

KNOWLEDGE ABOUT THE COVID-19 AND WAYS OF ITS PREVENTION AMONG MEDICAL UNIVERSITY OF WARSAW STUDENTS

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ABSTRACT

Background: The aim of the study was to assess the state of knowledge of Medical University of Warsaw (MUW) students on COVID-19, modes of transmission and preventive measures. **Material and Methods:** The study was conducted in October 2020. The participants were all the students attending classes at MUW – 8922 persons. All had completed the online training “Work safety and hygiene during COVID-19.” To assess their state of knowledge an online questionnaire was made available on the MUW e-learning platform. The questionnaire comprised 4 parts: (1) awareness of rules of hand hygiene, (2) medical aspects of COVID-19, (3) preventing SARS-CoV-2 infection transmission in health care facilities, and (4) preventing infection transmissions in the society. **Results:** The majority of students (93.9%) demonstrated a sufficient level of knowledge. The highest passing threshold was found on the medical programme (96.7% of students with satisfactory level of knowledge), dentistry (96.2%) and pharmacy (95.5%). The statistically significant factors that differentiated student results proved to be faculty ($p < 0.001$), study programme ($p < 0.001$), year of studies ($p = 0.001$), form of studies ($p < 0.001$). The participants most often showed full knowledge (100% correct answers in sub-area) of preventing infection transmissions in the society (93.3%) and medical aspects of COVID-19 (91.8%), less complete in terms of ways of preventing infection transmission in health care facilities (85.4%), and in particular hand hygiene rules (78.3%). All the variables characterizing academic status (study programme, faculty, year and form of studies) were statistically significant differentiating factors for students’ full knowledge in all of the 4 analyzed sub-areas, while students’ sex only in the sub-area of COVID-19 medical aspects. **Conclusions:** There is a clear need for conducting systematic educational activities among students of all medical study programmes and assessing their level of knowledge in those areas that were identified as least frequently controlled, namely, hand hygiene and infection transmission in health care facilities. *Med Pr.* 2022;73(5)

Key words: knowledge, Poland, medical students, COVID-19, SARS-CoV-2, infectious disease outbreak

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INTRODUCTION

The COVID-19 pandemic has become a serious challenge for the public health, both globally and in the context of particular countries of the world. According to the WHO statistics, at the beginning of the new academic year on October 1, 2020 34 471 151 confirmed cases of SARS-CoV-2 virus infections and 1 066 990 deaths were evidenced in the whole world [1]. In Poland the first confirmed case was discovered on March 4, 2020, and until October 1, 2020 there were in total 93 481 confirmed infections and 2542 deaths caused by COVID-19 [2].

The COVID-19 pandemic made both public health specialists and decision-makers face the challenge of

implementation of non-pharmacological methods of preventing the spread of SARS-CoV-2 infections on a massive scale. In the absence of a functioning vaccine many countries, including Poland, implemented a series of measures to limit the spread of infections and to slow down the speed of the pandemic development. These were, among others, mass-scale testing, isolation of infected persons, observing hand hygiene, breathing etiquette and using masks, as well as introducing social distancing measures, such as locking down schools and universities, banning large-scale gatherings, limiting travels and public transportation, making the public aware of a need to stay at home, or even introducing total lockdown with the right to only buy food and meds or using the healthcare system [3].

When facing undesirable social effects and economic challenges caused by lockdowns, public health institutions developed both global and national strategies for limiting risk to enable re-opening of higher education institutions in the 2020/2021 winter term [4,5]. Taking into account health safety of students, doctoral students and faculty the organizational solutions that were worked out were supposed to minimize the risk of infection transmission. Chief Sanitary Inspector issued detailed guidelines for both university students and faculty, including the regulations for running clinical classes. One of the crucial rules was that students should receive and read general information on possible ways of preventing coronavirus infections [6]. In response to these recommendations students of Medical University of Warsaw of all study programmes and years of studies were offered the e-learning course on rules of work safety and hygiene in the COVID-19 era. Its completion was mandatory and finished with a knowledge test. The aim of the course was to provide students of medical study programmes with knowledge of the pandemic and develop their attitudes towards it as a health hazard in this special moment.

The aim of the current study is to analyse the students' results obtained in knowledge test on health hazards related to the COVID-19 pandemic and ways of preventing infection transmission in health care facilities and in the society. The research problems were put forward as the following list of questions:

- What is the medical students' level of knowledge regarding COVID-19 and preventive actions adopted under COVID-19 pandemic?
- What is the medical students' level of knowledge in particular sub-areas: awareness of hand hygiene rules, medical aspects of COVID-19, ways of preventing SARS-CoV-2 infection transmission in health care facilities and in the society (knowledge of currently enforced restrictions)?
- Are such variables as sex, faculty, study programme, year of studies and form of studies differentiating factors for the students' knowledge level, both in general terms and within the particular sub-areas?

MATERIAL AND METHODS

Study setting

At the beginning of the academic year all MUW students, regardless of study programme and year of studies, were obliged to complete the work safety and hygiene in the COVID-19 era e-learning course.

