Special Series: Scientific Literacy

JMBE Journal of Microbiology & Biology Education

COVID-19 Scientific Literacy in Medical and Nursing Students

Maria Cabreja-Castillo,[a] Leislany Hernandez,[b] Alicia Mustafa,[a] Gregory Hungria,[a] and Maria T. Bertoli[a]
[a]*Keralty Research Center, Keralty Hospital Miami, Miami, Florida, USA*
[b]*Family Medicine Residency Program, Keralty Hospital Miami, Miami, Florida, USA*

The pandemic brought a whole newfound collection of words into our everyday language, some of which had been terms that were infrequently used outside academic and medical settings. However, as familiar as this new pandemic vocabulary has become, there are still several terms that often get mixed in everyday conversations, media communications, and even in the medical field. Some of these terms are often mistaken, which may lead to issues in the understanding of important concepts. Science communication, as a facet of scientific literacy, intends to educate people in an easy-to-understand manner, and this communication is even more important in health care, when a literate patient's medical decisions depend frequently on this process. In this article, we explore the use and misuse of some of the most common terms utilized during the 2019 coronavirus disease (COVID-19) pandemic by nursing and medical students, i.e., future health care professionals, in the hospital environment. This single-center hospital-based cross-sectional study, performed throughout September 2022, included 30 medical and nursing students. All participants completed a self-administered 15-item anonymous questionnaire at a single time point. Nine multiple-choice questions evaluated knowledge, diagnosis, disease manifestations, and vaccines related to the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) virus. Six questions provided demographics and quality assessment information. The analysis of the answers indicated that for at least 75% of the population surveyed, COVID-19 literacy was better for terms related to technology and actions (3/5 questions answered correctly) than for terms related to the disease (1/4 questions answered correctly). The overall median score for questions 1 to 9 was 4.5 of 9 points in total. Based on the results, the language used in the questionnaire was considered easy to understand, with an easy to medium level of complexity, and the perceived time required to complete the questionnaire was less than 5 min. In conclusion, our results showed that efforts need to be made in continuous professional education to increase the knowledge in COVID-19 literacy in the health care environment for medical and nursing students. Larger studies are recommended to identify and to fulfill the challenges that COVID-19 brought to medical and nursing education.

KEYWORDS COVID-19, scientific literacy, survey, infodemic, nursing students, medical students

INTRODUCTION

In the past 2 years, there has been an increasing effort worldwide for finding effective treatments, diagnostic tools, and vaccines to control the 2019 coronavirus disease (COVID-19) pandemic that, as of May 2022, had caused over 1 million confirmed deaths in the United States (1). Pneumonia and severe acute respiratory syndrome (SARS) are the most important clinical presentations of this infectious disease caused by SARS-coronavirus 2 (SARS-CoV-2) (2, 3), which was initially named COVID-19 virus by the World Health Organization (WHO) (2).

During this viral pandemic, we also experienced emergence of a "COVID-19 infodemic," an overflow of information that included false or misleading information in digital and physical environments (4). Mixed information in the field of health and hygiene flooded the Internet in a short period of time. Since it was difficult for the general public to distinguish between rumors and objective facts, such information had an adverse impact on the prevention and control of COVID-19 (4, 5). The COVID-19 pandemic has led to an accelerated use of new terminology into everyday conversations, but some of these terms are often mixed up, causing misunderstanding of important concepts (4, 6). Consequently, the dangers of health misinformation include

Editor Nicole C. Kelp, Colorado State University
Address correspondence to Keralty Research Center, Keralty Hospital Miami, Miami, Florida, USA. E-mail: maria.bertoli@keraltyhospital.com.
The authors declare no conflict of interest.
Received: 17 November 2022, Accepted: 23 February 2023, Published: 16 March 2023

but are not limited to inaccurate information shared by people who do not realize its inaccuracy (4, 6), most importantly in the health care environment, where scientific communication is a facet of scientific literacy (7).

