BMJ Open
Cross-sectional study of the knowledge, perception and attitude of first-year university students in Iraq towards SARS-CoV-2 Omicron variant and COVID-19 vaccines

Mostafa Abed,1 Sarah Al Omari,2 Rida Mourad,3 Achraf Al Faraj

ABSTRACT

Objectives The aim of this study was to first assess the knowledge and perception of first-year university students in Iraq about COVID-19 in general and SARS-CoV-2 latest variant of concern, and to evaluate the attitudes towards protection measures including vaccination.

Study design A cross-sectional study was conducted among newly enrolled students at the American University of Iraq-Baghdad. Mann-Whitney U and Kruskal-Wallis tests were used to test an association between the outcomes measured on a 5-point Likert scale and the binary and the categorical independent variables, respectively. $\chi^2$ test was used to test the association between nominal categorical variables, while Kendall’s $\tau$-b was used for ordinal variables.

Participants Students (n=432) were invited to fill out a survey specifically tailored to assess their knowledge, perception and attitude towards Omicron variant and COVID-19 vaccines acceptance. 363 students enrolled in various majors participated in this study.

Results Assessment of COVID-19 knowledge and perception revealed that students still lack reliable info and data about FDA-approved treatment options (70.5%), SARS-CoV-2 variants (96.5%) and approved vaccines. Students’ attitude and practices towards recommended safety measures should be reassessed to better manage the pandemic. Adherence level was shown to be associated with the belief in its capacity to effectively manage the new variant. Interestingly, 85% of the students have received at least one dose of approved vaccine. A significant positive correlation was detected between the level of adherence to recommended precautions and the intention to take a third booster shot if proven effective.

Conclusions Students’ reliable knowledge about COVID-19 pandemic including the various strains and approved vaccines should be improved to better manage the pandemic and set foundations for a more appropriate approach when another pandemic occurs. Special workshops should be organised to ensure that students and the public have a more trusted source of information about COVID-19.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The study was conducted during orientation sessions of first-year university students to offer participants adequate time to complete the survey.
⇒ The sample was surveyed at a university attracting students from middle to high socioeconomic status, and from the capital Baghdad, which is not representative of the entire Iraqi population of first-year university students.
⇒ Several statistical tests were performed to analyse and test associations between different variables.
⇒ As the statistically significant results are only suggestive of potential associations, multivariable analyses taking into consideration potential confounders are needed.

INTRODUCTION

The unprecedented rapid spread of COVID-19 caused by the SARS-CoV-2 has resulted in a global impact not only in terms of morbidity and mortality but has also affected almost all sectors worldwide including education and healthcare practice.1-3 In addition to using personal protection equipment such as masks, performing regular hand-washing and respecting physical distancing to minimise and even stop the transmission of SARS-CoV-2, the intensive implementation of vaccination is a major requirement for achieving herd immunity and overcoming the COVID-19 pandemic.4

According to the WHO, as of 22 April 2022, 195 vaccine candidates are in clinical phases of development using both traditional and non-traditional platforms, while 38 vaccines were approved by at least one country, and 10 vaccines were granted Emergency Use Listing by WHO.5 Most countries have granted emergency use authorisation to vaccines that have demonstrated high efficacy and elicited a robust immune response. The competition is
being led by vaccine candidates from Pfizer/BioNTech, Moderna, Oxford-AstraZeneca, Johnson & Johnson, Sputnik-V, Sinovac and Sinopharm. Most observational studies assessing these vaccines have reported their safety and high efficacy to prevent severe disease, hospitalisation and death against SARS-CoV-2.7

However, while scientists race to develop effective and safe COVID-19 vaccines, several variants of concern have emerged, including Alpha (B.1.1.7), Beta (B.1.351), Gamma (P1), Delta (B.1.617.2) and more recently Omicron (B.1.1.529). When compared with the original strain, these strains have been linked to increased COVID-19 transmission and/or mortality and may escape immunity, thus causing additional burden on healthcare and require further investigation by scientists.

