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Knowledge, attitudes and beliefs regarding HIV among medical students in Zagreb, Croatia

Dominik Ljubas[1*], Hana Škornjak[2] and Ivana Božičević[3,4]

Abstract

Background Medical students, as future health-care providers (HCPs) play a significant role in shaping attitudes towards people living with HIV/AIDS (PLWHA) and should possess adequate knowledge of this infection. The study aim was to assess knowledge about HIV among medical students of the University of Zagreb School of Medicine, and to determine the level of discriminatory attitudes towards PLWHA.

Methods We assessed knowledge about epidemiology, treatment, and prevention of HIV by using closed-ended and multiple-choice questions. Likert-scale questions were employed to determine attitudes towards PLWHA. Bivariate and multivariate ordinal logistic regression was used to assess correlates of certain discriminatory attitudes.

Results 561 medical students participated, with 46.7% attending preclinical courses. Overall, 42.1% of students think they received sufficient information on HIV/AIDS during elementary and high school education. Among clinical students, 42.6%, 20.8% and 11.8% estimated accurately transmission risk after a needle injury, unprotected vaginal, and anal intercourse, respectively. 66.8% of clinical students were aware that treatment can prevent AIDS, while 58.7% and 69.8% were familiar with the rationale of using pre-exposure (PrEP) and post-exposure prophylaxis (PEP). In the multivariate analysis, individuals lacking infectology course attendance (aOR = 1.45; CI: 1.00–2.09) and those unaware of transmission routes (aOR = 1.49; CI: 1.06–2.09) showed higher odds of advocating HIV status disclosure compared to those who did not yet attend an infectology course. Students supporting extra protection for handling PLWHA bodily fluids were more likely to support refusal to treat PLWHA (aOR = 1.80; CI: 1.22–2.69) compared to those who did not support that opinion. Males were more inclined to state that they would refuse to treat PLWHA (aOR = 1.66; CI: 1.11–2.50) and disclose their HIV status (aOR = 1.62; CI: 1.17–2.27) than females. Overestimating needle injury transmission risk raised treatment refusal likelihood (aOR = 2.22; CI = 1.29–3.92) compared to those accurately informed of this risk.

Conclusion Results indicate lack of knowledge of HIV transmission risks after specific exposures and about PrEP, PEP and treatment effectiveness. Gender and knowledge about HIV transmission risks influence students' attitudes towards PLWHA. Medical education should be focused on fostering correct attitudes and addressing stigma, which undermines prevention and treatment outcomes of PLWHA.

Keywords HIV, PLWHA, Knowledge, Attitudes, Medical students, Prevention

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Background

The Republic of Croatia is considered a country of low incidence of HIV. Croatia has one of the lowest rates (1.9) of newly diagnosed HIV infections per 100 000 inhabitants in the World Health Organization (WHO) European Region, and has the highest male-to-female ratio (11.8:1) in newly diagnosed HIV cases [1]. In 2022 there were 113 newly diagnosed HIV cases, among whom 19 were diagnosed with AIDS, while 6 died of AIDS-related causes in Croatia, compared to 22 995 newly diagnosed HIV cases, of which 2349 were diagnosed with AIDS and 767 died of AIDS-related causes in European Union/European Economic Area (EU/EEA) [2]. According to the latest report of National Public Health Institute of Croatia since 1985, a total of 2017 persons have been diagnosed with HIV, of whom 613 have developed AIDS and 256 died of AIDS-related causes. Men account for 89% of cases ever diagnosed and unprotected sex is the most common route of transmission (recorded in 89% of cases). Male-to-male sex is the most common transmission mode (62% of newly registered cases in 2022, and 71% in all ever-diagnosed cases), followed by heterosexual intercourse (24%). Injecting drug use and mother-to-child transmission (MTCT) account for 4% and less than 1% of cases, respectively [2]. In 2023, more than 95% of individuals diagnosed with HIV were receiving antiretroviral therapy (ART) and had reached viral suppresion, according to ECDC progress report on implementation of the Dublin Declaration [3].