Scientific literacy is the ability to use appropriate evidence-based scientific knowledge and skills, for everyday life and a career, in solving personally challenging decisions as well as making responsible socio-scientific decisions (8). Therefore, having a comprehensive understanding and making sense of conflicting information received daily through the influence of social media are important key aspects of scientific literacy (9).

In this context, scientific literacy during COVID-19 has been associated with the acceptance of public health measures adopted to control the pandemic, such as vaccine acceptance (1). How to fight the infodemic has become a major problem in the field of public health (10). Health communication intends to scientifically inform people about the COVID-19 severity and how to avoid getting or spreading the infection (5). Scientific literacy encourages constantly seeking knowledge about a disease or a treatment. It helps us to embrace revision, as what is known one day is replaced with a different explanation and allows us to sort through and select among competing alternatives (11).

The life cycle of science communication includes how scientists produce science information, how media compile and share the information, and how individuals process this information and decide their actions (6). Science literacy as part of the process of science communication could be conceptualized in the same way in three dimensions: civic science literacy, digital media science literacy, and cognitive science literacy (6). This led our research team to focus on the problem of COVID-19 scientific literacy in nursing and medical students in the hospital environment by administering a brief survey.

METHODS

This single-center hospital-based cross-sectional study was performed throughout September 2022 and included 30 medical and nursing students. All participants voluntarily completed a self-administered 15-item anonymous questionnaire at a single time point. This study was approved by the Medical Board of Keralty Hospital in Miami, Florida. The documents obtained were anonymous with direct or indirect identifiers included.

Cognitive science literacy dimension

Variables included nine multiple-choice questions (MCQ; Q1 to Q9) that evaluated the knowledge of concepts related to the disease (Q1, Q2, Q5, and Q6) and technology and actions (Q3, Q4, Q7, and Q8) related to the COVID-19 pandemic. Five of nine questions (Q1, Q3, Q4, Q5, Q6, Q7, and Q8) were single-select multiple-choice questions (SMCQ), and two of nine questions (Q2 and Q9) were multiselect multiple-choice questions (MMCQ) (Table 1). Additionally, to assess complexity, time spent for completion, and clarity of the language used in the questionnaire, five MCQ (Q10 to Q14) were included. Demographic items such as age, gender, and years working at the organization were collected at the end of the survey (Q15). Each overall questionnaire score (Q1–9 score) was calculated by adding all the questionnaire correct answers; questions with ambiguous answers were not considered correct. Q1–9 score ranges could vary from 0 to 9 points. Correct disease names were used following the International Classification of Diseases-10 (ICD10) (12), World Health Organization guidance (2), and the CDC COVID-19 webpage (3).

Digital media science literacy dimension

To explore some of the results obtained from answers Q1 and Q5, a literature search restricted to the English language was performed using PubMed (before 11 November 2022, for a 5-year period). Quoted phrases such as "COVID-19 pneumonia" and "COVID-19 infection" were used to identify articles with the virus name and disease name interchangeably, before and after COVID-19. Other viral diseases, such as influenza and varicella, were searched using similar quoted phrases with the same purpose. An additional search was done in the ICD10 for the terms that referred to viral pneumonia names.

Data analysis

Database and descriptive statistical analyses were done by using IBM SPSS Statistics for Windows, version 28.0 (IBM Corp., Armonk, NY). All graphs were created using GraphPad Prism version 9.4.1 (for MacOS; GraphPad Software, San Diego, CA, USA).

RESULTS

The analyses presented here are based on the 30 questionnaires that were returned by the nursing and medical students. Sixteen females (53.3%), 13 males (43.3%), and one (3.33%) person who did not answer the question related to sex completed the survey. The youngest participant in the survey was 24 years old and the oldest was 35 years old, with a mean age (± standard deviation [SD]) of 28.06 (±2.29) years.

