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Article

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Abstract: University students, particularly those in the healthcare disciplines, constitute a category of particular interest in regard to COVID-19 vaccines and the attitudes to vaccination, as their future professional role will enable them to inform and educate citizens regarding vaccination. The objectives of the study were to investigate the vaccination coverage with a COVID-19 vaccine among students from different degree programs at the Medical universities in Bulgaria behaviors and attitudes toward vaccination with a COVID-19 vaccine. A prospective cross-sectional study in the period September 2021- March 2022 was conducted. Information on demographics, university program, year of study, general attitudes and behavior towards vaccines and attitudes and personal experience with COVID-19 and COVID-19 vaccines were collected. The chi-square test was used to test for associations and binominal logistic regression was used to identify possible predictors for vaccination. A total of 3050 students with a median age of 22 years, predominantly female took part in the study. Three-thirds of the students (73.5%) have been vaccinated against COVID-19. The main reasons for vaccine hesitancy in both group of students were the fear of side effects and the doubts about the safety of the vaccines although non-vaccinated students significantly more frequently express those fears. Respondents who considered to have: a) limited access to sufficient information to inform COVID-19 vaccine uptake; b) lack of public awareness and education campaigns about effectiveness and safety of COVID-19 vaccines; c) insufficient information about COVID-19 vaccines during the University education; and d) had a positive COVID-19 diagnosis were less likely to be vaccinated. Students who have not completed the mandatory immunization cycle according to country schedule were also less likely to have completed COVID-19 vaccination. The students showed an overall positive attitude towards the COVID-19 vaccines. Promoting informational campaigns that emphasize the vaccine's safety will be more effective to further increase the vaccination coverage with COVID-19 vaccines.

Keywords: COVID-19; vaccines; hesitancy; attitudes; medical students; healthcare workers

1. Introduction

Three years after the World Health Organization (WHO) declared a COVID-19 pandemic, as of July 19, 2023, worldwide confirmed cases are 768,237,788, including 6,951,677 deaths (0.90%) [1]. The WHO European Region is in first place in terms of registered cases (275,760,968) and in second place

in the number of deaths (2,245,217) (lethality 0.81%). For the same period in Bulgaria, which belongs to upper middle-income countries, the registered number of cases is 1,309,499 with 38,440 deaths or 2.93% lethality [2].

Against the backdrop of a lack of highly effective treatment against COVID-19, the only scientifically proven solution is the development and introduction of safe vaccines and the deployment of a vaccination campaign. Bulgaria, as a member of the European Union, has practically the complete set of vaccines registered for use against COVID-19: Comirnaty (Pfizer-BioNTech, mRNA), Spikevax (Moderna, mRNA), Vaxzevria (AstraZeneca, ChAdOx1-S recombinant), Janssen (Johnson & Johnson, vector), Valneva (Valneva) and VidPrevtyn Beta (Sanofi, recombinant) in the respective formulations for adults and the first two of them for children. At the national level, on December 4, 2020, the "National Plan for Vaccination against COVID-19 in the Republic of Bulgaria" was announced. The plan included 5 phases, based first of all on the need to target the first supplies of vaccine to population groups according to the risk of infection and the need to maintain critical structures for the functioning of society. Medical staff, dentists, pharmacists, assistant pharmacists and other support staff in healthcare facilities were the priority group included in phase 1.

The beginning of the immunization campaign in Bulgaria started on December 27, 2020, with the participation of publicly known personalities with a view to a more significant impact on the population regarding the choice of vaccination. Since the end of the summer of 2021, COVID-19 vaccines have been freely available to the population. Despite this, the country still has the lowest immunization coverage among European countries (30.38% of the population has a completed vaccination course or 2,077,782 persons) [3], and the total number of vaccines administered from the beginning of the immunization campaign until 20 July 2023 is 4,613,280 [2]. The main factors influencing the success of an immunization program are vaccine safety and patient adherence [4], and according to the WHO, vaccination hesitancy ranks among the top ten threats to human health globally [5].

In the first two years of the pandemic alone (March 2020-March 2022), the number of hospitalizations reached 247,441 patients or 22% of all 1,126,945 officially confirmed and registered cases of coronavirus infection at that time. Relative to the population of the country (6,447,710 according to the data of the National Statistical Institute in Bulgaria as of 31.12.2022), the share of hospitalized people is 3.8% of the population. This has put our health system under extreme strain and a shortage of medical personnel in hospitals was reported.