Notably, Iraq has faced COVID-19 pandemic with an exhausted health system and unstable socioeconomic conditions and thus has applied severe public health measures to alleviate the drastic impact.9 According to WHO, as of 24 April 2022, only 17.8% of Iraqi population has been fully vaccinated while 24.4% has received at least one dose. These numbers are way below the global average where 59.4% of the population have been completely vaccinated and thus placed Iraq in Q4 category of vaccination race WHO.5 While four vaccines have been approved for use in Iraq namely Pfizer/BioNTech, Oxford-AstraZeneca, Sputnik V and Sinopharm, national campaigns are still required to increase vaccination rate and public health officials stay concerned with the public’s perception of the vaccine as well as its acceptability and willingness to get it, especially in rural areas.6

Several factors contribute to vaccine hesitancy, including worries about both short-term and long-term side effects, religious beliefs and conspiracy theories, lack of trust in government policy makers and negative perceptions of vaccine manufacturers.10,11

University or college students are a significant population of young adults to target for reaching COVID-19 herd immunity. Various reasons make university students vulnerable to SARS-CoV-2 infection, including communal living in on-campus and off-campus accommodation, sports and extracurricular activities, and the need to commute between home and university. Furthermore, university campuses have been identified as high-risk places that boost COVID-19 infections.12 Previous studies among university students revealed a higher intention to receive COVID-19 vaccination for certain group of students such as medical and healthcare students in addition to those with high vulnerability to COVID-19.13

While many university campuses in the USA are favouring vaccination mandates, several European countries favour adopting a different strategy. Vaccination obligations for university students have been a hotly discussed subject during the last months, especially after both Pfizer and Moderna mRNA vaccines have received emergency use (or conditional marketing) authorisation for ages 12 and above following positive clinical trial results.14

Whereas limited studies have assessed attitudes towards vaccination among university students in low-income or developing countries (or low-middle-income countries), some countries have shown a high level of knowledge and a good practice but negative attitude towards coronavirus.15 The aim of this study was to first assess the perception and knowledge of first-year university students at the American University of Iraq-Baghdad (AUIB) about COVID-19 in general and the last variant of concern (ie, Omicron) and to evaluate the attitudes towards COVID-19 protection measures including vaccination.

METHODS
Study design
This cross-sectional study was conducted among newly enrolled first-year university students at the AUIB. During the new students’ orientation sessions that took place on several dates in January 2022, few days before the latest wave caused by Omicron variant in Iraq, students were invited to fill out an online self-administrated questionnaire specifically tailored to assess their knowledge, perception and attitude towards the emerging SARS-CoV-2 variants (ie, Omicron) and COVID-19 vaccines acceptance. The questionnaire was set to be answered only once to decrease the risk of submitting more than once. After ethical clearance, a convenience sampling technique was preferred due to our limited access to newly enrolled students in Iraq. From the 432 students enrolled at AUIB in Spring 2022 semester, 363 students accepted to participate in this survey.

Participants
Newly enrolled students at AUIB were chosen, and already enrolled students were excluded because their knowledge, perception and attitude should not be affected by their majors. The students had unlimited time to answer but could not communicate with each other. Few students had problems understanding English, therefore the questionnaire was offered in Arabic too.

Sample size
The sample size was determined by the number of enrolled students at AUIB, due to limited access to other newly enrolled students in Iraq.

Survey instrument
The survey instrument was delivered using Microsoft Forms and was divided into 4 sections with a total of 32 questions. The first section included general information questions such as the gender, age, programme of study (ie, major) of the students and asked questions related to what extent has the COVID-19 pandemic influenced students’ choice of major (using 5-point scale, ranging from ‘low’ to ‘high’), if any of their first-degree relative (ie, parents, siblings) are working in the medical or healthcare field, and asked students to rate their adherence level to the recommended standard operating procedure during the

Open access

Abed M, et al. BMJ Open 2022;12:e064301. doi:10.1136/bmjopen-2022-064301
last month, that is, wearing a mask, physical distancing and regular use of hand sanitisers, etc (using 5-point scale, ranging from ‘poor’ to ‘excellent’). The second section of the survey assessed the participants’ perception and knowledge about COVID-19 (5-point Likert scale ranging from ‘not at all’ to ‘to a great extent’ was used), FDA-approved treatment options, WHO and Iraqi health authorities’ recommendations (5-point Likert scale was used as previously mentioned), and SARS-COV-2 variants. The third section was dedicated to participants’ knowledge towards Omicron variant by assessing their knowledge about the country where it was first reported, its spread speed, severity and symptoms, and considerations about the accuracy of currently used diagnostic tests and efficiency of available vaccines (questions regarding the symptoms, accuracy of current diagnostic test and efficiency of available vaccines were 5-point Likert scale questions with the same parameters as mentioned above). In addition, participants’ attitude was evaluated by rating their adherence to the recommended safety measures, consideration about the negative impact and adherence to recommended safety measures even after vaccination.