The overall Q1–9 score (i.e., with 1 point possible for each question) ranged from 3.0 to 6.5 points, the median was 4.5 points, and the most frequent overall score was 5.5 points. A detailed analysis of the COVID-19 scientific literacy survey answers to explore the cognitive science literacy dimension is shown in Fig. 1. Responses to 75% (3/4) of the COVID-19 technology and actions SMCQ (Q3, Q7, and Q8) and to 33% (1/3) of the COVID-19 disease-related SMCQ (Q6) were selected correctly by more than 75% of the students. In contrast, 25% (1/4) of responses for the COVID-19 technology and actions SMCQ (Q4) and 66% (2/

TABLE 1
Questionnaire content showing the appropriate use (correct answers) and misuse (incorrect answers) of terms related to COVID-19[a]

Topic (category)	Correct answer	Incorrect answer
Q1. COVID-19 is an infectious disease caused by SARS-CoV-2 (Disease)	Q1.2 SARS-CoV-2 infection (807 articles)	Q1.1 COVID-19 infection (18,450 articles)
Q2. Abbreviated name of the coronavirus disease that appeared in 2019 (Disease)	Q2.2 COVID-19 (ICD10)	Q2.1 COVID
		Q2.3 COVID-19 positive
		Q2.4 COVID-19 infection
		Q2.5 COVID-19 disease
Q3. Diagnostic test results (Technology and actions)	Q3.2 SARS-CoV-2 positive/ negative	Q3.1-COVID-19 positive/negative
Q4. Prevention of spread after COVID-19 confirmed diagnosis (Technology and actions)	Q4.1 Isolation	Q4.2 Quarantine
		Q4.3 Shelter in place
Q5. Pneumonia due to COVID-19 (ICD10) (Disease)	Q5.2 Pneumonia secondary to COVID-19 (ICD10)	Q5.1 COVID-19 pneumonia (5,557 articles)
		Q5.3 COVID-19 virus pneumonia (quoted phrase not found in PubMed)
		Q5.4 SARS-CoV-2 pneumonia (680 articles)
		Q5.5 All items are correct
Q6. SARS (Disease)	Q6.1 Severe acute respiratory syndrome (ICD10)	Q6. 2 Systemic acute respiratory syndrome
		Q6.3 Severe acute respiratory symptoms
Q7. Ventilator vs respirator (Technology and actions)	Q7.1 The patient is connected to the ventilator	Q7.2 The patient is connected to the respirator
		Q7.3 Both expressions are correct if referred to mechanical ventilation
Q8. SARS-CoV-2 mRNA vaccines (Technology and actions)	Q8.3 A fragment of the virus genetic material that produces a protein that allows the body to create immunity	Q8.1 A dead or weakened form of a virus that allows the body to create immunity
		Q8.2 A genetic therapy
Q9. COVID-19 vaccines composition (Technology and actions)	Q9.3 mRNA	Q9.1 Microchip
	Q9.4 Adenovirus with a coronavirus protein	Q9.2 Viral proteins