Medical students across the country are among the first to respond to calls for help by volunteering in COVID-19 wards. This has a wide social impact on the one hand, but on the other hand, it puts future doctors at risk.

University students, particularly those in the healthcare disciplines, constitute a category of particular interest, as their future professional role will enable them to inform and educate citizens regarding vaccination, which is of great ethical and social importance. Indeed, the positive opinion of university students can have a significant influence on social trends [6,7].

Vaccine hesitancy is a chronic public health threat that may undermine efforts to achieve herd immunity by vaccination. Despite the overwhelming volume of evidence on the benefits of immunization, widespread misconceptions and mistrust of information about vaccine efficacy and safety remain [7]. Key barriers to vaccination include lack of knowledge and confidence, lack of access to vaccines, concerns about the efficacy and safety of vaccines, and religious beliefs [8]. These barriers are also empowered by different conspiracy theories that circulate mainly in social media. Surprisingly, the vaccine hesitancy phenomenon is present even among healthcare professionals. Vaccination of healthcare workers (HCWs) is of utmost importance to prevent the spread of viruses as they are in the best position to understand patients' doubts and concerns, respond to their questions, and explain in simple words to them the importance and positives of vaccination [9]. However, more and more studies report low acceptance levels and high hesitancy levels to COVID-19 vaccination among healthcare professionals (medical doctors, nurses, dentists etc.), including those who provide vaccination to patients [10,11].

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The objectives of the study were to: 1) investigate the vaccination coverage with a COVID-19 vaccine among students from different degree programs at the Medical universities in Bulgaria and 2) investigate behaviors and attitudes toward vaccination with a COVID-19 vaccine, and to identify the potential factors that influence students' decisions regarding vaccination.

2. Materials and Methods

A cross-sectional study using a semi-structured anonymous questionnaire was conducted in the Bulgarian medical universities in the period September 2021- March 2022. Using the platforms of the universities for online teaching the questionnaire was distributed to students, enrolled in the respective university. A total of 3050 students participated in the study.

The questionnaire was prepared both in Bulgarian and in English using Google Forms and it consisted of four panels. The front page of the questionnaire included a description of the study and consent forms with an opt-out option if the respondent was not willing to continue further.

The first panel of the questionnaire gathered information about the demographics of the participants-age, sex, place of residence, university, the main subject of study and year of study. In the first section of the questionnaire, the respondents were asked whether they have been vaccinated against COVID-19 and if vaccinated what type of vaccine they have received.

The second section of the questionnaire collected information regarding the general attitudes and practices of the participants towards vaccines - vaccination with mandatory vaccines, included in the immunization calendar and vaccination with recommended vaccines, more specifically influenza vaccine.

The third panel consisted of questions examining the attitudes of the participants towards COVID-19 vaccines, such as personal opinions on the importance of vaccination with a COVID-19 vaccine, drivers for vaccine hesitancy such as fear of possible undesirable adverse events and the tendency to believe conspiracy theories.

The fourth section of the questionnaire consisted of questions exploring the personal experience of the respondents with COVID-19, such as having been infected with the virus, and personal experience with COVID-19-related disease or death of close relatives, and friends.

The questions exploring the attitudes of students towards mandatory vaccines and COVID-19 vaccines were 5-point Likert-type agreement items: from 0 (strongly disagree) to 5 (strongly agree).

A group of professionals with expertise in biostatistics and ethics came up with the questionnaire's concept, developed it, and then debated and reviewed it. The team also discussed whether the questions were acceptable and understandable, taking into account the training type and level of the students who had signed up.

2.2. Statistical analysis

Descriptive statistics was used to inform about: 1) quantitative variables, presented as mean (standard deviation), and median (25th percentile; 75th percentile) when variables lack normal distribution and 2) qualitative variables, presented as frequencies and percentages (n and %). Continuous variables were tested for normality of statistical distribution by Shapiro–Wilk test. Comparisons between two groups medians were analyzed with Mann-Whitney test for independent samples and between two groups proportions with z-test. Based on the introduced in the model independent variables with a $p<0.10$ identified by univariate analysis, the binominal logistic regression was used to estimate the probability that an observation falls into one of two categories of a dichotomous dependent variable – COVID-19 vaccine uptake based on multiple independent variables. Odds ratios [OR] and 95% confidence intervals [95% CI] for the fixed effects were calculated. The systematization, processing, and analysis of the data were performed using SPSS v.26 for Windows (IBM Corp. Released 2019. Armonk, NY: IBM Corp).