Finally, the last section was dedicated to evaluating students’ attitude and practice towards vaccination and vaccine acceptance. Various attitude-based questions were included, depending on the likelihood to receive an approved COVID-19 vaccine soon. If the likelihood was below average, participants had to complete a multiple answers question to state the reason of the hesitance or refusal of getting the vaccine. Six different reasons were stated. If one of the selected reasons is based on worries about possible side effects or long-term unknown side effects, participants had to answer a scenario-based question whether their perception about the vaccine and the likelihood to get the vaccines can change if provided with a solid proof about the vaccine efficiency and limited side effects. If the likelihood to get a vaccine is higher than average, their attitude (ie, preference) towards the various available vaccines was assessed. The last four questions investigated students’ attitude, perception and practice towards vaccination and acceptance of a third booster vaccine, and whether the university should force students to get the vaccine. Six different reasons were included, depending on the likelihood to receive an approved COVID-19 vaccine soon. If the likelihood was below average, participants had to complete a multiple answers question to state the reason of the hesitance or refusal of getting the vaccine. Six different reasons were stated. If one of the selected reasons is based on worries about possible side effects or long-term unknown side effects, participants had to answer a scenario-based question whether their perception about the vaccine and the likelihood to get the vaccines can change if provided with a solid proof about the vaccine efficiency and limited side effects. If the likelihood to get a vaccine is higher than average, their attitude (ie, preference) towards the various available vaccines was assessed. The last four questions investigated students’ attitude, perception and practice towards vaccination and acceptance of a third booster vaccine, and whether the university should force students to get the vaccine.

**Statistical analysis**

Measures: Knowledge was measured by eight necessary elements and two conditional items that were only required in certain circumstances, with a focus on the Omicron variant, treatment and vaccination. Four questions consisted of ‘yes’, ‘no’ and ‘I don’t know’ while three questions were multiple choice questions and three were 5-point Likert scale questions rating from ‘not at all’ to ‘to a great extent’.

Descriptive statistics: Mean and SD are displayed for the continuous variable ‘age’, while counts and proportions are shown for the remaining categorical variables.

Inferential statistics: Mann-Whitney U and Kruskal-Wallis tests were used to test an association between the outcomes measured on a 5-point Likert scale and the binary and the categorical independent variables, respectively. χ² test was used to test the association between nominal categorical variables, while Kendall’s τ-b was used for ordinal variables. Cochran-Armitage trend test was used for the association between binary and ordinal variable, while Somer’s D was applied in the case the dependent variable is binary. The significance level for the interpretation of all tests was set at 0.05. All data analyses were performed using SPSS 25 (IBM).

**Patient and public involvement**

Patients or the public were not involved in the design, or conduct, or reporting, or dissemination plans of our research.

**RESULTS**

A total of 363 newly enrolled students in undergraduate programmes at AUIB were included in the study. The average age was 19±3.78 years (17–32 years) with 53.2% of the participants being male. Most of the participants (71.6 %) were enrolled into healthcare-related study programmes (ie, dentistry and pharmacy). However, 46.3% of the students have reported that COVID-19 pandemic has a very little extent on their choice of major, while only 6.1% has reported very large extent. More than half of the students (56.2%) reported not having a first-degree relative (ie, parents, siblings) working in the medical or healthcare field (table 1).

| Table 1 Baseline characteristics and choice of major of newly enrolled first-year university students at AUIB participating in this study |
|---------------------------------------------------------------|---------|----------------|
| Age (17–32 years)                                             | 363     | 19±3.78        |
| Gender                                                        |         |                |
| Male                                                          | 193     | 53.2%          |
| Female                                                        | 170     | 46.8%          |
| Programme of study (health vs other)                          |         |                |
| Health related                                                | 260     | 71.6%          |
| Other                                                         | 103     | 28.4%          |
| To what extent has the COVID-19 pandemic influenced your choice of major? |         |                |
| Very little extent                                            | 168     | 46.3%          |
| Little extent                                                 | 60      | 16.5%          |
| Some extent                                                   | 79      | 21.8%          |
| Large extent                                                  | 34      | 9.4%           |
| Very large extent                                             | 22      | 6.1%           |
| First-degree relative working in the medical or healthcare field. |         |                |
| No                                                            | 204     | 56.2%          |
| Yes                                                           | 132     | 36.4%          |
| Prefer not to say                                             | 27      | 7.4%           |