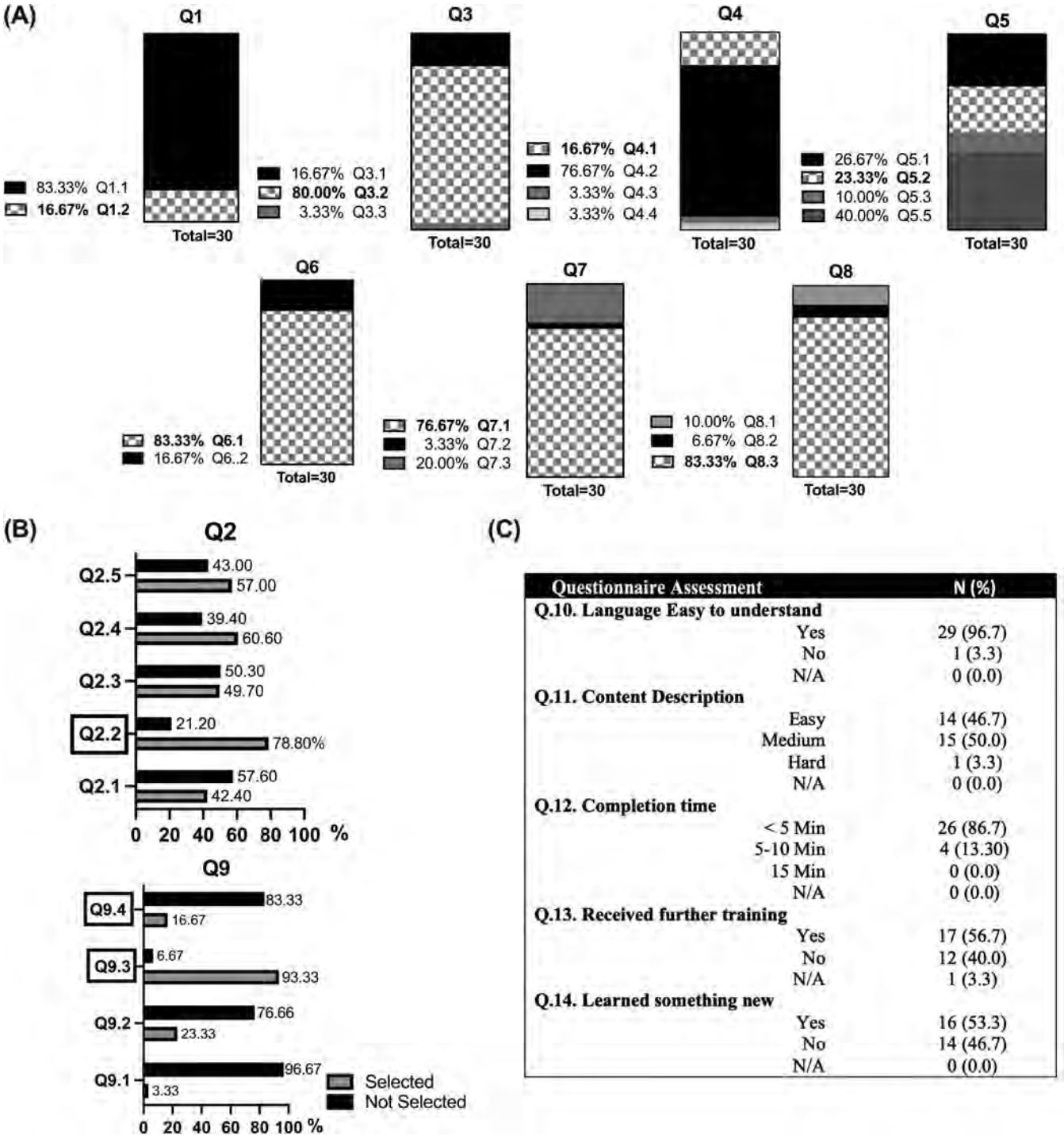
[a]MCQ Q1, Q2, Q5, and Q6 focused on concepts related to the disease, and MCQ Q3, Q4, Q7, Q8, and Q9 were related to technologies and actions. Article numbers, reported in parentheses, refer to the number of articles found in PubMed using the indicated term(s).

3) of COVID-19 disease-related SMCQ (Q1 and Q5) were selected correctly by less than 25% of the survey participants (Fig. 1A).

SMCQ Q5 explored the knowledge of the correct name for the pneumonia caused by SARS-CoV-2 virus (Q5.2 pneumonia secondary to COVID-19); only 23.33% of the participants selected Q5.2 as the correct answer, followed by 26.67% selecting Q5.1, 10% selecting Q5.3, and 40% selecting Q5.5 (Fig. 1A).

Answers for MMCQ Q2 (name of the coronavirus disease that appeared in 2019) were characterized by a similar uncertainty trend as that observed for SMCQ Q5, in which 78.80% of the participants selected the correct answer (Q2.2 COVID-19) but, additionally, ~50% selected Q2.1, Q2.3, Q2.4, and/or Q2.5. This was in contrast with MMCQ Q9 (COVID-19 vaccines composition, technology and action category), for which 93.33% of the participants selected Q9.4 (mRNA) as the correct answer and less than 20% selected Q9.1, Q9.2, and/or Q9.4 as the correct answer. Q9.4 (adenovirus with a coronavirus protein) was identified as a correct answer by only 16.67% of the students (Fig. 1B).