The course comprised 6 modules, covering such topics as virological and clinical aspects of COVID-19, preventing infections in healthcare institutions, including applying personal protection equipment, hand hygiene, preventing infection transmission in the society and organisational issues related to following currently enforced restrictions. Once the e-learning course was completed, each student took a knowledge test between October 1–17, 2020.

Participants

The participants were all MUW students starting or continuing studies in the 2020/2021 academic year. These were the students of the following faculties (study programmes in brackets): Faculty of Medicine (medicine), Faculty of Dental Medicine (dentistry, dental techniques, dental hygiene), Faculty of Pharmacy (pharmacy, medical analysis, medical technology assessment, toxicology with elements of forensics), Faculty of Medical Sciences (audiophonology with hearing care, electroradiology, physiotherapy, general and clinical speech therapy) and Faculty of Health Sciences (dietics, nursery, midwifery, medical emergency, public health).

Questionnaire development

The literature review on SARS-CoV-2 virus, COVID-19 disease and possibilities of implementing infection transmission control resulted in creating a 10-item test. It was prepared by epidemiological doctors, virologists, public health specialists, MUW research fellows. The questions were embedded in the educational content of modules present in the e-learning course. The test questionnaire comprised questions concerning hand hygiene techniques based on „Five moments of hand hygiene” described by WHO, which enabled the assessment of the participants' knowledge on optimal hygienic practices [7]. Two questions concerned knowledge of medical aspects connected with SARS-CoV-2 infections (knowledge of COVID-19 clinical symptoms and flu vaccine recommendations in the pandemic era), 3 concerned ways of preventing infection transmission in health care facilities (ways of limiting disease spread, using personal protection equipment). The final 2 questions dealt with ways of preventing infection transmission in the society (knowledge of currently enforced restrictions).

All items in the questionnaire were single-choice ones with 5 answers to choose from. Before its application the questionnaire was piloted with 10 persons.

Data collection

The test was administered online via the MUW e-learning platform, which is available for every student. All MUW students studying in the 2020/2021 academic year were obliged to take the test and pass it, which was a requirement for starting education: face-to-face classes of both theoretical and practical nature, including clinic-based ones. Due to the fact that passing the test was a pre-condition for taking part in classes, the participating students were allowed 3 attempts until they got passing scores. The current analysis, however, was based only on first-attempt results.

The minimum passing threshold was 80% of correct answers (8 out of 10 test items). While preparing the training materials and the test, its authors assumed that 95% of students from each study programme will reach a positive result (expected pass rate). Also, the level of knowledge in each of the 4 thematic sub-areas was assessed.

The obtained results were anonymised for the purposes of the current study. Data collected comprised test results (total and separately for all the ten items), student's sex, faculty, study programme, year of study and form of study.

Statistical analysis

For the whole research sample the following measures were calculated: the average test result of a single test-taker (arithmetic means), the percentage of students who passed the test (demonstrated sufficient knowledge), the percentage of students who completed the test perfectly (demonstrated full expected knowledge) with 95% confidence intervals (CI) for the means or the fraction respectively.

For the subgroups formed based on sex, faculty, study programme, year of studies and form of studies the percentage of students who passed the test with 95% CI was calculated. Statistical significance of differences between subgroups in terms of test passability was assessed with the χ^2 test.

For further investigation based on the obtained test results the following variables were put forward:

- 1) hand hygiene knowledge,
- 2) knowledge of medical aspects of SARS-CoV-2 infection,
- 3) knowledge of ways of preventing infection transmission in health care facilities, and
- 4) knowledge of currently enforced regulations.

The student who gave the correct answer to each question in a particular section was regarded as the one

with full knowledge in this area. For each of the 4 areas the average score in points and as percentage of possible points (due to the fact that particular areas differed in the number of test items) as well as the percentage of students with full knowledge in a particular area (with 95% CI) were calculated. Statistical significance of differences between areas was assessed with the χ^2 test. Moreover, the previously analyzed subgroups of students were compared in terms of having full knowledge in each of the 4 areas.

The significance level for all the analyses was established at 0.05.

All the data were analyzed using SPSS software v. 21.

RESULTS

Respondents

The study involved all MUW students (8922 persons), including 180 students of speech therapy of University of Warsaw taking their classes at the Medical Sciences of MUW. The quota for participants from particular faculties were as follows: Faculty of Medicine 41.3% (N = 3683), Faculty of Health Sciences 27.4% (N = 2442), Faculty of Medical Sciences 13.2% (N = 1181), Faculty of Pharmacy 11.2% (N = 1001) and Faculty of Dental Medicine 6.9% (N = 615). Almost half of the respondents (48.2%) were would-be doctors and dentists – students of the Faculty of Medicine and Faculty of Dental Medicine. Females amounted to 76.4% of the sample. Detailed characteristics of participating students can be found in Table 1.