2.3. Ethical considerations

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The study received approval from the Ethical Committee of the Medical University of Plovdiv, Bulgaria. The research was conducted in full accordance with the principles of the Declaration of Helsinki [12]. The present study was performed following the Strengthening and Reporting of Observational studies in Epidemiology (STROBE) guidelines [13].

3. Results

In the present study 3050 students filled in the questionnaire (Table 1). The median age was 22 years (25th percentile 20 y.o; 75th percentile 24 y.o). The female respondents predominated (n=2056, 67.4%). The substantial share of international students enrolled in English-based degree programs at medical universities in Bulgaria required development of bilingual questionnaire survey tool. There were 814 (26.7%) responses from English-speaking students. The majority of respondents were studying at the Medical University of Plovdiv (n=1669, 54.7%). There was an almost equal distribution of students regarding the year of study whereas more than half of them responded that they are studying medicine (n=1748, 57.3%).

Almost three-thirds of the students have been vaccinated against COVID-19 (n=2241, 73.5%). There were statistically significant differences among the vaccinated and unvaccinated respondents in terms of the language-based degree programs enrollment, the year of study, and the degree programs (Table 1).

Table 1. Demographic characteristics of the respondents (n=3050).

Variable	All respondents (n=3050)	COVID-19 vaccinated (n=2241)	COVID-19 non-vaccinated (n=809)	p-value
Age, median (25th percentile; 75th percentile)	22 (20;24)	22 (21;23)	21 (21;23)	0.180*
Gender, n (%)				
Male	994 (32.6)	822 (82.7)	172 (17.3)	<0.001**
Female	2056 (67.4)	1419 (69.0)	637 (31.0)	
Distribution of students by language-based degree programs enrollment, n (%)				
Bulgarian	2236 (73.3)	1473 (65.8)	763 (34.2)	<0.001**
English	814 (26.7)	768 (94.3)	46 (5.7)	
Medical university, n (%)				
Medical University of Plovdiv	1669 (54.7)	1236 (74.1)	433 (25.9)	
Medical University of Sofia	477 (15.6)	402 (84.3)	75 (15.7)	
Medical University of Pleven	421 (13.8)	189 (44.9)	232 (55.1)	<0.001**
Medical University of Varna	416 (13.6)	377 (90.6)	39 (9.4)	
Other	67 (2.2)	30 (44.8)	37 (55.2)	
Degree programs, n (%)				
Medicine	1748 (57.3)	1534 (87.7)	214 (12.3)	
Dental Medicine	343 (11.2)	259 (75.5)	84 (24.5)	
Pharmacy	248 (8.1)	155 (62.5)	93 (37.5)	<0.001**
Nursery	198 (6.5)	112 (56.6)	86 (43.4)	
Midwifery	84 (2.8)	43 (51.2)	41 (48.8)	
Physical therapist (FPH) ‡	83 (2.8)	18 (26.9)	49 (73.1)	
Other†	346 (11.3)	120 (32.8)	242 (67.2)	
Year of study, n (%)				

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1st year	684 (22.4)	439 (64.2)	245 (35.8)	
2nd year	610 (20.0)	398 (65.2)	212 (34.8)	<0.001**
3rd year	578 (19.0)	406 (70.2)	172 (29.8)	
4th year	478 (15.7)	381 (79.7)	97 (20.3)	
5th year	375 (12.3)	328 (87.5)	47 (12.5)	
6th year	325 (10.7)	289 (88.9)	36 (11.1)	

*Mann-Whitney test

**z-test

†Other – Dental technician; Dietician; Medical cosmetics; Medical laboratory assistant; Assistant Pharmacist, Physician assistant; X-ray laboratory technician; Physical therapy,Wellness and SPA(Medical college); Healthcare management;

3.2. General attitudes and practices towards vaccines

From all respondents 487 (16%) have received the influenza vaccine in the previous season, and the majority of them were studying medicine (n=335, 68.8%) (Table 2). When further asked whether they plan to receive the flu vaccine in the flu season (2021/2022) 743 (24.4%) gave a positive answer. Additionally, the proportion of students who received the influenza vaccine and chose to receive the COVID-19 vaccine also was significantly higher than that of COVID-19 non-vaccinated (19.2% for COVID-19 vaccinated vs. 6.9% for COVID-19 non-vaccinated p<0.0001).