Based on the assessment of the participant's answers to

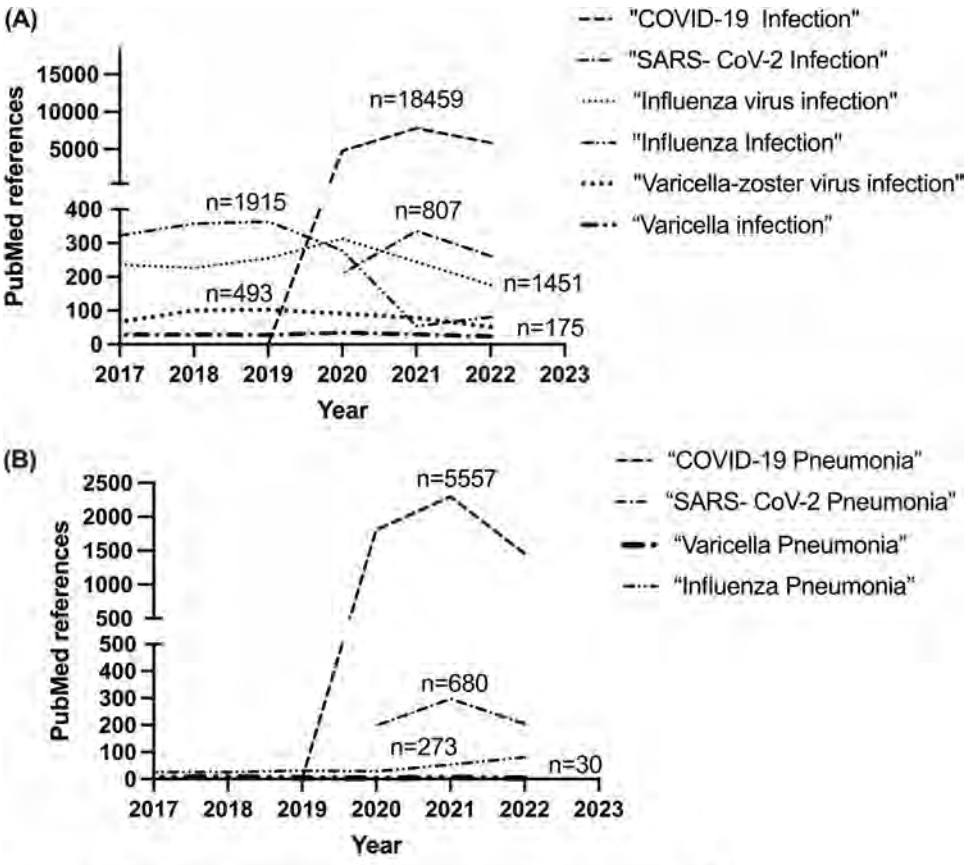


Questionnaire Assessment		N (%)
Q.10. Language Easy to understand		
	Yes	29 (96.7)
	No	1 (3.3)
	N/A	0 (0.0)
Q.11. Content Description		
	Easy	14 (46.7)
	Medium	15 (50.0)
	Hard	1 (3.3)
	N/A	0 (0.0)
Q.12. Completion time		
	< 5 Min	26 (86.7)
	5-10 Min	4 (13.30)
	15 Min	0 (0.0)
	N/A	0 (0.0)
Q.13. Received further training		
	Yes	17 (56.7)
	No	12 (40.0)
	N/A	1 (3.3)
Q.14. Learned something new		
	Yes	16 (53.3)
	No	14 (46.7)
	N/A	0 (0.0)