Students' knowledge on work safety and hygiene during the COVID-19 pandemic

First of all, the percentage of students with satisfactory level of knowledge (score of $\geq 80\%$ of correct answers from the whole test) on work safety and hygiene during the COVID-19 pandemic was established. The majority of students – 8377 respondents (93.9%, 95% CI: 93.4–94.4) got a passing score in the knowledge test. The average score was 9.42 (95% CI: 9.40–9.44)/10 pts, which means that a student scored on average 94.2% (95% CI: 94.0–94.4) out of the total number of points. The whole test was fully completed (10 pts, 100.0%) by 5834 persons, which is 65.4% (95% CI: 64.4–66.4) of the respondents.

The pass rate for particular study programmes established at 95.0% of students was achieved in the case of 3 programmes: medicine (96.7% of all the students of this study programme), dentistry (96.2%) and pharmacy

Table 1. Characteristics of study participants (N = 8922), October 2020, Medical University of Warsaw

Variable	Participants (N = 8922)	
	n	%
Gender		
female	6814	76.4
male	2108	23.6
Faculty		
of Medicine	3683	41.3
of Dental Medicine	615	6.9
of Pharmacy	1001	11.2
of Medical Sciences	1181	13.2
of Health Sciences	2442	27.4
Study programme		
medical analysis	186	2.1
audiophonology with hearing care	78	0.9
dietetics	425	4.8
medical technology assessment	16	0.2
electroradiology	191	2.1
pharmacy	783	8.8
physiotherapy	579	6.5
dental hygiene	74	0.8
medicine	3683	41.3
dentistry	477	5.4
general and clinical speech therapy	153	1.7
nursery	972	10.9
midwifery	555	6.2
medical emergency	122	1.4
dental techniques	64	0.7
toxicology with elements of forensics	16	0.2
speech therapy (University of Warsaw students)	180	2.0
public health	368	4.1
Year of studies		
1	1944	21.8
2	1600	17.9
3	1537	17.2
4	1773	19.9
5	1351	15.1
6*	717	8.0
Form of studies		
long-cycle	5914	66.3
first-cycle (bachelor's)	1701	19.1
second-cycle (master's)	1307	14.7

* Only students of Faculty of Medicine and Faculty of Pharmacy.

(95.5%). The lowest scores were produced by students from toxicology with elements of forensics (only 62.5% of passing scores), medical emergency (83.6%) and public health (84.2%).

As many as 96.0% students of the sixth year of studies (only students of medicine and pharmacy) got a positive score. The lowest percentage of tests with positive scores was among students of the fourth year (91.8%). All the characteristics of academic context proved to be differentiating for students' knowledge with statistical significance: faculty ($p < 0.001$), study programme ($p < 0.001$), year of studies ($p = 0.001$) and form of studies ($p < 0.001$). Students of both sexes were equally frequent to exhibit a satisfactory level of knowledge (94%). Detailed results can be found in Table 2.

Students' knowledge in particular sub-areas, namely hand hygiene rules, medical aspects of SARS-CoV-2 infections, regulations on preventing infection transmission in health care facilities and in the society (awareness of currently enforced restrictions)

The students' level of knowledge in particular sub-areas varied a lot. Figure 1 demonstrates the numbers and percentages of students with full knowledge (100% correct answers) of the particular sub-areas of the test – the differences proved to be statistically significant ($p < 0.001$). Full knowledge of the currently enforced restrictions (preventing SARS-CoV-2 infection transmission in the society) was displayed by 8328 students (93.3%, 95% CI: 92.8–93.8) completed this part of the test with no mistakes). The average score was 1.93 (95% CI: 1.92–1.94)/2 pts, which means, on average 96.5% (95% CI: 96.0–97.0) out of the total number of points.

In the second place of correct answers one can find the medical aspects of SARS-CoV-2 infections – 91.8% (95% CI: 91.2–92.4) students (8188 people) completed this part of the test perfectly. The average score was 1.91 (95% CI: 1.9–1.92)/2 pts, which means on average 95.5% (95% CI: 95.0–96.0) out of the total number of pts in this area.

A smaller group of students completed with no mistakes all the items related to the ways of preventing infection transmission in health care facilities (7616 tests completed all the 3 items in this area, 85.4%, 95% CI: 84.7–86.1). The average score here was 2.82 (95% CI: 2.81–2.83)/3 pts, which means on average 94.0% (95% CI: 93.7–94.3) pts.

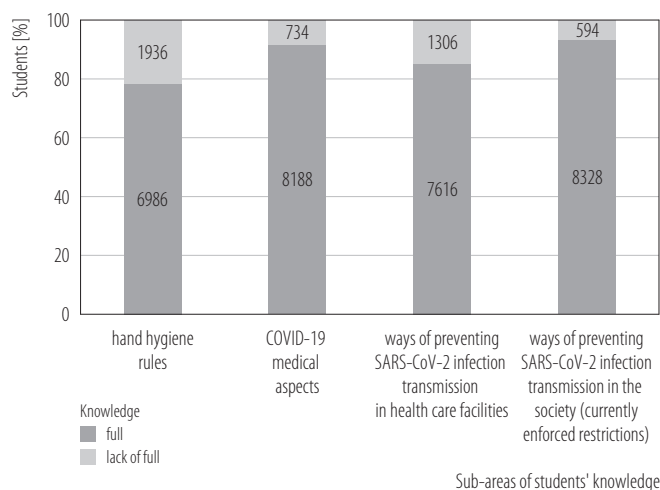
Table 2. Students demonstrating satisfactory level of knowledge (score of $\geq 80\%$ of correct answers from the whole test) in reference to sex and academic status characteristics (N = 8922), October 2020, Medical University of Warsaw