AUIB, American University of Iraq - Baghdad.
COVID-19 knowledge and perceptions

The majority of students (70.5%) have reported being unaware that Food and Drug Administration (FDA) has recently approved some treatment options for COVID-19. Only 25.2% of the students correctly identified Remdesivir as the treatment option approved by FDA (figure 1). Students of non-health programmes were found to be more likely aware of the FDA approval of treatment options (p=0.001). Interestingly, these students are also more likely to report being aware of the WHO COVID-19 recommendations. The majority (78.5%) reported being aware that new variants/strains of SARS-CoV-2 exist. Strikingly, only 3.5% of the students correctly reported the number of existing variants as five and only 26.2% correctly identified the country of origin of the Omicron variant as South Africa (figure 1).

The majority of students (56.5%) think that Omicron (B.1.1.5.29) variant spreads faster and is more contagious, while 36.6% were not sure. Most students (63.4%) moderately to largely think that current diagnostic tests (ie, PCR) can effectively detect the Omicron (B.1.1.5.29) variant. Most students moderately to largely think that Omicron (B.1.1.5.29) variant presents the same symptoms as the previous SARS-CoV-2 strains (65.6%) and moderately to weakly believe that the current approved vaccines are efficient against the Omicron (B.1.1.5.29) variant (65.6%).

The majority of students (68.9%) correctly reported that COVID-19 infection could still happen after completing the recommended vaccination dose. Most of them (68.3%) weakly to moderately thought that they have enough and credible knowledge about the COVID-19-related information. Furthermore, most of them (62.5%) weakly to moderately thought that they are aware of the WHO recommendations for COVID-19. Moreover, the majority (63.1%) weakly to moderately believe that they have sufficient scientific knowledge about the currently available approved vaccines.

COVID-19 attitudes

The majority of students (65%) moderately to largely thought that the recommendations by the Iraqi health authorities on COVID-19 are sufficient. The majority (86.5%) do not believe that adherence to the recommended safety measures can help effectively manage this new variant, whereas only (28.1%) weakly to moderately believe in the statement. Slightly more than half (53.7%) of the students do not believe Iraqis are seriously considering the negative impact that this new variant can cause.

In addition, 39.3% of the students reported having little interest (ie, poor and fair) in getting an approved COVID-19 vaccine soon, while 39.3% reported being largely interested (ie, very good and excellent). The vast majority (88.2%) of those interested reported preferring to take Pfizer-BioNTech COVID-19 vaccine in particular (figure 2).

When asked what extent they would be interested in getting the vaccine if they were provided with solid proof that vaccines are highly efficient and have very limited side effects, half of the students reported being moderately interested, while 18.2% were largely interested. 52.1% of the students reported that the rumours about the lower efficacy on new strains do not prevent from getting the available vaccines, while 32.5% reported not being sure. Around half of the students (49.3%) largely believe that
the university should force all students, staff and faculty to be vaccinated to secure easy access to the campus, while only 17.1% were not in favour (ie, poor and fair) of these enforcements (figure 2).

COVID-19 practices

2.5% of the students reported not adhering (ie, poor) to the recommended standard operating procedure during the last month, and a small fraction (6.6%) reported adhering to a little extent (ie, fair), while around 49.3% reported being largely adherent (figure 3). When asked about receiving vaccination, around two-thirds have reported receiving two doses, a fifth have received one dose, while 15.4% have not received any dose yet at the time of the study. The large majority (83.1%) of those vaccinated have received the Pfizer vaccine. When asked whether students would take a third booster vaccine shot more efficient to this new variant when required, the majority (63.1%) reported that they would, while 26.2% were not sure (figure 3).