Table 2. Personal vaccination behavior and general attitudes towards vaccines of the respondents.

Question	All respondents (n=3050)	COVID-19 vaccinated (n=2241)	COVID-19 unvaccinated (n=809)	p-value
	Participants that responded affirmatively (yes)			
Flu vaccination in the previous season (2020/2021), n (%)	487 (16.0)	431 (19.2)	56 (6.9)	<0.001
Plan to receive the flu vaccine in the current season (2021/2022), n (%)	743 (24.4)	671 (29.9)	72 (8.9)	<0.001
People receive more vaccines than needed, n (%)	561 (18.4)	262 (11.7)	299 (36.9)	<0.001
Has the responsibility to be aware of the types of vaccines and the recommendations for their administration, n(%)	2762 (90.5)	2125 (94.8)	637 (78.7)	<0.001

3.3. Personal experience with COVID-19 and COVID-19 vaccines attitudes

Almost half of the respondents reported to have been infected with COVID-19 (n=1340, 43.9%) (Table 3). In both groups of vaccinated and non-vaccinated students there was a high share who personally know someone who had had a COVID-19 infection history and someone who had died of COVID-19. When exploring the attitudes of the respondents in regard to the COVID-19 vaccines we could clearly identify a difference between the two groups. A very small share of the unvaccinated students believed that the COVID-19 vaccines were important for them as future healthcare providers and that they should be mandatory for the HCW (n=72, 8.9% and n=58, 7.2% respectively). Additionally, the non-vaccinated respondents tended to believe more to conspiracy theories such as that the COVID-19 vaccines have been developed too quickly (n=324; 14.4 % for COVID-19 vaccinated vs. n=555, 68.6% for COVID-19 non-vaccinated respectively Pearson $\chi 2$ test=1035.10, p=0.000) and that they might be part of a conspiracy plan (n=163; 7.2 % for COVID-19 vaccinated vs. n=294, 36.3% for COVID-19 non-vaccinated respectively Pearson $\chi 2$ test=706.91, p=0.384). The main reasons for

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vaccine hesitancy in both group of students were the fear of side effects and the doubts about the safety of the vaccines although non-vaccinated students significantly more frequently express those fears. When it comes to the main source of information in regard to COVID-19 vaccines the vaccinated students significantly more relied on official sources (Ministry of Health, World Health Organization, Center for Disease Control and Prevention) (n=2008, 89.6% vs. n=522, 64.6% Pearson $\chi 2$ test=264.35, p<0.001), and university teachers (n= 942, 42% vs. n=281, 34.8% Pearson $\chi 2$ test=13.19, p<0.001) compared to non-vaccinated students.

Table 3. Personal experience with COVID-19 and COVID-19 vaccines attitudes.