Variable	Participants (N = 8922)					P
	total [n]	satisfactory knowledge level				
		no		yes		
	n	% (range)	n	% (range)		
Sex					n.s.	
female	6814	407	6.0 (5.4–6.6)	6407	94.0 (93.4–94.6)	
male	2108	138	6.5 (5.4–6.6)	1970	93.5 (92.4–94.6)	
Faculty					<0.001	
of Medicine	3683	121	3.3 (2.7–3.9)	3562	96.7 (96.1–97.3)	
of Dental Medicine	615	26	4.2 (2.6–5.8)	589	95.8 (94.2–97.4)	
of Pharmacy	1001	59	5.9 (4.4–7.4)	942	94.1 (92.6–95.6)	
of Medical Sciences	1181	102	8.6 (7.0–10.2)	1079	91.4 (89.8–93.0)	
of Health Sciences	2442	237	9.7 (8.5–10.9)	2205	90.3 (89.1–91.5)	
Study programme					<0.001	
medical analysis	186	16	8.6 (4.6–12.6)	170	91.4 (87.4–95.4)	
audiophonology with hearing care	78	6	7.7 (1.8–13.6)	72	92.3 (86.4–98.2)	
dietetics	425	50	11.8 (8.7–14.9)	375	88.2 (85.1–91.3)	
medical technology assessment	16	2	12.5 (0–28.7)	14	87.5 (71.3–100)	
electroradiology	191	14	7.3 (3.6–11.0)	177	92.7 (89.0–96.4)	
pharmacy	783	35	4.5 (3.1–5.9)	748	95.5 (94.1–96.9)	
physiotherapy	579	55	9.5 (7.1–11.9)	524	90.5 (88.1–92.9)	
dental hygiene	74	6	8.1 (1.9–14.3)	68	91.9 (85.7–98.3)	
medicine	3683	121	3.3 (2.7–3.9)	3562	96.7 (96.1–97.3)	
dentistry	477	18	3.8 (2.1–5.5)	459	96.2 (94.5–97.9)	
general and clinical speech therapy	153	15	9.8 (5.1–14.5)	138	90.2 (85.5–94.9)	
nursery	972	67	6.9 (5.3–8.5)	905	93.1 (91.5–94.7)	
midwifery	555	42	7.6 (5.4–9.8)	513	92.4 (90.2–94.6)	
medical emergency	122	20	16.4 (9.8–23.0)	102	83.6 (77.0–90.2)	
dental techniques	64	2	3.1 (0–7.4)	62	96.9 (92.6–100)	
toxicology with elements of forensics	16	6	37.5 (13.8–61.2)	10	62.5 (38.8–86.2)	
speech therapy (University of Warsaw students)	180	12	6.7 (3.1–10.3)	168	93.3 (89.7–96.9)	
public health	368	58	15.8 (12.1–19.5)	310	84.2 (80.5–87.9)	
Year of studies					0.001	
1	1944	119	6.1 (5.0–7.2)	1825	93.9 (92.8–95.0)	
2	1600	88	5.5 (4.4–6.6)	1512	94.5 (93.4–95.6)	
3	1537	81	5.3 (4.2–6.4)	1456	94.7 (93.6–95.8)	
4	1773	145	8.2 (6.9–9.5)	1628	91.8 (90.5–93.1)	
5	1351	83	6.1 (4.8–7.4)	1268	93.9 (92.6–95.2)	
6*	717	29	4.0 (2.6–5.4)	688	96.0 (94.6–97.4)	

Table 2. Students demonstrating satisfactory level of knowledge (score of $\geq 80\%$ of correct answers from the whole test) in reference to sex and academic status characteristics (N = 8922), October 2020, Medical University of Warsaw – cont.

Variable	Participants (N = 8922)				P	
	total [n]	satisfactory knowledge level				
		no		yes		
		n	% (range)	n		% (range)
Form of studies					<0.001	
long-cycle	5914	263	4.4 (3.9–4.9)	5651	95.6 (95.1–96.1)	
first-cycle (bachelor's)	1701	132	7.8 (6.5–9.1)	1569	92.2 (90.9–93.5)	
second-cycle (master's)	1307	150	11.5 (9.8–13.2)	1157	88.5 (86.8–90.2)	
Total	8922	545	6.1 (5.6–6.6)	8377	93.9 (93.4–94.4)	

* Only students of Faculty of Medicine and Faculty of Pharmacy.
Statistically significant values indicated in bold.



Student has full knowledge if he or she provided correct answers to each question from a particular sub-area.

