



# Knowledge of HIV and HIV pre-exposure prophylaxis among medical and pharmacy students: A national, multi-site, cross-sectional study

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## ABSTRACT

Pre-exposure prophylaxis (PrEP) is a highly effective strategy for preventing HIV. However, prescription of PrEP has not reached the scale that is necessary to meet the public health need of reducing HIV incidence. A factor contributing to this slow scale-up is limited healthcare practitioners' knowledge of PrEP, making PrEP education a priority. We conducted a national, cross-sectional study of medical (allopathic and osteopathic) and pharmacy students regarding knowledge of PrEP and HIV between October 2020 and February 2021. We included 28 items in our knowledge assessment. Analysis sought to identify gaps in knowledge as well as academic and demographic correlates of knowledge. A total of 2,353 students participated in the study (response rate = 17.0%). The overall mean HIV knowledge score was 79.6% correct. Regarding specific items, 68.7% of participants believed HIV treatment was difficult because it required many pills, and 61.1% incorrectly indicated a person with an undetectable HIV viral load could transmit the virus to their sexual partners. Overall mean PrEP knowledge was 84.1%. Approximately one-third of participants did not identify HIV-negative status as a requirement to be a PrEP candidate. Gay/lesbian participants and those who were in the late-phase of training reported higher knowledge of both HIV and PrEP than did heterosexual participants and those in the early-phase of training. This study identifies specific gaps in training on HIV prevention with PrEP that must be improved in health professions education to ensure PrEP reaches its full potential in ending the HIV epidemic.

## 1. Introduction

HIV remains a significant public health burden in the United States, with over 30,000 new diagnoses of HIV in 2018 and an estimated 1.2 million people living with HIV (Centers for Disease Control Prevention. HIV Surveillance Report, 2018). Pre-exposure prophylaxis (PrEP) is highly effective for preventing HIV, reducing the risk of sexual transmission of HIV by 99% when taken daily, as established by several large-scale clinical trials conducted among men who have sex with men (MSM), heterosexual men and women, and transgender women (Anderson et al., 2012; Centers for Disease Control Prevention 2018; Grant et al., 2010; Baeten et al., 2012; Deutsch et al., 2015). Two drugs

are currently approved in the U.S. for use as HIV PrEP: emtricitabine/tenofovir disoproxil fumarate (TDF/FTC) and emtricitabine/tenofovir alafenamide (TAF/FTC) (Mayer et al., 2020). Both medications are safe with few side effects (Mayer et al., 2020; Tetteh et al., 2017). TDF/FTC is approved for use in all adults and adolescents over age 13, while TAF/FTC is approved for cisgender men and transgender women only (Truvada, 2018; Descovy, 2019). The U.S. Preventive Services Task Force, Centers for Disease Control and Prevention (CDC), and World Health Organization recommend PrEP for patients with HIV risk-factors (Centers for Disease Control, 2018; U. S. Preventive Services Task Force, 2019; World Health Organization, 2020).

Despite the effectiveness and safety of these regimens for PrEP,

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prescription has not matched the public health need for HIV prevention. An 2015 estimate found approximately 1.2 million people in the U.S. had HIV risk-factors and indications for PrEP (Smith et al., 2015). However, only an estimated 10% of these people were prescribed PrEP as of 2018 (Smith et al., 2015; Sullivan et al., 2018; Hammack et al., 2018; Siegler et al., 2018). Specifically, Black MSM alone comprised approximately 25% of new HIV diagnoses in 2018, but represented an estimated 1% of PrEP prescriptions (Centers for Disease Control Prevention 2018; Huang et al., 2018; Kanny, et al., 2017; Finlayson et al., 2019; HIV prevention, 2018). Similar disparities with respect to HIV incidence and PrEP prescription are present among transgender people (Smith et al., 2015; Siegler et al., 2020; Reisner et al., 2019; Poteat et al., 2016).

A commonly cited factor contributing to the low uptake of PrEP is limited clinician knowledge and awareness of PrEP (Mayer et al., 2020; Pleuhs et al., 2020; Smith et al., 2016; Wood et al., 2018). Specific knowledge gaps include unfamiliarity with PrEP prescribing guidelines and requirements to manage patients taking PrEP (Smith et al., 2016; Wood et al., 2018). One recent study found that of patients denied PrEP by a healthcare provider, nearly 40% were denied because the clinician was unsure of how to prescribe it (Furukawa et al., 2020). Crucially, other studies have shown that knowledge of PrEP is linked to greater rates of PrEP prescription (Blumenthal et al., 2015; Walsh and Petroll, 2017). Physicians and other PrEP-prescribing clinicians have identified a need for additional training about PrEP overall, identifying patients who may be PrEP candidates, follow-up requirements, and the counseling skills needed to initiate and sustain PrEP (Bleasdale et al., 2020; Rao et al., 2021). This includes skills to specifically discuss sensitive topics, like sexual history and drug use, with the patient to determine HIV-risk and subsequently initiate PrEP counseling (Bleasdale et al., 2020; Wilson and Bleasdale, 2020). Previous training initiatives have shown promise with respect to improving clinician knowledge of PrEP to increase prescription (Clement et al., 2018; Bunting et al., 2020; Newman et al., 2018; Bunting et al., 2019).