Variables	All respondents (n=3050)	COVID-19 vaccinated (n=2241)	COVID-19 non-vaccinated (n=809)	p-value
COVID-19 infection history				
	Participants that responded affirmatively (yes)			
Recovered from a COVID-19 infection, n (%)	1340 (43.9)	856 (38.2)	484 (59.8)	<0.001
Cases of COVID-19 infection in the family, n (%)	2064 (67.7)	1489 (66.4)	575 (71.1)	0.016
Personally know someone who has had COVID-19 infection, n (%)	2949 (96.7)	2175 (97.0)	774 (95.7)	0.060
Personally know someone who has died from COVID-19, n (%)	1503 (49.3)	1160 (51.8)	343 (42.4)	<0.001
Attitudes to COVID-19 vaccines				
	Participants that responded affirmatively (agree/strongly agree)			
COVID-19 vaccines are important for me as a health care provider, n (%)	1918 (62.9)	1846 (82.4)	72 (8.9)	<0.001
COVID-19 vaccines should be mandatory for the general public, n (%)	1170 (38.4)	1147 (51.8)	23 (2.8)	<0.001
COVID-19 vaccines should be mandatory for the healthcare providers, n (%)	1765 (57.9)	1707 (76.2)	58 (7.2)	<0.001
I am more likely to be exposed to COVID-19 as a future healthcare provider, n (%)	2326 (76.3)	1949 (87.0)	377 (46.6)	<0.001
COVID-19 vaccination is important to decrease spread of the disease, n (%)	1988 (65.2)	1855 (82.8)	133 (16.4)	<0.001
I am worried that the COVID-19 vaccine won't be effective in preventing an illness, n (%)	1308 (42.9)	717 (32.0)	591 (73.0)	<0.001
I am worried about possible adverse events following COVID-19 vaccination, n (%)	1429 (46.8)	718 (32.0)	711 (88.1)	<0.001
I have confidence in the information that I received on the COVID-19 vaccine from public health experts, n (%)	1580 (51.8)	1496(66.7)	84 (10.4)	<0.001
COVID-19 vaccines were developed too quickly and this makes them dangerous, n (%)	879 (28.8)	324 (14.4)	555 (68.6)	<0.001
COVID-19 vaccines are part of a conspiracy plan to reduce the human population, n (%)	457 (15.0)	163 (7.2)	294 (36.3)	<0.001
Main reasons for vaccine hesitancy, n (%)				
Fear of adverse events	1019 (33.4)	282 (12.6)	737 (91.1)	<0.001
Doubts about vaccine safety	1001 (32.8)	366 (16.3)	653 (80.7)	
Main source of information about the COVID-19 vaccines, n (%)				<0.001

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Official sources (WHO, CDC, MH)	2530 (82.9)	2008 (89.6)	522 (64.6)
University teachers	1223 (41)	942 (42)	281 (34.8)
Friends and relatives	268 (8.8)	145 (6.5)	123 (15.2)
Internet/Social media	217 (7.1)	133 (5.9)	84 (10.4)

3.4. Logistic regression to identify potential factors that influence students' decisions regarding vaccination.

A binomial logistic regression was performed to predict the probability that an observation falls into one of two categories of a dichotomous dependent variable – COVID-19 vaccine uptake based on multiple independent variables (Table 4). The model was statistically significant, $\chi 2(42) = 2074.65$, p=0.000. The model explained 72.0% (Nagelkerke R2) of the variance in COVID-19 vaccine uptake and correctly classified 89.6% of cases.

Bulgarian students were less likely to have received COVID-19 vaccine compared to the international students (odds ratio [OR] 0.42, 95% confidence interval [CI] 0.27 to 0.68). Medical students were more likely to be vaccinated in comparison with students in the following degree programs – Health care management (OR=0.31, 95% CI 0.06–0.98), Rehabilitation, Wellness and SPA (OR=0.12, 95% CI 0.01–0.98), Assistant pharmacist (OR=0.17, 95% CI 0.07–0.73), Dental technician (OR=0.31, 95% CI 0.10–0.93), Physical therapist (OR= 0.29, 95% CI 0.13–0.66), Medical cosmetics (OR=0.34, 95% CI 0.14–0.84), Medical laboratory assistant (OR=0.30, 95% CI 0.11–0.83).

Students who felt responsible as a future healthcare professionals and for the patients' wellbeing to be familiar with the types of vaccines were more likely to be vaccinated than these students who did not recognize themselves in that role (I neither agree nor disagree: OR=1.72, 95% CI 1.07–2.76); I agree: OR=1.44, 95% CI 1.17–2.06). Compared to the students who highly valued the importance of COVID-19 vaccines all the rest were less likely to undergo vaccination. Students who did not agree that COVID-19 vaccination should be mandatory for medical personnel were less likely to receive such a vaccine. Concerns about possible side effects from the administration of the COVID-19 vaccine reflected in lower likelihood of vaccine uptake in almost all categories. Students who did not believe vaccines are part of a conspiracy plan to reduce the population, and the virus was artificially created for this purpose were more likely to have vaccination (OR=1.82, 95% CI 1.14–2.92). Respondents who considered to have: a) limited access to sufficient information to inform COVID-19 vaccine uptake; b) lack of public awareness and education campaigns about effectiveness and safety of COVID-19 vaccines; c) insufficient information about COVID-19 vaccines during the University education; and d) had a positive COVID-19 diagnosis were less likely to be vaccinated. Students who have not completed the mandatory immunization cycle according to country schedule were also less likely to have completed COVID-19 vaccination.