Figure 1. Completeness of students' knowledge according to the sub-areas (N = 8922), October 2020, Medical University of Warsaw

The students found the items related to hand hygiene rules the most difficult – almost one-fourth of the investigated group did not have full knowledge in this area. Only 78.3% (95% CI: 77.4–79.2) of the tests (i.e. 6986) gave all the 3 correct answers in this area. The average score was 2.76 (95% CI: 2.75–2.77)/3 pts, which means 92.0% (95% CI: 91.7–92.3) pts. On average, one item from this section was completed incorrectly by 7.2% (95% CI: 6.7–7.8) of the students. In the remaining areas it was 3.3% (95% CI: 3.0–3.7), 4.1% (95% CI: 3.7–4.5) and 4.9% (95% CI: 4.4–5.3), respectively.

The students' knowledge in particular sub-areas were analyzed in reference to such variables as sex, faculty,

study programme, year of studies, form of studies (for detailed results, see Table 3).

Sex proved to be a differentiating factor only in the sub-area of knowledge of COVID-19 medical aspects. Males were statistically more frequent than females to give all the correct responses in this area (93.4% vs. 91.3%, $p = 0.002$).

All the variables characterizing academic status of the students (study programme, faculty, year and form of studies) were statistically significantly differentiating factors for their knowledge in all of the 4 analyzed sub-areas (in almost all analyses $p < 0.001$, only for knowledge of hand hygiene rules in reference to year of studies it was $p = 0.009$). The highest percentage of students with full knowledge of hand hygiene rules was at Faculty of Medicine, while the lowest – at Faculty of Health Sciences (81.5% and 71.9%, respectively). The students of toxicology with elements of forensics gained the lowest scores out of all the study programmes in 3 sub-areas: hand hygiene rules (50.0% of students with knowledge in this sub-area), ways of preventing SARS-CoV-2 infection transmission in health care facilities (37.5%) and in the society (75.0%).

As regards the medical aspects of COVID-19, the lowest scores were achieved by the students of audiophonology with hearing care (74.4%). First-year students dominated in such sub-areas as knowledge of hand hygiene rules (80.8%) and knowledge of preventing infection transmission in health care facilities (88.4%). In the sub-area of knowledge of COVID-19 medical aspects the best results were achieved by fifth-year students, who were in the final year for most study programmes (93.2% with full knowledge). On the other hand, sixth-year students prevailed in the area of knowledge of

Table 3. Students with full knowledge (100% correct answers) in particular sub-areas in reference to sex and characteristics related to academic status (N = 8922), October 2020, Medical University of Warsaw

Variable	Participants (N = 8922)																	
	knowledge of hand hygiene rules							knowledge of ways of preventing SARS-CoV-2 infection transmission in the society										
	total			knowledge of COVID-19 medical aspects				in health care facilities			in the society							
	n	%	P	no	n	%	yes	n	%	P	no	n	%	yes	n	%	P	
Sex																		
female	6814	1480	21.7	5334	78.3	594	8.7	6220	91.3	1002	14.7	5812	85.3	440	6.5	6374	93.5	n.s.
male	2108	456	21.6	1652	78.4	140	6.6	1968	93.4	304	14.4	1804	85.6	154	7.3	1954	92.7	<0.001
Faculty																		
of Medicine	3683	680	18.5	3003	81.5	196	5.3	3487	94.7	385	10.5	3298	89.5	155	4.2	3528	95.8	<0.001
of Dental Medicine	615	119	19.3	496	80.7	27	4.4	588	95.6	72	11.7	543	88.3	40	6.5	575	93.5	<0.001
of Pharmacy	1001	194	19.4	807	80.6	61	6.1	940	93.9	156	15.6	845	84.4	47	4.7	954	95.3	<0.001
of Medical Sciences	1181	256	21.7	925	78.3	114	9.7	1067	90.3	221	18.7	960	81.3	91	7.7	1090	92.3	<0.001
of Health Sciences	2442	687	28.1	1755	71.9	336	13.8	2106	86.2	472	19.3	1970	80.7	261	10.7	2181	89.3	<0.001
Study programme																		
medical analysis	186	46	24.7	140	75.3	12	6.5	174	93.5	41	22.0	145	78.0	10	5.4	176	94.6	<0.001
audiophonology with hearing care	78	11	14.1	67	85.9	20	25.6	58	74.4	13	16.7	65	83.3	5	6.4	73	93.61	<0.001
dietetics	425	115	27.1	310	72.9	47	11.1	378	88.9	110	25.9	315	74.1	44	10.4	381	89.6	<0.001
medical technology assessment	16	4	25.0	12	75.0	1	6.3	15	93.8	3	18.8	13	81.3	0	0.0	16	100.0	<0.001
electroradiology	191	49	25.7	142	74.3	11	5.8	180	94.2	36	18.8	155	81.2	11	5.8	180	94.2	<0.001
pharmacy	783	136	17.4	647	82.6	45	5.7	738	94.3	102	13.0	681	87.0	33	4.2	750	95.8	<0.001
physiotherapy	579	128	22.1	451	77.9	57	9.8	522	90.2	114	19.7	465	80.3	54	9.3	525	90.7	<0.001
dental hygiene	74	15	20.3	59	79.7	8	10.8	66	89.2	11	14.9	63	85.1	15	20.3	59	79.7	<0.001
medicine	3683	680	18.5	3003	81.5	196	5.3	3487	94.7	385	10.5	3298	89.5	155	4.2	3528	95.8	<0.001
dentistry	477	88	18.4	389	81.6	16	3.4	461	96.6	57	11.9	420	88.1	23	4.8	454	95.2	<0.001
general and clinical speech therapy	153	32	20.9	121	79.1	15	9.8	138	90.2	32	20.9	121	79.1	14	9.2	139	90.8	<0.001
nursery	972	280	28.8	692	71.2	156	16.0	816	84.0	134	13.8	838	86.2	77	7.9	895	92.1	<0.001
midwifery	555	136	24.5	419	75.5	69	12.4	486	87.6	102	18.4	453	81.6	60	10.8	495	89.2	<0.001

