidimensional approach to effectively address technostress in the educational context. This approach entails the coordination of responsibilities and actions by various key actors in the educational process. On the one hand, educational institutions play an essential role in providing adequate technological resources, creating structured learning environments, and providing access to technical and psychological support, in addition to ensuring ongoing training in digital skills (28). In parallel, teachers contribute significantly by adopting teaching-learning methodologies, promoting instruction focused on constant feedback, active student participation, and empathy in the face of technological challenges. In turn, students, through an active and conscious role, develop self-regulation skills, such as time management, seeking social support, and adopting healthy habits, which allows them to face the demands of the digital environment more resiliently (29-30).

Research limitations and areas for future research

One of the main limitations recognized by the studies is the limited availability of longitudinal research that allows for the analysis and understanding of clear causal relationships between the variables associated with technostress. In this sense, it is suggested that the challenge for the future is to conduct long-term research on students and include variables such as teacher training in the prevention and management of technostress (18, 23). Also, the importance of considering cultural and socioeconomic factors is recognized; therefore, it is necessary to investigate how these factors can influence the experience of technostress in different groups. Finally, the idea of evaluating coping strategies is reinforced, reviewing the most commonly used ones, their effectiveness, and the development of new strategies that could be viable and more effective for health sciences students (16, 17, 19).

5. Conclusions

- Technostress constitutes a significant challenge for health sciences education in the digital age. It must be addressed comprehensively, mitigating the conditions that foster technostress and promoting mitigating measures to improve student well-being and their transition through university life.

- Planned and organized curricular adjustments to medical and health curricula are recommended. Examples include interventions that incorporate moving the classroom to the virtual world, teacher collaboration to share digital resources on platforms, teacher empowerment in developing creative assessments, and assessing professionalism in the virtual domain for the use of telemedicine in clinical training rotations, where students need technological literacy, a clear understanding of privacy when presenting reports, and prescribing and communication skills to present coaching using virtual methods, among others.

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Table 1. Assessment of methodological rigor and communication according to the STROBE statement .

STROBE criterion	Alvarez (19)	Khlaif (15)	Madaan (16)	Mushtaque (18)	Erdogan (17)	Huanacani (21)	Torales (22)	Kasemy (23)
1. Title/Abstract: Specify the study design.	1	1	0	1	1	1	1	1
2. Introduction: Context.	1	1	0	1	1	1	1	1
3. Introduction: Objectives.	1	1	1	1	1	1	1	1
4. Methods: Study design.	1	1	1	1	1	1	1	1
5. Methods: Context.	1	1	1	1	1	1	1	1
6. Methods: Participants.	1	1	1	1	1	1	1	1
7. Methods: Variables.	1	1	1	1	1	1	1	1
8. Methods: Data source.	1	1	1	1	1	1	0	1
9. Methods: Biases.	0	0	0	0	0	0	0	0
10. Methods: Sample size.	1	1	1	1	1	1	1	1
11. Methods: Quantitative variables.	1	1	1	1	1	1	1	1
12. Methods: Statistical methods.	1	1	1	1	1	1	1	1
13. Results: Participants.	1	1	1	1	1	1	1	1
14. Results: Descriptive data.	1	1	1	1	1	1	1	1
15. Results: Outcome variable.	1	1	1	1	1	1	1	1
16. Results: Main results.	1	1	1	1	1	1	1	1
17. Results: Additional analysis	1	1	0	1	0	0	1	1
18. Discussion: Key findings.	1	1	1	1	1	1	1	1
19. Discussion: Limitations.	1	1	1	1	1	1	1	1
20. Discussion: Interpretation.	1	1	1	1	1	1	1	1
21. Discussion: Generalization.	0	0	0	0	0	0	0	0
22. Additional information: Financing.	1	0	0	0	0	0	1	1
Total score (out of 22)	**20**	**19**	**16**	**20**	**18**	**18**	**20**	**20**