Table 4. Binominal logistic regression model for COVID-19 vaccine uptake.

Model	Unstandardized Coefficients		Wald	df	Sig.	Exp(B)	95% Confidence Interval for B	
	B	Std. Error					Lower Bound	Upper Bound
(Constant)								
Language of education								
English (baseline)								
Bulgarian	**-0.850**	**0.238**	**12.736**	**1**	**0.000**	**0.428**	**0.268**	**0.682**
University programs								
Medicine (baseline)								
Dental medicine	-0.134	0.227	0.347	1	0.556	0.875	0.561	1.364
Pharmacy	-0.353	0.231	2.333	1	0.127	0.702	0.446	1.105

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Nurse	-0.453	0.247	3.369	1	0.066	0.636	0.392	1.031
Midwifery	-0.606	0.332	3.329	1	0.068	0.545	0.284	1.046
Health care management	**-1.187**	**0.569**	**4.354**	**1**	**0.037**	**0.305**	**0.100**	**0.930**
Rehabilitation,Wellness and SPA	**-2.095**	**1.061**	**3.900**	**1**	**0.048**	**0.123**	**0.015**	**0.984**
Public health inspector	-1.145	0.596	3.695	1	0.055	0.318	0.099	1.023
X-ray laboratory technician	0.472	0.566	0.694	1	0.405	1.603	0.528	4.862
Assistant pharmacist	**-1.793**	**0.418**	**18.432**	**1**	**0.000**	**0.166**	**0.073**	**0.377**
Dental technician	**-1.728**	**0.621**	**7.737**	**1**	**0.005**	**0.178**	**0.053**	**0.600**
Physical therapist	**-1.240**	**0.418**	**8.776**	**1**	**0.003**	**0.289**	**0.127**	**0.657**
Medical cosmetics	**-1.078**	**0.458**	**5.527**	**1**	**0.019**	**0.340**	**0.139**	**0.836**
Medical laboratory assistant	**-1.203**	**0.517**	**5.410**	**1**	**0.020**	**0.300**	**0.109**	**0.827**
Physician assistant	0.381	0.637	0.358	1	0.550	1.464	0.420	5.108
Responsibility as a future HCW to be familiar with the types of vaccines								
Strongly agree (baseline)								
Strongly disagree	0.729	0.379	3.701	1	0.054	2.074	0.986	4.359
Disagree	0.743	0.420	3.129	1	0.077	2.103	0.923	4.792
Neither agree nor disagree	**0.542**	**0.242**	**5.017**	**1**	**0.025**	**1.719**	**1.070**	**2.763**
Agree	**0.365**	**0.182**	**4.033**	**1**	**0.045**	**1.440**	**1.009**	**2.056**
Vaccination against COVID-19 is important								
Strongly agree (baseline)								
Strongly disagree	**-3.431**	**0.352**	**95.218**	**1**	**0.000**	**0.032**	**0.016**	**0.064**
Disagree	**-2.734**	**0.342**	**63.920**	**1**	**0.000**	**0.065**	**0.033**	**0.127**
Neither agree nor disagree	**-2.090**	**0.299**	**48.833**	**1**	**0.000**	**0.124**	**0.069**	**0.222**
Agree	**-1.263**	**0.298**	**17.983**	**1**	**0.000**	**0.283**	**0.158**	**0.507**
Vaccines against COVID-19 should be mandatory for medical personnel								
Strongly agree (baseline)								
Strongly disagree	**-1.479**	**0.290**	**25.958**	**1**	**0.000**	**0.228**	**0.129**	**0.403**
Disagree	**-1.206**	**0.300**	**16.136**	**1**	**0.000**	**0.299**	**0.166**	**0.539**
Neither agree nor disagree	-0.540	0.281	3.691	1	0.055	0.582	0.336	1.011
Agree	0.011	0.303	.001	1	0.971	1.011	0.559	1.829
Concerns about possible side effects from the administration of the COVID-19 vaccine								
Strongly agree (baseline)								
Strongly disagree	**0.957**	**0.361**	**7.011**	**1**	**0.008**	**2.603**	**1.282**	**5.283**
Disagree	**0.672**	**0.315**	**4.538**	**1**	**0.033**	**1.958**	**1.055**	**3.634**
Neither agree nor disagree	**0.487**	**0.232**	**4.422**	**1**	**0.035**	**1.628**	**1.034**	**2.563**
Agree	0.094	0.187	0.255	1	0.613	1.099	0.762	1.585