Stigmatization of people living with HIV/AIDS (PLWHA) is common in healthcare settings globally [4]. According to European Centre for Disease Prevention and Control (ECDC) survey conducted in 2021 among 3272 individuals living with HIV in EU, 21% of HIV positive individuals were afraid to go to healthcare services due to fear of their HIV status being disclosed, and 16% avoided using healthcare services due to fear of being treated differently. More importantly, 23% experienced treatment rejection or a delay in treatment based on their HIV status [4]. Discrimination and stigmatization of PLWHA in healthcare stems on health care providers (HCPs) attitudes towards PLWHA and HCPs' fear of contracting HIV as well as institutional environment [5]. Apart from pharmacological treatment and knowledge regarding epidemiology, transmission and clinical course of HIV, attitudes and beliefs towards PLWHA among HCPs are important in ensuring proper treatment and quality of care. HIV-related stigma contributes to lower follow-up rates and adherence to treatment [6, 7]. PLWHA who experience stigma due to their HIV status are more inclined to postpone seeking care until they are severely ill, compared to those who do not anticipate encountering stigma [8]. Research on discrimination against PLWHA in Croatia is scarce. A study from 2015 involving 160 PLWHA showed that 49% experienced discrimination at healthcare level, rising to 72% among those who voluntarily disclosed their HIV status. A sizeable number faced an HCP who refused to treat PLWHA. Alarmingly, 38% reported breaches of confidentiality from HCPs. However, individuals diagnosed after 2001 reported less discrimination, suggesting a positive patterns in reducing stigma [9].

The aim of this study was to assess knowledge about HIV among medical students of the University of Zagreb School of Medicine, and to determine the level of discriminatory attitudes towards PLWHA. In Croatia, there are four medical schools, with 300 students enrolling annually in University of Zagreb, contributing to as much as 51% of the country's medical graduates each year. At the University of Zagreb, medicine is taught over six years, with the first three years consisting of preclinical subjects, followed by three years of clinical subjects. Infectious disease course is a part of the fourth year of study. During the last year of study, there are courses that address stigma and discrimination towards PWLHA and ethical issuses related to HIV and how they impact uptake of HIV prevention and treatment.

Methods

Study setting

We conducted a cross-sectional study among students attending the School of Medicine at the University of Zagreb. The questionnaire was distributed online through social media (Facebook), and was filled-out online using Google Forms. Data were collected from September 2021 to April 2022. Eligible for the survey were all students, aged 18 to 26 years. Out of 1900 students, 561 filled out the questionnaire (response rate of 29.5%). Among students attending preclinical and clinical courses, response rates were 26.4% and 33.0%, respectively.

Questionnaire design

The questionnaire consisted of questions from several previously validated questionnaires that were administered as part of published, peer-reviewed studies in English language [10–12]. The questionnaire examined three main features: socio-demographic characteristics including age, gender, level of study and level of received HIV education during elementary/high-school education, HIV-related knowledge, and discriminatory attitudes towards PLWHA. No questions were mandatory, and missing data were excluded from analysis.

The questions aiming to assess knowledge were divided into categories regarding HIV transmission, prevention and treatment. We evaluated knowledge about routes of transmission and risk of contracting HIV through various transmission pathways. Prevention knowledge included questions about pre-exposure (PrEP), post-exposure

prophylaxis (PEP), ART, and HIV testing using PCR and rapid tests. We used closed-ended (Yes/No; Correct/Incorrect) and multiple choice type questions with one correct answer. Only the question about possible modes of HIV transmision was multiple choice type with more than one answer correct. For this question, listing all modes of transmission correctly was considered as a correct answer, while omitting at least one route of transmission was considered as an incorrect answer.

The section of the questionnaire related to discrimination contained 14 Likert type questions scaled from 1 to 5 (1- 'Strongly disagree', 5 - 'Strongly agree'), which are presented in Fig. 1. Some of them were not analzyed in the manuscript to maintain focus on more important aspects of the research. For questions 'HIV testing should be voluntary' and 'HIV testing should be free of charge' the scores were reversed accordingly when performing regression analysis (1 – 'Strongly agree', 5 – 'Strongly disagree').

We selected three statements ('A doctor should have the right not to treat a person if he/she is HIV positive', 'HIV status of each patient should be indicated in the patient's medical record', 'I would disclose a patient's HIV status to another medical professional despite the patient's objection'), which we considered to best indicate level of discrimination among medical students and included them as dependent variables in ordinal regression models, based on our personal interest. Independent variables, selected based on internal data analysis, included gender, infectiology course attendence, and knowledge regarding HIV transmision and risk.

Statistical analysis

For questions regarding knowledge absolute frequency was calculated. Crohnbach's alpha was used to assess reliability of discriminatory statements. All questions expressed good internal consistency (Cronbach's alpha = 0.705).

Chi-square test was used to compare differences between knowledge among female and male students, as well as students attending preclinical and clinical courses. Kruskall Wallis test was used to compare means of Likert-scale questions (i.e. attitudes towards PLWHA) between genders, level of study and certain aspect of HIV prevention (Supplementary material). The statistical significance was set at $p < 0.05$. When designing tables for the manuscript, we transformed questions into statements.