A significant positive weak correlation was detected between perceived knowledge level about the approved vaccine, and the intent to take an approved vaccine in non-vaccinated students (Kendall’s τ=0.322, p=0.006). Similarly, perceived knowledge about COVID-19, and perceived awareness of the WHO COVID-19 precautions are significantly correlated with self-rated adherence level to the recommended precautionary measures in the past month (Kendall’s τ=0.194, p<0.001; τ=0.207, p<0.001). Expectedly, adherence level was shown to be associated with the belief in its capacity to effectively manage the new variant (Kendall’s τ=0.198, p<0.001). Interestingly, a significant association exists between the level of adherence to recommended precautions and the intention to take a third booster shot if proven effective (Somers’ D=0.126, p=0.001).

DISCUSSION

Our results showed that students who are enrolled in non-health majors tended to have more knowledge regarding the recommendations of WHO and FDA for the prevention and vaccination for COVID-19 than students who are enrolled in one of the health majors in AUIB, also having a relatively improperly perceived COVID-19 knowledge. This constituted a surprising outcome, since the results from other countries were different. For instance, a study in Jordan that was conducted to assess the knowledge of undergraduate students majoring in health-related majors found that first-year students majoring in a health-related major had satisfactory knowledge, and the knowledge gets higher for medical students in their clinical years. Moreover, Palestinian students showed high knowledge scores regarding the prevention practices among other categories. They also expressed that they trusted the Palestinian Ministry of Health and adopted its decrees as a reliable source of information. In Saudi Arabia, the knowledge of the Saudi nursing students was significantly high, reaching around 82%. It was also noted that around three-fourth of the students demonstrated a great trust in the local government and the Saudi Ministry of Health. The students pursuing health-related majors showed insufficient knowledge about COVID-19. These findings were also observed in various other countries. A study conducted in Southern Iran showed that the students in the universities in Southern Iran showed insufficient knowledge regarding COVID-19, thus compromising the awareness of the students in perceiving the risks of COVID-19 and its consequences. Furthermore, the perceptions of the nursing students in Brazil regarding COVID-19 were deemed inadequate, mainly in the aspect of preventive measure, mainly in the hospital environment. This status found in AUIB can be explained by the nature of the educational hierarchy in Iraq, where majors are not chosen by the preference of the student alone, but it depends more on the average scored in the last class in the school and the official exam scores. Thus, a new approach should be taken into consideration in order to improve the educational outcomes and to bring more satisfaction to the students in their studies and majors.

In our study, females were found to be more knowledgeable and more willing to abide by the preventive approaches, including acceptance to take a third dose. This was congruent with studies from different countries. Albaqawi et al showed that Saudi female nursing students were more knowledgeable than their male counterparts regarding COVID-19 and its preventive measures in particular. Females in the universities in Southern Iran followed the recommended health behaviours more than males. In addition, females in Canada and the UK were more likely to abide by the preventive measures, like self-isolating, than males. In the study conducted by Salameh et al on Palestinian students, there was no significant difference in knowledge between males and females, but females tended to be more aware of the severity of COVID-19, whereas male students considered this disease to be hyped by the media.

Interestingly, the participants in our study showed high percentages of having at least one vaccine dosage...
(84.6%), almost the double of vaccination rate in the country. In addition, 60.7% of these students are interested in taking further doses. Moreover, females were more acceptable of a third dose, and this was associated with actual higher knowledge regarding COVID-19. This hesitancy featured here is found in different countries. Medical and dental students in the USA were asked about their readiness to accept and take a COVID-19 vaccine. Twenty-three per cent of medical students, and 45% of dental students were hesitant about taking the vaccine.23 In another study conducted in Bangladesh, it was found that students displayed good knowledge and positive attitudes towards COVID-19 vaccines. However, 37% of the respondents displayed negative perceptions and hesitancy towards the vaccine.24 This indicates that the spread of SARS-CoV-2 variant Omicron could influence the vaccination rate since our study was conducted after the outbreak of this variant in the country. In India, the researchers tried to investigate the reasons behind this hesitancy. Their conducted study among medical students showed a relationship between the hesitancy towards receiving a vaccine, and gathering information concerning COVID-19 from social media, and not from teachers from their medical schools or the scientific websites.25 Furthermore, one might expect China to be a country where its citizens accept vaccines and treatments for pandemics and epidemics, considering the country’s past and present approach in ameliorating epidemics. For example, one of the differences between the Chinese people and others is that Chinese people reported wearing masks when going out, unlike other people of other nations, like the Palestinians, who reported that wearing a face mask was not required for the protection against COVID-19.17 However, this was not the case. In a study conducted primarily by the West China School of Nursing, the researchers found that the respondents, who were students from different universities, displayed good knowledge about the vaccine (77%) and high willingness to take it (86%). However, their perception of COVID-19 and its risks was low and, notably, a large percentage of 69.8% had less positive attitudes towards taking the vaccine.26 This was in contrast with the results found among Palestinian students, where the majority were found to be willing to take the vaccine, regardless of their gender.17