Table 3. Students with full knowledge (100% correct answers) in particular sub-areas in reference to sex and characteristics related to academic status (N = 8922), October 2020, Medical University of Warsaw – cont.

Variable	Participants (N = 8922)																			
	knowledge of hand hygiene rules						knowledge of COVID-19 medical aspects						knowledge of ways of preventing SARS-CoV-2 infection transmission in the society							
	no		yes		P		no		yes		P		no		yes		P			
	n	%	n	%			n	%	n	%			n	%	n	%			n	%
total																				
[n]																				
Study programme – cont.																				
medical emergency	122	37	30.3	85	69.7		23	18.9	99	81.1		28	23.0	94	77.0		22	18.0	100	82.0
dental techniques	64	16	25.0	48	75.0		3	4.7	61	95.3		4	6.3	60	93.8		2	3.1	62	96.9
toxicology with elements of forensics	16	8	50.0	8	50.0		3	18.8	13	81.3		10	62.5	6	37.5		4	25.0	12	75.0
speech therapy (University of Warsaw students)	180	36	20.0	144	80.0		11	6.1	169	93.9		26	14.4	154	85.6		7	3.9	173	96.1
public health	368	119	32.3	249	67.7	0.009	41	11.1	327	88.9	<0.001	98	26.6	270	73.4	<0.001	58	15.8	310	84.2
Year of studies																				
1	1944	373	19.2	1571	80.8		143	7.4	1801	92.6		226	11.6	1718	88.4		107	5.5	1837	94.5
2	1600	349	21.8	1251	78.2		129	8.1	1471	91.9		195	12.2	1405	87.8		108	6.8	1492	93.3
3	1537	344	22.4	1193	77.6		162	10.5	1375	89.5		242	15.7	1295	84.3		101	6.6	1436	93.4
4	1773	432	24.4	1341	75.6		128	7.2	1645	92.8		338	19.1	1435	80.9		168	9.5	1605	90.5
5	1351	287	21.2	1064	78.8		92	6.8	1259	93.2		218	16.1	1133	83.9		76	5.6	1275	94.4
6*	717	151	21.1	566	78.9		80	11.2	637	88.8		87	12.1	630	87.9		34	4.7	683	95.3
Form of studies																				
long-cycle	5914	1118	18.9	4796	81.1	<0.001	363	6.1	5551	93.9	<0.001	726	12.3	5188	87.7	<0.001	305	5.2	5609	94.8
first-cycle (bachelor)	1701	438	25.7	1263	74.3		250	14.7	1451	85.3		273	16.0	1428	84.0		128	7.5	1573	92.5
second-cycle (master's)	1307	380	29.1	927	70.9		121	9.3	1186	90.7		307	23.5	1000	76.5		161	12.3	1146	87.7
Total	8922	1936	21.7	6986	78.3		734	8.2	8188	91.8		1306	14.6	7616	85.4		594	6.7	8328	93.3

* Only students of Faculty of Medicine and Faculty of Pharmacy. Statistically significant values indicated in bold.

ways of preventing infection transmission in the society (95.3%). The students of long-cycle studies possessed full knowledge in all the areas in the highest percentage.

DISCUSSION

The COVID-19 pandemic constitutes a major threat for healthcare systems in particular countries and in the entire world. Justified fears about health security appear in relation to medical staff education and functioning of medical universities during the period of global health threats. Students may potentially spread infections (among others, to patients in clinical wards) but they may also get infected during university classes [8].

Medical universities must react quickly and appropriately to protect their own faculty, students and patients by preventing SARS-CoV-2 infection transmission in the university community during the pandemic. The students of medical faculties must possess a sufficient amount of knowledge and skills that would be essential for proper functioning and preventing infection transmission both in health care facilities and in the society [9].

Even though the process of gaining knowledge and experience takes place throughout one's whole education and professional career, the period of university education is for future health care workers (HCWs) fundamental as this is when they gain skills that make them professionals in this sphere [10]. This is particularly important at the moment as the COVID-19 pandemic may lead to insufficient supply of healthcare specialists and, as a result, medical students might need to be engaged as workforce and incorporated into the clinical community [11].

Numerous studies pertaining to medical students' knowledge on COVID-19 have been conducted recently and are still being conducted, however, they rarely involve the entire student community of a selected university, which was the case in the study carried out among MUW students. For instance, Alzoubi et al. [12] examined knowledge, attitudes and practices related to COVID-19 among 323 medical students in the only medical university in Jordan, which is a small sample in comparison to the entire MUW community incorporated in the current study.