When performing regression analysis, we opted for ordinal instead of logistic regression because we utilized Likert scores to determine discrimination attitudes, and dummy coding of ordinal scale could possibly lead to data misinterpretation. We assessed the proportional odds assumption for the ordinal logistic regression model using the poTest function from the MASS package in R (version v. 4.1.1.) We selected variables based

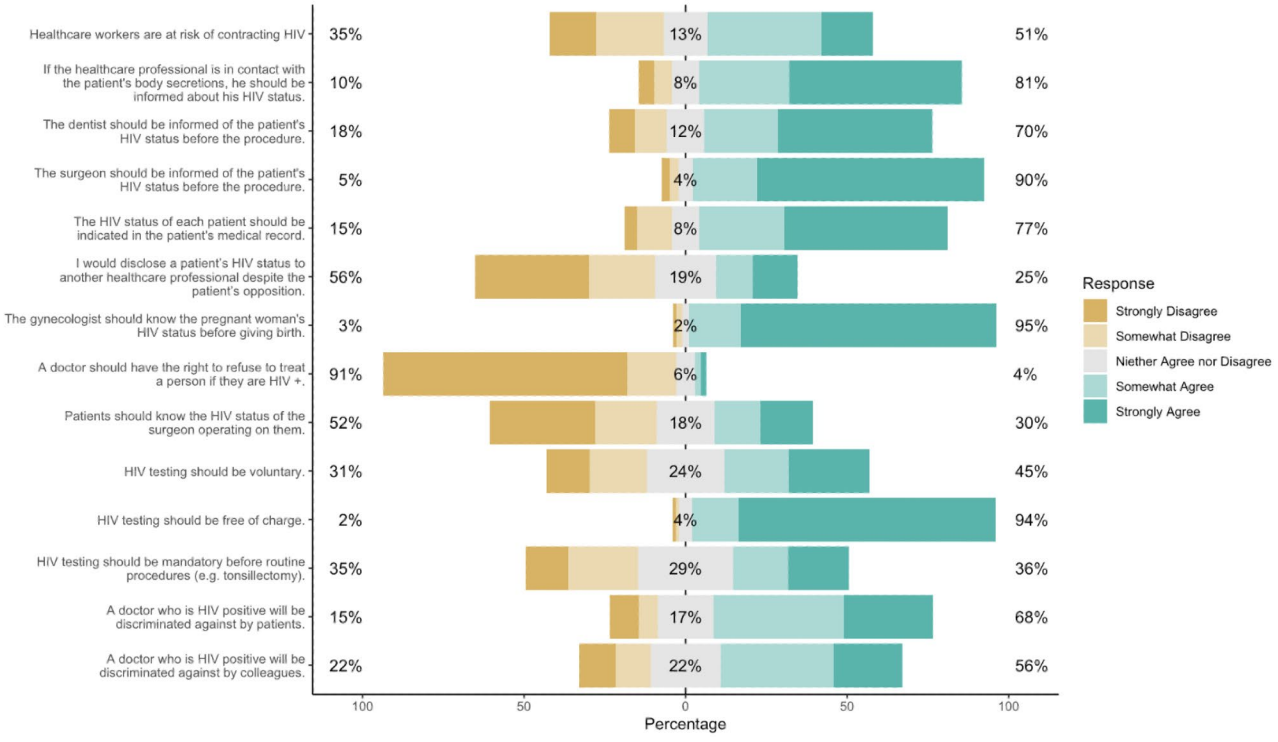

Fig. 1 Answers for Likert-scale questions regarding attitudes towards PLWHA ($N = 561$)

on the previous research related to this topic and internal data analysis. To ensure the validity of our models, we excluded variables which did not meet proportional odds criteria. To assess multicollinearity among the predictor variables, we calculated the Variance Inflation Factor (VIF) using standard procedures. Odds ratios (OR), confidence intervals (CI) and *p*-values were calculated for each model. R programming language v.4.1.1. was used for statistical analysis.

Ethics

The study was approved by the Ethics Committee of the University of Zagreb Medical School. The informed consent was enclosed at the introductory section of the questionnaire. Questionnaire was completely anonymous and no personal data was obtained.

Results

Overall, 561 respondents, of whom 65.6% were women, completed the questionnaire (Table 1). The mean age of respondents was 21.6 years. Preclinical courses were being attended by 46.9% of respondents at the time of the survey. Approximately one in two students (57.9%) reported receiving insufficient education regarding HIV during elementary and high-school education.