In conclusion, this study should be built on in order to improve the knowledge of the students and thus this would help in ameliorating the pandemic and set the foundations for a more appropriate approach if (or when) another pandemic occurs. For instance, a lot of consideration should be taken in order to find better criteria for the choice of majors among high school students. In addition, special workshops should be organised to inform the students and the general public about COVID-19 and its available vaccines and their efficiency. This way one can ensure that the students, and the public, have a more trusted source of information regarding COVID-19.

This study has some limitations. Data were collected only from one university, and a few faculties and departments. This cannot be generalised but can be considered a descriptive piece of evidence that may give an idea about the status quo of a certain class of the Iraqi society. In addition, this is only cross-sectional study which does not investigate causation or account for confounding factors to better make sense of the findings. Future research needs to delve more into social, political and economic factors that drive university students’ knowledge, attitudes and practices towards large-scale epidemics like COVID-19.

Contributors SAO and AAF contributed to the conception and design of the study. AAF is the author acting as guarantor. All authors (MA, SAO, RM and AAF) analysed and interpreted the data and drafted the manuscript. All authors critically revised the manuscript for significant intellectual content and insight, had full access to all the data, and take responsibility for the integrity and accuracy of the data analysis. In addition, all authors gave final approval of the manuscript version for publication.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants and was approved by Institutional Review Board committee at AUB Reference number: 2022-001A. Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available on reasonable request. Data access queries should be addressed to the corresponding author (AAF). All data are anonymised, and individual unit-level data are not available.

Supplemental material This content has been supplied by the author(s). It has not been vetted by BMJ Publishing Group Limited (BMJ) and may not have been peer-reviewed. Any opinions or recommendations discussed are solely those of the author(s) and are not endorsed by BMJ. BMJ disclaims all liability and responsibility arising from any reliance placed on the content. Where the content includes any translated material, BMJ does not warrant the accuracy and reliability of the translations (including but not limited to local regulations, clinical guidelines, terminology, drug names and drug dosages), and is not responsible for any error and/or omissions arising from translation and adaptation or otherwise.

Open access This is an open access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited, appropriate credit is given, any changes made indicated, and the use is non-commercial. See: http://creativecommons.org/licenses/by-nc/4.0/.