Students are frequently used as research participants due to their social representativeness [8,11–13]. Students of Medical University of Warsaw come from different parts of the country and display great diversity of socio-demographic characteristics. Thus, their

knowledge of COVID-19 and the resultant behaviour are important not only for the academic community and the patients they have contact with but also for their family members and local communities. Once students returned to university after the COVID-19 lockdown, a unique opportunity to investigate their knowledge level during the global health crisis was opened up.

The study identified differences in the knowledge level on SARS-CoV-2 infection transmission and ways of preventing infections. This was possible despite the fact that the content of the e-learning course and the very test items were identical for all students regardless of their study programme, year and form of studies. Students' sex has not turned out to be a differentiating factor in reference to possessed knowledge – students of both sexes were equally frequent to exhibit a satisfactory level of knowledge (score of $\geq 80\%$ of correct answers from the whole test). In contrast, all the characteristics of the academic context (faculty, study programme, year of studies and form of studies) proved to be differentiating for students' knowledge. Sex proved to be a differentiating factor only in the sub-area of full knowledge of COVID-19 medical aspects. Males were statistically more frequent than females to give all the correct responses in this area.

The knowledge of future doctors, dentists and pharmacists turned out to be higher than students of other medical faculties. Similar differences were observed by other researchers when comparing doctors with other HCWs [14]. The best results in the knowledge test ($>95.0\%$ of students of a particular faculty with a passing grade) were gained by students of medical faculties with a long tradition of medical education in Poland – medicine, dentistry and pharmacy.

One should be worried, on the other hand, by the results of students of 2 study programmes: medical emergency and public health. The former should already possess a high amount of knowledge on work safety and hygiene during the pandemic due to the fact that they are the medical staff in closest contact with patients. The level of exposure of this group to infection during the pandemic is particularly high. As regards the public health students, in the near future they are going to be responsible for essential public health operations, especially those related to monitoring and undertaking action in the case of threat to citizen's health safety and providing public health services in the area of health protection, disease prevention and health promotion. All these challenges pose particularly high expectations for them [15].

The research has not revealed a tendency for gradual increase in the percentage of students with satisfactory knowledge level with completion of years of studies (which was observed, for instance, among Pakistani students). Even though 96.0% of sixth-year students did prove to possess satisfactory knowledge level, the differentiating factor here was the study programme – medicine or pharmacy (only these 2 were 6-year programmes). The lowest percentage of students with satisfactory knowledge was found among fourth-year students. It is interesting that the percentage of first-year and fifth-year students passing the knowledge test was exactly the same. This seems to be the evidence for the former's diligence in approaching their medical education at its start, since they had not had any chance to be exposed to the subject matter contents in study subjects or elective courses [16]. During such pandemics as that caused by COVID-19, healthcare systems are put under tremendous pressure and the lack of health care workers may encourage less experienced HCWs, such as students of medical faculties, to participate in provision of medical services. Medical students' involvement in taking care of patients, together with high infection transmission of SARS-CoV-2, puts this subpopulation at risk of contracting and transmitting the disease. Students of medical faculties also serve an important role as health educators. They are a source of health-related information for those people that are closest to them – family members and friends. Thus, medical education can be perceived by them, apart from preparation for future professional duties, as a chance to become engaged in educating the society about health-related issues during the pandemic [17].

The obtained results clearly indicate an urgent need for dissemination of knowledge about COVID-19 and ways of preventing infections among all groups of students – in particular, those studying at faculties other than medicine and dentistry – and adapting the content and form of the educational message to this target group. The results, however, need to be considered in a very special context – taking an e-learning course is very different from a traditional face-to-face training with personal contact with the trainer and other students. Studying at home usually demands much greater self-management and motivation to complete online classes, especially in the initial period when students need to get accustomed to the new system of learning. This can trigger a perception of difficulty and increased amount of study-related duties [18].

Since vaccinations were not available during the study, the most fundamental ways of preventing infection transmission were wearing masks, maintaining social distance and washing hands. From the perspective of a medical university it was important to examine students' knowledge on hand hygiene, awareness of medical aspects related to COVID-19, ways of preventing infection transmission in health care facilities and in the society (currently enforced regulations). This gave a chance to better understand students' risky behaviours in order to identify potential public health interventions targeted at this group.