Knowledge related to HIV/AIDS epidemiology, transmission, and prevention

Knowledge regarding HIV epidemiology and transmission is shown in Table 2. More than 95% of students knew that HIV can be transmitted by sex, sharing needles, blood transfusions and from mother to a child. There were misconceptions regarding HIV transmission during oral sex. A sizeable number thought that HIV can be transmitted via sharing underwear (15.2%), mosquito bites (8.7%), and kissing (3.9%). Noteworthy, social interactions such as hugging and handshaking were not identified as risk behaviors. Students overestimated the risk of transmission following unprotected vaginal and anal intercourse. Although they demonstrated better HIV risk estimation for percutaneous exposure, they still perceived the risk as relatively high, with 20.5% and 36.5% reporting risk being 20 to 50% and 50 to 90%, respectively. Male-to-male sex was correctly reported as the main HIV transmission mode in Croatia by 66.3% of students (Table 2). Approximately one in three students falsely believed that PCR testing can detect the virus within the first 3 days of infection. Moreover, 39.4% were aware that saliva can be used for rapid HIV testing and 33.2% knew that timely ART initiation can prevent progression to AIDS. Although 70.6% understood that a person with undetectable viremia is not contagious, it is intriguing that only 28% knew that a person who is stable on ART does not need to use a condom to prevent infecting their partner. Although around two-thirds (67.0%) were familiar with the fact that there is a medication that could prevent HIV transmission (PrEP), misconception regarding its utilization were prevalent with 46.9% mistakenly believing that PrEP is a medication taken by HIV positive individuals to prevent infecting their partners. Similarly, 61.0% correctly stated that PEP is a medication taken by HIV negative individuals to reduce the chance of getting HIV after exposure.

Knowledge gaps were evident in the understanding MTCT, with 50.6% of participants stating that HIV positive mothers on adequate therapy can give birth naturally. Additionally, 57.8% were aware that HIV positive women are advised not to breastfeed.

Although noteworthy improvements in knowledge were observed, significant gaps related to HIV knowledge persisted among clinical students (Table 1, Supplement). Notably, misconceptions are prevalent in understanding the probability of HIV transmission after a needlestick injury, with only 4.9% of preclinical students estimating the correct risk compared to 42.6% in the clinical group ($p<0.01$). Additionally, misapprehension persisted concerning the probability of transmission through unprotected sexual intercourse, where 95.1% in the pre-clinical group compared to 79.2% in the clinical group held inaccurate beliefs ($p<0.01$). Miscomprehension regarding the transmission risk from HIV positive individuals with undetectable viremia are evident, with 51.0% of the preclinical group accurately assessing the risk as low, compared to 87.9% in the clinical group ($p<0.01$). Accurate knowledge about the incurability of HIV but its manageability through treatment is lacking, with 42.2% in the pre-clinical group and 66.8% in the clinical group believing that AIDS can be prevented through timely treatment ($p<0.01$). Approximately one in two preclinical students know the purpose of PrEP (46.8%) and PEP (50.9%) while

Table 1 Demographic and academic characteristics of respondents ($N=561$)

	Total	Male	Female
	N(%)	*N* (%)	*N* (%)
Number of participants (n)	561 (100.0)	193 (34.4)	368 (65.6)
Mean age (SD)	21.6 (2.06)	21.9 (1.96)	21.4 (2.08)
Attendance of course in infectious diseases			
Have not attended the course	305 (54.4)	95 (49.2)	210 (57.1)
Attended the course	256 (45.6)	98 (50.8)	158 (42.9)
Place of residence			
< 50 000 inhabitants	239 (42.6)	69 (35.8)	170 (46.2)
> 50 001 inhabitants	322 (57.4)	124 (64.2)	198 (53.8)
Elementary and high school education regarding HIV/AIDS			
Recieved basic or no information about HIV/AIDS	325 (57.9)	102 (52.8)	223 (60.6)
Recieved sufficient information about HIV/AIDS	236 (42.1)	91 (47.2)	145 (39.4)

Table 2 Student's responses to questions related to HIV epidemiology and transmission (*N* = 561)