ORCID iD
Achraf Al Faraj http://orcid.org/0000-0002-8943-1354

REFERENCES
1 Pouwels BDC, Simons SO, Theunissen M, et al. Healthcare use during COVID-19 and the effect on psychological distress in patients with chronic cardiopulmonary disorders in the Netherlands: a cross-sectional study. BMJ Open 2021;11:e046883.
2 Chakraborty P, Mittal P, Gupta MS, et al. Opinion of students on online education during the COVID-19 pandemic. Hum Behav Emerg Technol 2021;3:357–65.
3 McIntosh A, Bachmann M, Siedner MJ, et al. Effect of COVID-19 lockdown on hospital admissions and mortality in rural KwaZulu-Natal, South Africa: interrupted time series analysis. BMJ Open 2021;11:e047961.
4 Yadegari I, Omidii M, Smith SR. The herd-immunity threshold must be updated for multi-vaccine strategies and multiple variants. Sci Rep 2021;11:22970.
5 World Health Organization. WHO COVID-19 Dashboard. Geneva, 2020. https://covid19.who.int/
6 Cascella M, Rajnik M, Aleem A. Features, Evaluation, and Treatment of Coronavirus (COVID-19). In: Statpearls. Treasure Island (FL): StatPearls Publishing, 2022 Jan.
7 Simnani FZ, Singh D, Kaur R. COVID-19 phase 4 vaccine candidates, effectiveness on SARS-CoV-2 variants, neutralizing antibody, rare side effects, traditional and nano-based vaccine platforms: a review. 3 Biotech 2022;12:12
8 Garcia-Beltran WF, St Denis KJ, Hoelzemer A, et al. mRNA-Based COVID-19 vaccine boosters induce neutralizing immunity against SARS-CoV-2 omicron variant. Cell 2022;185:457–66.
9 Lam J, Rashak HA, Khaleel HA, et al. Iraq experience in handling the COVID-19 pandemic: implications of public health challenges and lessons learned for future epidemic preparedness planning. J Public Health 2021;43:i19–28.
10 Syed Awl SAR, Rafidah E, Zurraini A, et al. A survey on COVID-19 vaccine acceptance and concern among Malaysians. BMC Public Health 2021;21:1129.
11 Patelarou E, Galanis P, Mechili EA, et al. Factors influencing nursing students’ intention to accept COVID-19 vaccination: a pooled analysis of seven European countries. Nurse Educ Today 2021;104:105010.
12 Lu H, Weintz C, Pace J, et al. Are college campuses superspreaders? A data-driven modeling study. Comput Methods Biomech Biomed Engin 2021;24:1136–45.
13 Riad A, Pokorná A, Antalová N, et al. Prevalence and drivers of COVID-19 vaccine Hesitancy among Czech university students: national cross-sectional study. Vaccines 2021;9:948.
14 Ioannidis JPA. COVID-19 vaccination in children and university students. Eur J Clin Invest 2021;51:e13678.
15 Patwary MM, Disha AS, Bardhan M, et al. Knowledge, attitudes, and practices toward coronavirus and associated anxiety symptoms among university students: a cross-sectional study during the early stages of the COVID-19 pandemic in Bangladesh. Front Psychiatry 2022;13:856202.
16 Mustafa RM, Alrabadi NN, Alshali RZ, et al. Knowledge, attitude, behavior, and stress related to COVID-19 among undergraduate health care students in Jordan. Eur J Dent 2020;14:S50–5.
17 Salameh B, Basha S, Basha W, et al. Knowledge, perceptions, and prevention practices among Palestinian university students during the COVID-19 pandemic: a questionnaire-based survey. Inquiry 2021;58:004695802199394.
18 Albaqawi HM, Alquezee N, Balay-Odoo E, et al. Nursing students’ perceptions, knowledge, and preventive behaviors toward COVID-19: a Multi-University study. Front Public Health 2020;8:57390.
19 Rayani M, Rayani S, Najafi-Sharijabadi F. COVID-19-related knowledge, risk perception, information seeking, and adherence to preventive behaviors among undergraduate students, southern Iran. Environ Sci Pollut Res 2021;28:59953–62.
20 Reis RK, Meneguelli MG, Malaguti-Toffano SE, et al. Knowledge, behaviors, and perceptions of risk of COVID-19 among Brazilian nursing students: a cross-sectional study. Nurse Educ 2021;46:E158.
21 Mant M, Holland A, Prine A. Canadian university students’ perceptions of COVID-19 severity, susceptibility, and health behaviours during the early pandemic period. Public Health Pract 2021;2:100114.
22 Atchison C, Bowman LR, Vrinten C, et al. Early perceptions and behavioural responses during the COVID-19 pandemic: a cross-sectional survey of UK adults. BMJ Open 2021;11:e043577.
23 Kelekar AK, Lucia VC, Afonso NM, et al. COVID-19 vaccine acceptance and hesitancy among dental and medical students. J Am Dent Assoc 2021;152:596–603.
24 Hossain ME, Islam MS, Ghose TK, et al. COVID-19 vaccine acceptability among public university students in Bangladesh: highlighting knowledge, perceptions, and attitude. Hum Vaccin Immunother 2021;17:5089–98.
25 Jain J, Saurabh S, Kumar P, et al. COVID-19 vaccine hesitancy among medical students in India. Epidemiol Infect 2021;149:e132.
26 Jiang N, Gu P, Liu K, et al. Acceptance of COVID-19 vaccines among college students: a study of the attitudes, knowledge, and willingness of students to vaccinate. Hum Vaccin Immunother 2021;17:4914–24.