The simplest and the most effective non-pharmaceutical measure of preventing SARS-CoV-2 infection transmission is appropriate hand hygiene. „Five moments of hand hygiene” are defined by WHO as key moments in which healthcare professionals need to take care of hand hygiene. For many years hand hygiene of healthcare professionals has been one of the most effective ways of reducing healthcare-related infections. Key to hand hygiene is the way they should be washed, the frequency and the duration of handwashing procedure and the chemicals used. The same is the case with hand disinfection with alcohol-based solutions [19]. Students of medical faculties have everyday contact with patients during clinical classes in health care facilities. Their lack of knowledge on how to wash hands may lead to undesirable behaviours and infection spread. As was evidenced by presented study, even though all the participants completed their work safety and hygiene training during the COVID-19 pandemic, only 78.3% of students responded correctly to all the items concerning the role of hand hygiene in infection control. At the same time, a study of neurosurgery residents from different countries showed that as few as 52% of the respondents knew the handwashing procedure recommended in health care facilities [20]. On the other hand, two-thirds of the participants of Thakker et al.'s study [21] reported low or fair level of knowledge and practices related to hand hygiene. These results show insufficient amount of knowledge on hand hygiene of students of dentistry, nursery and medicine. As was evidenced by another study, less than half final-year medical students from Sri Lanka knew the correct rubbing time and amount of hand rub to be used for successful hand disinfection, according to the WHO guidelines [19,22].

Another study conducted among Jordanian university students (medical and non-medical) by Alzoubi et al. [12] demonstrated good knowledge of medical

aspects related to COVID-19 by more than 90% of students and generally good practice in using protective equipment. As other scholars report, following hand hygiene rules is rather infrequent both among students of medical faculties and HCWs [23,24].

The second area of interest in the current study have been medical aspects related to COVID-19. The knowledge about symptoms of the disease was high (91.8% students answered all the items in this section correctly), as opposed to the results received from a sample collected from Chinese universities [25]. In this area students' sex proved to be a factor differentiating the frequency of possession of full knowledge. Males were statistically significantly more frequent to get maximum score from this section of the test. On the other hand, Noreen et al.'s study [16] of Pakistani students reported females to possess more knowledge than males.

Thoughtful use of personal protective equipment (PPE) in case of suspicion or confirmation of COVID-19 infections was quite high among MUW students. The majority of respondents (85.4% students) displayed satisfactory level of knowledge on infection prevention and control with patients suspected of or confirmed to have Coronavirus disease 2019 (COVID-19) in healthcare settings in regards to using PPE.

Numerous public health institutions regard education as an important factor in prevention and control of infections. This is because gaps in knowledge in this respect are the main reason why students of medical faculties do not follow guidelines and regulations in this area in their future work with patients in healthcare institutions [26]. It is particularly essential given the results of studies conducted worldwide, which point out that less frequent to follow public health recommendations are males, persons with no health risk factors in themselves and their families, persons with higher education and of higher socio-economic status [27,28].

Research conducted in other countries seems to demonstrate that students of medical faculties frequently have insufficient knowledge related to healthcare-related infections and ways of preventing them [21–23]. This is mainly caused by outdated curricula of university trainings on these infections, which are insufficient in terms of content and form. As a result, some authors recommend strengthening theoretical and practical aspects of this topic and creating special courses devoted to healthcare-associated infections (HAIs) and ways of preventing them [12,14,21–24]. Students' knowledge about HAIs and their prevention is essential to reduce

patients' morbidity and mortality caused by these infections. Owing to that, medical universities need to emphasize future medical professionals' awareness-raising of ways of infection transmission that they will encounter in their clinical practice. Moreover, this knowledge must be systematically updated during studies and consolidated after start of professional practice as this enables improvement of attitudes and practices related to HAI prevention and control. The results of studies conducted worldwide clearly indicate that following enforced regulations related to this area is improving together with the increase of knowledge [29,30].

It is expected that medical faculty authorities will use both current and extinguished epidemics as a stimulus to improve training curricula for future healthcare professionals by building necessary competences in the areas of public health, epidemiology and infection control.

CONCLUSIONS

The COVID-19 pandemic has considerably changed the life of people all over the world, including that of medical university students. Taking into account high level of interpersonal relations occurring in university settings and required health safety it is essential that students should possess an appropriate amount of knowledge about infection transmission and ways of preventing them. As evidenced by the findings of presented research, there is a need for educating students of all medical faculties, also non-clinical ones, in this respect. Such trainings are a useful and safe tool towards increasing health awareness of future healthcare professionals. The educational message should underline the actual threat of the COVID-19 pandemic for the students and their closest, including patients and emphasize the importance of skilled protection and application of protective measures and equipment.

On the whole, the students' knowledge level about COVID-19 and ways of preventing infection transmission turned out to be satisfactory. It is particularly important as successful implementation of preventive strategies requires possessing knowledge about ways of SARS-CoV-2 infection transmission, increasing awareness on preventive strategies, dispelling myths and false assumptions on COVID-19 and shaping proper attitudes and behaviours which will help to reduce the effects of the pandemic.

The university setting is a place to acquire knowledge and shape good practices in terms of patient safety

in the process of educating and preparing for professional practice in the healthcare system. Authorities need to undertake regular review of study curricula and adapt them to the requirements of good clinical practice and changing epidemiological situation.

Students' knowledge should be assessed systematically so that relevant measures could be adopted in proper moment to ensure increased level of knowledge and following rules in everyday life (e.g. planning and executing educational interventions designed to address deficient knowledge, directing students to reputable sources of information and providing guidance on social network platforms, improving COVID-19 literacy, implementing training activities, utilising simulation for training and face-to-face lessons instead of e-learning, being a role-model for students' preventive behaviours). There has never been a better time for this than now.

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