Responses to questions	*N* (%)
Possible modes of HIV transmission	
Vaginal sexual intercourse	557 (99.3)
Sharing needles for IV drugs	555 (98.9)
From mother to child	552 (98.4)
Anal sexual intercourse	548 (97.7)
Blood transfussion	545 (97.2)
Oral sexual intercourse	368 (65.6)
Using shaving accessories	149 (26.6)
Wearing other people's underwear	85 (15.2)
Mosquito bite	49 (8.7)
Kissing	22 (3.9)
Hugging and handshaking	0 (0.0)
Most common route of HIV transmission in Croatia	
Sexual intercourse between men	372 (66.3)
Sexual intercourse between men and women	90 (16.0)
Sharing needles for IV drugs	88 (15.7)
From mother to child	11 (2.0)
Probability of HIV transmission after a needlestick injury	
Less than 2%	140 (25.0)
2 to 20%	101 (18.0)
20 to 50%	115 (20.5)
50 to 90%	205 (36.5)
Probability of HIV transmission after an unprotected vaginal sexual intercourse	
Less than 2%	49 (8.8)
2 to 20%	113 (20.1)
20 to 50%	187 (33.3)
50 to 90%	212 (37.8)
Probability of HIV transmission after an unprotected anal sexual intercourse	
Less than 2%	75 (13.4)
2 to 20%	114 (20.3)
20 to 50%	157 (28.0)
50 to 90%	215 (38.3)
If working with saliva, urine or feces of an HIV positive person, HCPs should be warned about an additional level of protection	
Yes	254 (45.3)
No	307 (54.7)
PreP is a medication taken by HIV positive person to prevent them from infecting their partners	
Yes	263 (46.9)
No†	298 (53.1)
PEP is a medication taken by HIV negative people to reduce the chance of contracting the virus	
Yes†	342 (61.0)
No	219 (39.0)
HIV positive person on adequate therapy does not have to use protection (a condom) during sexual intercourse to prevent the transmission of the virus*	158 (28.2)
Despite treatment, HIV positive mother must give birth by caesarean section to prevent the transmission of the virus to the child*	284 (50.6)
Know that HIV positive women are advised not to breastfeed*	324 (57.8)
Know that the virus can not be detected by PCR test within 3 days of infection*	358 (63.8)
Know that patient's saliva can be used when performing rapid HIV-test*	221 (39.4)
Know that HIV is not a curable disease, but AIDS can be prevented with therapy*	186 (33.2)
Know that there is a medication that can be taken after risky intercourse to reduce the likelihood of contracting HIV*	376 (67.0)
Know that there is no vaccine that prevents HIV infection*	484 (86.3)
Know that the risk of HIV transmission from an HIV positive person with an undetectable viremia is very low*	396 (70.6)

*, † correct answers

this was the case with 58.7% and 69.8% of clinical students, respectively.

Males demonstrated a higher level of knowledge of the probability of HIV transmission after a percutaneous exposure (35.8% vs. 19.3%, $p<0.01$), during unprotected vaginal (22.3% vs. 8.4%, $p<0.01$) and anal sex (14.0% vs. 6.0%, $p<0.01$) compared to females (Table 1, Supplement). No significant distinctions were found in knowledge related to the necessity of using condom during sexual intercourse by an HIV positive person on ART (31.1% vs. 26.6%, $p=0.31$), and recommendations for HIV positive mothers regarding childbirth (50.8% vs. 50.5%, $p=1.00$) and breastfeeding (57.0% vs. 58.2%, $p=0.86$). Differences were not observed for PrEP and PEP usage either.

Interestingly, students who were familiar with PEP and knew that risk of HIV transmission in persons with undetectable viremia is low still perceived HCPs to be at risk for HIV infection (3.27 vs. 3.02, $p=0.02$, and 3.27 vs. 2.94, $p<0.01$; Table 2, Supplement).

Attitudes related to HIV and PLWHA

Figure 1. shows opinions regarding HIV and PLWHA. Approximately one in two students (51.6%) perceived HCPs being at risk of contracting HIV, and even higher portion (81.5%) thought that they should be informed about patient's HIV status if dealing with his bodily fluids. Similarly, 77.2% believed that HIV status should be stated in medical records and 25.5% would disclose patient's HIV status to their colleague. Most importantly, 90.9% of respondents disagree with HCPs refusing treatment of PLWHA. While 94.1% advocated for free HIV testing, considerably fewer (45.3%) thought that it should be voluntary. Only 15.0% of students held the opinion that an HIV positive physician would not be discriminated against by patients, while 22.3% thought he would not be discriminated against by colleagues.

The data reveal interesting gender and academic stage-based variations in attitudes related to HIV, as seen in Table 3. Male participants exhibited a slightly higher perception of health care workers being at risk of contracting HIV compared to females ($p=0.03$). While the attitude that a patient's HIV status should be indicated in his medical record did not significantly differ between genders, significant difference was observed between academic stages, with preclinical students showing stronger agreement than clinical students ($p<0.01$). Male participants were more inclined to disclose a patient's HIV status to another medical professional despite the patient's objection compared to females ($p=0.01$). However, no significant difference was observed between preclinical and clinical students. Male participants were more likely to believe that a doctor who is HIV positive will be discriminated against by colleagues compared to females ($p=0.03$) as did clinical students compared to preclinical ($p<0.01$).