FIG 1. Answers to the COVID-19 scientific literacy survey administered to medical and nursing students ($n = 30$) in exploring the cognitive science literacy dimension. (A) Graphic presentation of answers to Q1 to Q9 included single-select multiple-choice questions (Q1, Q5, Q6, and Q7 on Disease; Q3, Q4, and Q8 on Technology and actions). Correct answers for each question are noted on the legend with bold letters and a checkered fill pattern. Incorrect answers are represented in black-gray scale. (B) Answers to the multiselect multiple-option questions (Q2, Disease; Q9, Technology and actions). Correct answers for each question are shown by a rectangle on the *y* axis. (C) Student assessment of the questionnaire.

the SMCQ (Fig. 1C), the language used in the questionnaire was considered easy to understand (Q10.1, 96.70%), with an easy to medium level of complexity (Q11.1 and Q11.2, approximately 97%), and the perceived time required to complete was less than 5 min (Q12.1, 86.70%). Additionally, a neutral response was obtained for Q13 and Q14, for which only 56.70% and 53.30% answered that they would like to receive further training and learned something new.

The number of failed answers exploring the cognitive science literacy dimension in terms of disease concepts,



(C)

Examples of the ICD10 Codes for viral pneumonia based on clinical and laboratory diagnosis

J10.0 Influenza with pneumonia, seasonal influenza virus identified
J11.0 Influenza with pneumonia, virus not identified
J12 Viral pneumonia, not elsewhere classified
J12.0 Adenoviral pneumonia
J12.1 Respiratory syncytial virus pneumonia
J12.3 Human metapneumovirus pneumonia
J12.8 Other viral pneumonia
12.82 Pneumonia due to coronavirus disease 2019
J12.9 Viral pneumonia, unspecified
J17.1 Pneumonia in viral diseases classified elsewhere
Pneumonia in:
- cytomegalovirus disease
- rubella
- varicella

FIG 2. Digital media science literacy dimension, exploring virus name and disease name interchangeability found in the literature published during the last 5 years (A and B), compared to the ICD10 codes (C).

particularly virus name and disease name interchangeability, motivated us to expand our search to the digital media science literacy dimension. The PubMed search for "COVID-19 infection" and "SARS-CoV-2 infection" showed that from 2019 to 2022, 18,459 references used the phrase "COVID-19 infection" (incorrect term) when referring to the infection caused by SARS-CoV-2, compared to 807 references that used "SARS-CoV-2 infection" (correct term) in the same period of time. Additionally, we searched for influenza virus and varicella-zoster virus using similar quoted phrases from 2017 to 2022. The results for this search are shown in Fig. 2A; influenza virus phrases had the same trend as observed for SARS-CoV-2 from 2017 to 2020, and this trend changed from 2020 to 2022. Varicella-zoster virus do not show an interchangeable trend for names.

The same search strategy was used for the phrase "COVID-19 pneumonia" and "SARS-CoV-2 pneumonia". A total of 5,557 searches used the term "COVID-19 pneumonia," compared to 680 references that used "SARS-CoV-2 pneumonia" (Fig. 2B). The search for "influenza pneumonia"

and "varicella pneumonia" showed interchangeability of the virus names and the disease names. Figure 2C shows some examples of ICD10 codes for viral pneumonias; the code J12.82, pneumonia due to coronavirus disease 2019 was introduced during the pandemic. Interestingly, in none of the examples is the disease name interchanged with the virus name.

DISCUSSION

In recent years, it has been increasingly noted that epidemics and pandemics are accompanied by an infodemic, which requires new skill sets applied to public health to understand and address the overwhelming amount of information, including mis- and disinformation (4, 13), and the COVID-19 pandemic was not an exception (1, 5, 10, 14). Multiple science-based disciplines require a technology-driven background to develop a broader approach, with problem-solving, critical thinking, oral and written communication, and the ability to interpret data as four core components of scientific literacy (15).