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Vaccines are part of a conspiracy plan to reduce the population, and the virus was artificially created for this purpose								
Strongly disagree (baseline)								
Disagree	-0.149	0.220	0.458	1	0.499	0.862	0.560	1.326
Neither agree nor disagree	-0.141	0.194	0.533	1	0.466	0.868	0.594	1.269
Agree	-0.206	0.278	0.550	1	0.458	0.813	0.471	1.404
Strongly agree	**0.601**	**0.240**	**6.286**	**1**	**0.012**	**1.823**	**1.140**	**2.916**
Access to sufficient information to inform COVID-19 vaccine uptake								
Yes (baseline)								
No	**-0.552**	**0.181**	**9.277**	**1**	**0.002**	**0.576**	**0.404**	**0.821**
Availability of public awareness and education campaigns about effectiveness and safety of COVID-19 vaccines								
Yes (baseline)								
No	**-0.454**	**0.213**	**4.543**	**1**	**0.033**	**0.635**	**0.419**	**0.964**
Access to sufficient information about COVID-19 vaccines during university education								
Yes (baseline)								
No	**0.430**	**0.180**	**5.740**	**1**	**0.017**	**1.537**	**1.081**	**2.186**
COVID-19 diagnosis								
Yes (baseline)								
No	**0.884**	**0.141**	**39.574**	**1**	**0.000**	**2.421**	**1.838**	**3.188**
Has received all vaccines according to the mandatory immunization schedule								
I do not know (baseline)								
No	**-2.383**	**0.438**	**29.629**	**1**	**0.000**	**0.092**	**0.039**	**0.218**
Yes	0.137	0.294	0.218	1	0.641	1.147	0.645	2.040

4. Discussion

This study gives an overview of the students enrolled in various health degree programs at medical universities in Bulgaria – acceptance of COVID-19 vaccines and the associated predictors for vaccine uptake. Given the greater literacy of our sample with regard to health-related issues, our findings of 73.5% coverage with the COVID-19 vaccine corresponds to a similar study from our country [14], and the study of Gallè et al. [15], who enrolled undergraduate students from Central and Southern Italy, and with international data on undergraduate medical students [15,16]. In a recent survey of Japanese medical students, 89.1% had received the second dose of COVID-19 vaccine, and 90.7% stated that they would be willing to receive the vaccine in the future [16].

There is a discrepancy between the rates of COVID-19 vaccination between the students who took part in our study and the general population. According to the latest data in Bulgaria the coverage with at least one of the COVID-19 vaccine is 30.38% compared to 73.5% of students vaccinated in our study. These results underline the overall more positive attitude to COVID-19

vaccines of students who enrolled various health degree programs at medical universities in Bulgaria and the important role they can play as future HCWs and opinion leaders in overcoming vaccine hesitancy. University students can also assist in spotting and correcting misinformation regarding COVID-19, especially misinformation about immunization. This role is of particularly important when it comes to social media platforms, considering the younger demographics of social media users.

The higher relative share of the vaccinated among foreign student is related on one hand to the requirements for a COVID travel certificate in the first two years of the pandemic, but also is a reflection in general of the higher confidence and immunization coverage of the COVID-19 vaccines, characteristic of the countries of Western and Central Europe compared to the Balkan countries and Eastern Europe in general, to which Bulgaria also belongs [17].

In our study respondents studying medicine were more likely to be vaccinated compared to nursing or rehabilitator students for instance, and the university program was one of the predictive the intention of vaccination variable. Several studies have shown that medical students express higher intentions to be vaccinated than the general population [18], non-medical students [19,20], nursing students [21], and dental students [22]. This might be explained with the more advanced levels of education of medical students in epidemiology, immunology, and infectious diseases which might results in a better understanding of COVID-19 research, impact of vaccination and higher resistance to conspiracy theories.

The respondents who were on the opinion that they haven't received enough information regarding COVID-19 vaccines were less likely to have received the vaccine in our study. We need to provide HCWs with greater training and information about vaccines in order to increase their confidence in vaccines in general. The importance of training and a better informational campaign regarding COVID-19 vaccines among students in medical universities is supported by one of the results in our study.