Results of the multivariate ordinal regression analysis are shown in Table 4. Those who are unfamiliar with all routes of HIV transmission (aOR=1.49, 95% CI: 1.06–2.09) and believe that additional protection is needed when working with body fluids of HIV-positive persons (aOR=1.65, 95% CI: 1.19–2.28) think that HIV status should be mandatory disclosed in medical records.

Male students (aOR=1.66, 95% CI: 1.11–2.50) and those advocating for additional protection when handling bodily fluids of PLWHA (aOR=1.80, 95% CI: 1.22–2.69) were more likely to support the idea of refusing treatment based on HIV status, as well as those who overestimated the risk of HIV transmission after a needle stick injury (aOR=2.22, 95% CI: 1.29–3.92).

Particularly interesting finding was that individuals who had not attended an infectology course were significantly less likely to disclose a patient's HIV status to another medical professional despite the patient's objection (aOR=0.65, 95% CI: 0.46–0.93) compared to those who attended. Additionally, males were notably more likely to support a disclosure of HIV positive status (aOR=1.62, 95% CI: 1.17–2.27) compared to females, as

Table 3 Comparison of likert scores[†] regarding attitudes towards PLWHA by gender and the stage of studying ($N=561$)

	Male	Female	*p**	Preclinical	Clinical	*p**
Health care workers are at risk for contracting HIV	**3.33**	**3.09**	**0.03**	**2.84**	**3.47**	**<0.01**
If in contact with the patient's bodily secretions, the healthcare worker should be informed about his HIV status	4.19	4.20	0.90	4.10	4.29	0.10
The HIV status of each patient should be indicated in the patient's medical record	4.04	4.13	0.53	**4.27**	**3.95**	**<0.01**
I would disclose a patient's HIV status to another medical professional despite the patient's objection	**2.71**	**2.37**	**0.01**	2.37	2.59	0.12
A doctor should have the right not to treat a person if they are HIV positive	1.47	1.35	0.06	1.39	1.39	0.97
HIV testing should be voluntary	2.69	2.77	0.57	2.74	2.75	0.99
HIV testing should be free	**1.38**	**1.24**	**0.01**	1.32	1.27	0.45
HIV testing should be mandatory before routine procedures (e.g., tonsillectomy)	2.97	3.13	0.18	**3.42**	**2.77**	**<0.01**
A doctor who is HIV positive will be discriminated against by colleagues	**3.60**	**3.35**	**0.03**	**3.13**	**3.70**	**<0.01**

[†] five-item scale: 1 – strongly disagree, 2 – somewhat disagree, 3 – neither agree nor disagree, 4 – somewhat agree, 5 – strongly agree, * Mann Whitney test

Table 4 Multivariate* ordinal regression models of selected discriminatory attitudes towards PLWHA

Attitude	aOR (95% CI)
HIV status of each patient should be indicated in the patient's medical record	
Male gender	1.05 (0.75–1.48)
Not yet attended infectology course	1.45 (1.00–2.09)
Not being familiar with all routes of HIV transmission	**1.49 (1.06–2.09)**
Overestimating risk of HIV transmission after needlestick injury	1.33 (0.89–1.99)
Not knowing that there is low risk for HIV transmission if HIV positive person has undetectable viremia	1.45 (0.98–2.16)
HP should be warned about additional level of protection when working with bodyfluids of HIV + persons	**1.65 (1.19–2.28)**
A doctor should have the right not to treat a person if he/she is HIV+	
Male gender	**1.66 (1.11–2.50)**
Not yet attended infectology course	0.71 (0.44–1.10)
Not being familiar with all routes of HIV transmission	1.17 (0.76–1.83)
Overestimating risk of HIV transmission after needlestick injury	**2.22 (1.29–3.92)**
Not knowing that there is low risk for HIV transmission if HIV positive person has undetectable viremia	1.13 (0.70–1.79)
HP should be warned about additional level of protection when working with bodyfluids of HIV + person	**1.80 (1.22–2.69)**
I would disclose a patient's HIV status to another medical professional despite the patient's objection	
Male gender	**1.62 (1.17–2.27)**
Not yet attended infectology course	**0.65 (0.46–0.93)**
Not being familiar with all routes of HIV transmission	1.30 (0.94–1.80)
Overestimating risk of HIV transmission after needlestick injury	1.47 (0.98–2.21)
Not knowing that there is low risk for HIV transmission if HIV positive person has undetectable viremia	1.32 (0.91–1.89)
HP should be warned about additional level of protection when working with bodyfluids of HIV + persons	**1.64 (1.21–2.23)**

* adjusted for all variables selected for the bivariate analysis

well as those advocating for additional protection when handling bodily fluids of PLWHA (aOR = 1.64, 95% CI: 1.21–2.23) compared to those who do not support this practice.