The increase in the use of social media in clinical care highlights the need for awareness and its implications for the medical profession. Expectations in society about its medical practitioners include the ability to appropriately use scientific evidence, by applying credible and reliable sources of information (11, 16). During these times, where information is easily accessible and sources are from an unknown provenance, these elements are of immense importance. In our study, we explored the problem of COVID-19 literacy in two different dimensions of scientific literacy: cognitive science literacy, by administering a survey to a group of 30 nursing and medical students, and digital media science literacy, by performing a literature search in PubMed.

The mean overall Q1–9 score for participants was 4.63 ± 1.09 (SD) points. This result was influenced by a deficient answer to the question exploring concepts related to COVID-19 as a viral disease. In this context, it is worth mentioning the drastic and unprecedented change in the education system from traditional face-to-face education to digital remote learning acting as a catalyst for communication development (14, 17, 18) during the "quarantine time." Consequently, the students probably were more exposed to digital content from diverse sources, which may have been used as a learning tool. In our study, we also conducted searches in PubMed, a digital media with more than 35 million citations and abstracts of biomedical literature (19) and one of the most widely accessible biomedical resources globally (20), and we found phrases that used interchangeably the disease name and the virus name.

This life experience joined to the confusion generated by the infodemic most probably generated the distortion in the response to Q4 (prevention of COVID-19 spread after confirmed diagnosis), for which Q4.2 (quarantine) was the selected answer by 76.67% of the participants. Our results showed that probably during this period the students also learned by their exposures to real-life situations, since most of the universities closed and sent the students back home during the quarantine (lockdowns).

In a study by Rodon et al., higher COVID-19 health literacy was associated with the adoption of effective protective behaviors (PBs). In contrast, people with low literacy would be more likely to adopt PBs if they believed that they may get COVID-19 due to the behavior and health conditions of others. This study showed the implications for the design of public health campaigns for people with inadequate health literacy (21).

The interchangeability of the virus name with the disease name, as found in the students, e.g., COVID-19 infection versus SARS CoV-2 infection, or COVID-19 pneumonia versus pneumonia due to COVID-19, also reflected deficiencies in terms of basic concepts. This problem was also influenced by the journalism language, as illustrated in Fig. 2A and B. Based on the literature search done in PubMed, the problem seems to have been present before the COVID-19 pandemic. Specialized languages should influence the lexis and syntax of the common language, leading to the "scientification of literature" of the other languages (14). The problem with lack of an appropriate pneumonia classification system (22) may also influence the knowledge deficiencies found in Q5 (Fig. 1A).

This study is a first approach of identifying knowledge in medical students and provides valuable insights into the need to reinforce training in critical appraisal of scientific literature during medical school. Its impact could increase awareness of the potential improvements to be made for easier understanding and use of the appropriate terminology.

In conclusion, our results show that efforts need to be made in continuous professional education to increase the knowledge in COVID-19 literacy in the health care environment in medical and nursing students. Larger studies are recommended to identify and to fulfill all the deficiencies that the unprecedented COVID-19 pandemic times brought to medical and nursing education.

SUPPLEMENTAL MATERIAL

Supplemental material is available online only.

SUPPLEMENTAL FILE 1, PDF file, 0.3 MB.

REFERENCES

1. Carbano G. 2021. Understanding the pandemic: the COVID-19 terms you might get wrong. CGTN. https://newseu.cgtn.com/news/2021-01-04/The-COVID-19-terms-you-might-still-be-getting-wrong-WL3p01BiSY/index.html. Accessed 26 September 2022.
2. World Health Organization. 2020. Country and technical guidance: coronavirus disease (COVID-19). https://www.who.int/