According to several studies men are more likely to be vaccinated [23,24] and this corresponds with our study – statistically significantly higher rates of COVID-19 vaccination were reported in males (n=822, 82.7% for males vs. n=1419, 69% for females, Pearson $\chi 2$ test=64.329, $p<0.001$), although it did not prove to be a predictor for possible vaccination.

A significant determinant for vaccination is any previous history of recommended vaccination (e.g., against influenza) [25-27]. In previous studies the likelihood of influenza vaccination was correlated with the likelihood of COVID-19 vaccination, suggesting a possible correlation between vaccination intention and behavior among different vaccines [28,29]. In our study also statistically significantly more COVID-19 vaccinated students have chosen to receive the influenza vaccine compared to the COVID-19 non-vaccinated respondents. On the other hand, one factor that was negatively associated with the likelihood of COVID-19 vaccination was the lack of completed mandatory immunization cycle according to the country's schedule. These findings suggest that the widespread acceptance and uptake of a new vaccine when it is placed on the market can be predicted by the HCWs' and the general public's positive attitudes toward vaccinations, whether they are mandatory or recommended.

The students who have had a previous COVID-19 infection were less likely to be vaccinated which might be due to the lower perceived risk of a subsequent infection and the false sense of protection against the virus. This results corresponds to other studies [30] although there are studies indicating that the history of COVID-19 infection is associated with a higher probability of vaccination [31].

In our study the concerns of possible side effects due to the COVID-19 vaccines and the lack of enough information about the vaccines were negatively associated with the possibility of vaccination. Several similar studies [32,33] reported that vaccine reluctance was a result of concerns about the safety and possible adverse effects of the vaccine and a lack of reliable information. Lack of advanced vaccination knowledge and inaccurate vaccine information can cause worry, which can lead to an overestimation of potential side effects [33]. This demonstrates again how important it will be for HCWs to receive scientific information about vaccine safety and effectiveness. It is necessary to

develop specific communication methods to distribute more safety information in order to boost HCWs' confidence in the COVID-19 vaccination, which will help to raise the adoption of the vaccine among HCWs and the general public as a subsequent result.

It is particularly interesting that two factors predicting the higher possibility for vaccination were the perceived importance of the COVID-19 vaccines to stop the transmission of the disease and other related negative consequences, and the personal perception that for the students is important to be aware of the vaccines in general and the recommendations for vaccination as future HCWs. These results suggest that attitudes to vaccination are influenced not only by the level of knowledge on particular problem but by other ethical reasons such as moral responsibility towards the community and correspond with other studies [34].

Strengths and limitations

To the best of our knowledge this is the first study to look into the potential drivers for COVID-19 vaccination among Bulgarian students enrolled various health degree programs at medical universities in Bulgaria. The target group for our study is anticipated to have very high health literacy levels and frequently can act as community opinion leaders in regards to vaccines and vaccination recommendations. The current study shed light on the variations among health sciences students in terms of gender, academic year, and university program with relation to COVID-19 vaccines and the motivations for vaccination. As with any survey-based study, non-respondents may have been reluctant to receive the recommended vaccinations, which can overstate the true rate of vaccine reluctance among this group of students. The study's snapshot scope inevitably limits it as a cross-sectional study, but because vaccine hesitancy levels have been constantly changing over time, prospective cohort studies are suitable for tracking these developments.

5. Conclusions

The students in our study showed an overall positive attitude towards the COVID-19 vaccines and a higher rate of uptake of the vaccine compared to the general Bulgarian population. There were discrepancies in the vaccination coverage between the students in different university programs which indicated the necessity of increasing the knowledge of health sciences students in the field of vaccinology. Safety and quality issues with the vaccination were frequently raised. For these reasons, we believe that promoting informational campaigns that emphasize the vaccine's safety will be more effective than emphasizing the disease's severity.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: We encourage all authors of articles published in MDPI journals to share their research data. In this section, please provide details regarding where data supporting reported results can be found, including links to publicly archived datasets analyzed or generated during the study. Where no new data were created, or where data is unavailable due to privacy or ethical restrictions, a statement is still required. Suggested Data Availability Statements are available in section "MDPI Research Data Policies" at https://www.mdpi.com/ethics.

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