Discussion

Although knowledge regarding HIV transmission, prophylaxis, diagnosis and treatment is better in clinical compared to pre-clinical medical students, gaps still exist. In general, students seem to be familiar with common ways of HIV transmission, with exception of oral sex, which was reported as a transmission route in only two-thirds of respondents. According to Gerbert and colleauges, uncertainity about the risk of HIV infection through oral sex among HCPs seems to be an issue [13]. Simultaneously, students seem to overestimate HIV-transmission risk in the context of sexual intercourse, but also following a needle injury. Overestimation of HIV risk in certain clinical settings among German medical students has been reported and seem to be influenced by national epidemiological trends of HIV infection, which are similar to those observed in Croatian population [14]. When comparing preclinical and clinical students, greatest improvements were seen in estimation of risk following a needle injury, while for anal and vaginal sexual intercourse risk estimation changed to a minor extend. False beliefs regarding certain transmission routes that are not relevant for HIV (e.g., kissing, sharing underwear) still persist. Improved knowledge among clinical students was also noted in Germany, but still only 34% correctly stated all modes of HIV transmission [15]. Moreover, transmission by kissing and mosquito bites was also frequently reported as possible and analogous findings within other studies suggest these false beliefs to be irrespective of social and cultural context [15, 16]. In our study, there is a limited understanding regarding MTCT, and no improvements were seen after the infectology course, which is potentially influenced by the epidemiological context of HIV infection in Croatia, where MTCT of HIV is negligible and occurs only sporadically [17].

Most notably, we observed substantial gaps in knowledge regarding PEP, PrEP and ART. Although the proportion of clinical students aware of the existance of medications for prevention of HIV infection is almost twice as large when compared to preclinical group, knowledge about PrEP and PEP among clinical students is sub-optimal. Our observations regarding HIV prevention seem to be comparable with other studies revealing low or medium level of PEP and PrEP knowledge, among both HCPs and medical students [18, 19]. Moreover, around one-third of clinical students were unfamiliar with the fact that ART could prevent AIDS. Lack of comprehension of HIV PCR and rapid testing practices was found to be prominent as well. There were no substantial differences in HIV-related knowledge between male and female students, except in understanding HIV transmission modes.

Comparison of attitudes towards PLWHA among clinical and preclinical students revealed contradictory results. Clinical students were less likely to support the practice of recording HIV status in medical records not related to the treatment of HIV and pre-procedural routine HIV testing compared to pre-clinical students, but

perceived the risk of HIV acquisition in occupational setting to be higher. Attendance of infectious diseases courses and clinical training likely enhances awareness of ethical considerations relevant to PLWHA, but simultaneously might raise concerns about occupational exposure to infections. There was no difference in the opinion regarding HCPs' refusals to treat PLWHA between preclinical and clinical students, which we considered the greatest stigmatizing attitude.

In the studies of Begovac et al., better knowledge and less intolerance towards PLWHA was observed among Croatian students across time, in the 1993–2003 period, and these were particularly more pronounced among students who had contact with PLWHA during clinical training [20]. When compared to the studies done in 1993 and 2003, similar percentage of students in our study knew that HIV can be transmitted by sexual intercourse, needle injury and from mother to child. Additionally, minor improvements were noted regarding knowledge about improbable transmission modes such as mosquito bites (81%, 88% and 91% of correct answers in the years 1993, 2003, and 2023, respectively) and handshaking (97%, 98% and 100% of correct answers in 1993, 2003, 2023, respectively). On the other hand, students in 1993 and 2003 assessed the risk after percutaneous exposure more correctly compared to 2023 (43% and 53% in 1993 and 2003 vs. 25% in 2023) [20]. There was also a notable decline in the willingness of students to disclose a patient's HIV status to their colleague (from 76% in 1993 and 50% in 2003 to 25% in our study). Significant to note is that 14% of students in 1993 and 20% in 2002 stated that HCPs should have the right to refuse to treat PWLHA, while only 4% in our sample held this opinion, and 6% neither agreed nor disagreed (Fig. 1). These findings seem to imply a positive shift in the attitudes towards PLWHA among future HCPs though there is still a sizeable minority with discriminatory attitudes.

While familiarity with occupational PEP could possibly yield better attitudes towards PLWHA, participants in our study familiar with the concept of PEP and those accurately recognizing that low HIV viremia significantly lowers the risk from infection still considered HCPs to be at higher risk of infection (Table 2, Supplement) [12]. These observations possibly stem from misuderstandings regarding the professional utilization of PEP, but qualitative resarch on this topic are scarce and should be conducted in the future to better clarify this findings. Even among medical students in countries with high HIV prevalence poor education on PEP has been reported, and similar was seen in Croatia among dental medicine students, of whom 49% were not aware that PEP is indicated after percutaneous exposure [21, 22].