emergencies/diseases/novel-coronavirus-2019/technical-guidance. Accessed 9 November 2022.
3. U.S. Centers for Disease Control and Prevention. 2020. COVID-19. https://www.cdc.gov/coronavirus/2019-ncov/index.html. Accessed 13 November 2022.
4. World Health Organization. 2022. Infodemic. https://www.who.int/health-topics/infodemic. Accessed 13 November 2022.
5. Prem K, Liu Y, Russell TW, Kucharski AJ, Eggo RM, Davies N, Jit M, Klepac P. Centre for the Mathematical Modelling of Infectious Diseases COVID-19 Working Group. 2020. The effect of control strategies to reduce social mixing on outcomes of the COVID-19 epidemic in Wuhan, China: a modelling study. Lancet Public Health 5:e261–e270. https://doi.org/10.1016/S2468-2667(20)30073-6.
6. Howell EL, Brossard D. 2021. (Mis)informed about what? What it means to be a science-literate citizen in a digital world. Proc Natl Acad Sci U S A 118:e19124361l7. https://doi.org/10.1073/pnas.19124361l7.
7. Li Y, Guo M. 2021. Scientific literacy in communicating science and socio-scientific issues: prospects and challenges. Front Psychol 12. https://doi.org/10.3389/fpsyg.2021.758000.
8. Holbrook J, Rannikmae M. 2009. The meaning of scientific literacy. Int J Environ Sci Educ 4:275–288.
9. Rillero P. 1998. Process skills and content knowledge. Sci Act Classr Proj Curric Ideas 35:3–4. https://doi.org/10.1080/00368129809600910.
10. Li Y, Guo Y, Wu X, Hu Q, Hu D. 2022. The development and preliminary application of the Chinese version of the COVID-19 vaccine literacy scale. Int J Environ Res Public Health 19:13601. https://doi.org/10.3390/ijerph192013601.
11. Maienschein J. 1998. Scientific literacy. Science 281:917. https://doi.org/10.1126/science.281.5379.917.
12. World Health Organization. 2019. ICD-10, version 2019. WHO International Statistical Classification of Diseases and Related Health Problems, 10th rev. https://icd.who.int/browse10/2019/en#/J09-J18. Accessed 14 November 2022.
13. Zarocostas J. 2020. How to fight an infodemic. Lancet 395:676. https://doi.org/10.1016/S0140-6736(20)30461-X.
14. Trzaskawka P, Kic-Drgas J. 2022. Penetration of COVID-19 related terminology into legal, medical, and journalistic discourses. Int J Semiot Law 35:937–960. https://doi.org/10.1007/s11196-021-09881-3.
15. Coil D, Wenderoth MP, Cunningham M, Dirks C. 2010. Teaching the process of science: faculty perceptions and an effective methodology. CBE Life Sci Educ 9:524–535. https://doi.org/10.1187/cbe.10-01-0005.
16. Mohan L, Singh Y, Kathrotia R, Cariappa M, Khera A, Ghosh S. 2020. Scientific literacy and the medical student: a cross-sectional study. Natl Med J India 33:35–37. https://doi.org/10.4103/0970-258X.308242.
17. Svrluga S. 5 January 2022. With COVID surging, many college students are confined in isolation and quarantine. Washington Post. https://www.washingtonpost.com/education/2022/01/04/colleges-student-quarantines-omicron/. Accessed 1 February 2023.
18. Singer N. 9 September 2020. College quarantine breakdowns leave some at risk. New York Times. https://www.nytimes.com/2020/09/09/business/colleges-coronavirus-dormitories-quarantine.html. Accessed 1 February 2023.
19. National Library of Medicine. 2023. PubMed overview. https://pubmed.ncbi.nlm.nih.gov/about/. Accessed 6 February 2023.
20. Ossom Williamson P, Minter CIJ. 2019. Exploring PubMed as a reliable resource for scholarly communications services. J Med Library Assoc 107:16–29. https://doi.org/10.5195/jmla.2019.433.
21. Rodon C, Chin J, Chevalier A. 2022. Assessing COVID-19 health literacy (CoHL) and its relationships with sociodemographic features, locus of control and compliance with social distancing rules during the first lockdown in France. Health Educ Res 37:143–154. https://doi.org/10.1093/her/cyac009.
22. Mackenzie G. 2016. The definition and classification of pneumonia. Pneumonia (Nathan) 8:14. https://doi.org/10.1186/s41479-016-0012-z.