Table 2. Summary of the articles included in the review

Title/Author/Journal	Aim	Type of Study	Methodology	Main findings
Influence of Technostress on Academic Performance of University Medicine Students in Peru during the COVID-19 Pandemic (19)	To analyze the influence of technostress on the academic performance of medical students, using communication and social overload as predictors and burnout as a mediator.	Study observational	Descriptive and inferential. Data were collected from medical students in all 25 regions of Peru using non-probability sampling. Participants completed an online questionnaire administered from July 11 to August 28, 2020. Surveys were distributed to 2,800 students, and 2,286 questionnaires were completed and returned.	Communication overload and social overload have a positive influence on technostress. Technostress has a positive influence on burnout. Burnout has a negative influence on academic performance.
Mobile technology features and technostress in mandatory online teaching during the COVID-19 crisis (15)	To investigate the characteristics of mobile technology that influence teachers' experience of technostress when using new mobile technologies in their teaching within a higher education setting.	Study mixed observational	Qualitative phase: focus groups and semi-structured interviews with 37 participants to explore the technological characteristics that influence technostress. Quantitative phase: online survey developed from the findings of the qualitative phase, with 692 valid responses.	The most influential mobile technology characteristics for teachers' technostress were identified, including perceived usefulness, complexity, complementarity, digital privacy, regular updating/updating, and connectivity. A significant causal relationship was found between mobile technology characteristics and technostress, as well as intentions to continue using mobile technology.
Technostress among medical freshmen: An exploratory study (16)	To explore technostress among first-year students at a medical institute and suggest measures to reduce problematic use of Internet-related technology.	Study observational exploratory	This was a descriptive, cross-sectional, and quantitative study. A semi-structured questionnaire was used to collect sociodemographic data and technology use patterns. The Perceived Stress Scale was used to measure stress. The sample consisted of 61 first-year medical students.	Ninety-two percent of students used technology for educational purposes, followed by entertainment (89%), social media (77.78%), watching movies (70.37%), communication (66.67%), and viewing pornography (46.3%). Eleven point four percent had symptoms suggestive of problematic internet use. 1% had cravings suggestive of addiction. All students with symptoms of problematic Internet use or addiction presented stress, of which 43% had high levels and 57% had

				moderate levels.
Technostress Creators and Outcomes Among Egyptian Medical Staff and Students: A Multicenter Cross-Sectional Study of Remote Working Environment During COVID-19 Pandemic (23)	To investigate the causes and outcomes of technostress among medical staff and university students as direct effects of the shift to a remote work environment during the COVID-19 pandemic.	Study observational cross	A quantitative study using a predesigned questionnaire included demographic data, work and technology characteristics, technostress triggers, and technostress outcomes. Biomarkers such as cortisol and CoQ10 were also measured. The sample consisted of 1,056 staff members and 2,526 students.	Five main dimensions of technostress were identified: techno-overload, techno-invasion, techno-complexity, techno-insecurity, and techno-uncertainty. A moderate to high prevalence of technostress was found among medical staff (33.3%) and students (7.6%). Technostress was significantly associated with higher levels of cortisol, tension, and burnout, and lower levels of engagement and CoQ10.
Technostress and medical students' intention to use online learning during the COVID-19 pandemic in Pakistan: The moderating effect of computer self-efficacy (18)	To examine the relationship between technostress and intention to use online learning among medical students in Pakistan, and the moderating role of computer self-efficacy in this relationship.	Study observational quantitative	A cross-sectional study using a questionnaire assessing technostress, computer self-efficacy, and intention to use online learning. A convenience sample was used with a sample of 369 medical students.	Technostress has a significant negative association with the intention to use online learning. Computer self-efficacy positively moderates the relationship between technostress and online learning intentions, meaning that students with higher computer self-efficacy experience a lower negative impact of technostress on their online learning intentions.
Technostress in Medical Students During Pandemic-Prompted Distance Education: Adaptation of Technostress Scale Based on Person-Environment Misfit Theory (17)	To investigate the phenomenon of technostress in medical students and its predictors during pandemic-driven distance learning.	Study observational quantitative	A cross-sectional study using an online questionnaire adapted from Wang et al. (2020) based on the person-environment mismatch theory. The sample consisted of 259 medical students from the Faculty of Medicine, University of, Turkey.	Medical students reported experiencing a relatively low level of technostress. Regular attendance and participation, a suitable learning environment, negative perceptions of distance education, perceived need for psychological support, and year in medical school were significant predictors of technostress. The main component of technostress originated in the component related to technological tools.

Technostress and Academic Performance in Nursing Students in Times of COVID-19 (21)	To analyze the relationship between technostress and academic performance in nursing students at the Jorge Basadre Grohmann National University during the COVID-19 pandemic.	Study quantitative observational	This was a descriptive, non-experimental, cross-sectional study using a deductive method. The technique used was a survey and the RED-TIC "technostress" questionnaire (modified for the research) was used as an instrument, using a Likert scale. The sample consisted of 140 second-, third-, and fourth-year nursing students.	No significant relationship was found between technostress and academic performance in nursing students. Most students presented a medium-high level of technostress (86.4%). Academic performance was average in 82.14% of the students.
Technostress, anxiety, and depression among university students: A report from Paraguay (22)	To explore the association between technostress, anxiety, and depression in university students in Paraguay.	Study observational cross	A quantitative study was conducted using an online questionnaire that included the Technostress Scale (ETS), the Generalized Anxiety Scale-7 (GAD-7), and the Patient Health Questionnaire-2 (PHQ-2). The sample consisted of 378 participants.	A significant association was found between technostress and anxiety and depression. Students with higher levels of technostress were more likely to report symptoms of anxiety and depression.