Results of a systematic review by Chory et al. suggest that male students from low- and middle-income countries of Europe, Asia, and Africa demonstrated higher scores of HIV transmission and prevention knowledge compared to female students [23]. In our sample, male participants also displayed better knowledge of HIV transmission risk following needlestick injury, vaginal as well as anal sexual intercourse, and were more familiar with the 'undetectable=untransmittable' rule. Among students in Bosnia and Herzegovina, females had better knowledge about HIV, and in the same study willingness to work with PWLHA and less stigmatizing attitudes were observed among those achieving higher scores in HIV transmission knowledge [24]. Although in our sample males were better informed about HIV transmission, they also perceived HCPs being at risk for HIV acquisition and were more prone to disclose patient's HIV status. Furthermore, male individuals held the belief that a doctor who is HIV positive would face discrimination from colleagues, suggesting that discriminatory attitudes might be gender-related. Students in our sample frequently expressed beliefs that an HIV positive phsyician will face discrimination from both patients and colleagues, which might reflect awareness of a wider societal stigma towards PLWHA. Analysis of surveys conducted among PLWHA in the Netherlands in 2007, 2009, and 2019 showed an upswing in health system stigma, counterbalanced by a decline in stigma within family, friends, and workplace [25]. The causes contributing to the development of stigma towards PLWHA in European countries with low HIV prevalence have not been comprehensively investigated.

In the previous studies among medical students in Croatia, students expressed a need for more comprehensive education on HIV in high schools [20]. In spite of that, in our study students reported receiving suboptimal education about HIV matters in high school, implying a continuing pattern of inadequate education about HIV, even with a three-decade span. In Croatia, an attempt was made to introduce sexual education in 2013, but unsuccessfully. Since then, there have been occasional initiatives to reintroduce it, but it still remains a subject of public debate, and its implementation currently relies on the individual school policies. Croatia should aim to adopt a national sexual education plan that will be systematically implemented and should include issues of stigmatizaton and education about sexually transmitted infections.

This study provided evidence on HIV-related issues that should be better elaborated during medical education, and these are specifically risks of transmission, PrEP and PEP and ART effectiveness. Emphasis should also be put on development of anti-discriminatory attitudes towards PLWHA among medical students, while future studies should aim to elucidate other aspects shaping stigmatization towards PLWHA, with emphasis on

the interaction of professional, social, and psychological determinants underlying discrimination.

Our study has several limitations. Firstly, the response rate was rather low though we employed various activities to increase the participation (such as regularly reminding students to participate, shared the questionnaire on social media, and informing students about the ability to participate at various official student gatherings). Secondly, we did not incorporate questions on sexual orientation and behaviours, professional exposure to HIV, having high-risk family members or friends, which could potentially influence discriminatory attitudes and knowledge levels. Furthermore, our assessment did not extend to personal attitudes towards groups at high risk of HIV transmission beyond the professional context, thus overlooking the broader social dynamics that influence personal attitudes.

Conclusion

Knowledge gaps related to HIV are prevalent among medical students in Croatia. Academic education surely plays an important role in filling knowledge gaps, albeit significant misconceptions regarding transmission, prevention and infectivity of HIV endure. The key point to highlight is sub-optimal knowledge about PrEP and PEP, which stands as the cornerstone in effectively controlling the HIV pandemic. Improvements in HCPs education regarding PEP utilization within the healthcare system could diminish fear from infection, and contribute to destigmatization of PLWHA.

Abbreviations

ART	Antiretroviral therapy
ECDC	European Centre for Disease Prevention and Control
HCPs	Health-care professionals
MTCT	Mother-to-child-transmission
PEP	Post-exposure Prophylaxis
PLWHA	People Living with HIV/AIDS
PrEP	Pre-exposure Prophylaxis
WHO	World Health Organization

Supplementary Information

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Supplementary Material 1

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Author contributions

D.LJ. and H.Š. designed a questionnaire. D.LJ. and H.Š. performed literature search and writing. D.LJ. performed statistical analysis and figure design. I.B. performed study conceptualization and revised the manuscript for important intellectual content.

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Data availability

The datasets used and analyzed during the study are available from the corresponding author upon reasonable request.

Declarations

Ethical approval and consent to participate

Ethical approval for the study was obtained from the Ethical Committee of School of Medicine Univeristy of Zagreb (approval number: 380-59-10106-21-111/151). Written informed consent was obtained from the study pariticpants.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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