As efforts to scale-up PrEP prescription continue, including non-physician clinicians such as pharmacists is essential (Okoro and Hillman, 2018; Havens et al., 2019; Bruno and Saberi, 2012; Myers et al., 2019). However, studies of pharmacists have also identified knowledge gaps, with pharmacists indicating a need for additional training to identify patients at risk for HIV and to prescribe and manage PrEP (Broekhuis et al., 2018). Correspondingly, only an estimated 46% of surveyed pharmacists were aware of PrEP for HIV-prevention, and only 33% had dispensed PrEP to a patient (Okoro and Hillman, 2018).

Ensuring current disparities in HIV incidence and PrEP prescription are not propagated requires educating health professionals in training about HIV-prevention in the biomedical era. Previous work evaluating health professions curriculum has found that medical and pharmacy students receive inadequate training about PrEP effectiveness, patient indications, and PrEP and HIV disparities, and that over 30% of fourth-year medical and pharmacy students did not receive training about PrEP (Bunting et al., 2020). A national study of medical and pharmacy students conducted in 2019 found that students were unsure of the connection between PrEP and widespread HIV-resistance, and which patient populations are indicated for PrEP (Bunting et al., 2020). Single-institution investigations of medical and pharmacy students found that approximately 50% of students were not knowledgeable about approved PrEP medications, recommended HIV testing frequency for patients taking PrEP, and contraindications to PrEP (Przybyla et al., 2019; Przybyla et al., 2021).

There is a need to more comprehensively understand knowledge gaps to specifically design curriculum to train the next generation of clinicians about PrEP for HIV prevention. Previous studies have been limited by relatively small samples and inclusion of only allopathic medical students (Przybyla et al., 2019; Przybyla et al., 2021). This limits generalizability because they omitted osteopathic medical students who comprise approximately 25% of U.S. medical students

(American Association of Colleges of Osteopathic Medicine, 2020; Association of American Medical Colleges, 2019). Osteopathic medical education programs train physicians with a holistic approach to care and a focus on preventive medicine (Shannon and Teitelbaum, 2009; Krueger et al., 2009). Previous studies have also been limited to brief PrEP knowledge inventories (5–6 items) (Bunting et al., 2020; Przybyla et al., 2019; Przybyla et al., 2021). To address these gaps, the goals of the present study were: 1) to evaluate knowledge of PrEP and HIV among medical and pharmacy students, 2) to identify specific knowledge gaps regarding PrEP and HIV, and 3) to determine demographic and educational correlates of PrEP and HIV knowledge.

## 2. Methods

### 2.1. Participants and procedure

Information about the study was distributed to a convenience sample of students enrolled at 20 U.S. medical and pharmacy schools, representing 10 allopathic medicine, 6 osteopathic medicine, and 4 pharmacy education programs with an overall, combined enrollment of 13,839 students. Institutions were in the Midwestern (7), Northeastern (5), Southern (3), and Western (5) U.S. University administrators shared an email message with information about the study, including a link for students to sign-up to receive more information about the study. If a potential participant met the inclusion criteria of: 1) at least 18 years of age, and 2) currently enrolled in a U.S. allopathic medicine, osteopathic medicine, or pharmacy education program, they were sent a separate, unique link to complete the study. We purposely avoided disclosing the focus of the study in the information provided to limit the risk of selection bias. The text of the recruitment message is included in Appendix A. Data were collected between October 2020-February 2021, and participants were able to complete the study any time within this period. Participants were given a \$10.00 gift card as compensation. Participants were sent a debrief message upon completion.

### 2.2. Study instrument

The first study section was a series of 28 true/false items regarding PrEP and HIV. (Appendix A) These items were developed based on instruments used in previous investigations of students' and clinicians' knowledge of PrEP and HIV, as well as adaptation of key aspects of the CDC PrEP Clinical Practice Guidelines (Centers for Disease Control Prevention, 2018; Blumenthal et al., 2015; Bunting et al., 2020; Przybyla et al., 2019; Castel et al., 2015; Petroll et al., 2017; Tellalian et al., 2013; Blackstock et al., 2017; Mimiaga et al., 2014; Silapaswan et al., 2017; Turner et al., 2018; Seidman et al., 2016; Desai et al., 2016; Krakower et al., 2015; Rickles et al., 2016; Hakre et al., 2016; Moore et al., 2020; Terndrup et al., 2019; Bunting et al., 2020). Items were reviewed by three physicians, two specializing in infectious disease and one in primary care, all of whom had expertise in HIV and PrEP. A focus group of 10 allopathic medical students completed the study instrument, with minor edits to item wording made prior to distribution. Knowledge items represented two domains: 1) PrEP Knowledge (15 items), and 2) HIV Knowledge (13 items). After the knowledge items, participants completed basic demographic items (e.g., race/ethnicity, gender identity, religiosity) and academic information (e.g., program, year in training).

### 2.3. Statistical analysis

The percentage correctly answering each item was calculated. The percentage who correctly answered each item was compared between participants in the early-phase (years 1&2) vs. late-phase (years 3&4) of training utilizing Pearson's chi-squared tests ( $\chi^2$ ). Correct items in each domain were summed and divided by the total number of items in each domain to create a percentage correct for HIV knowledge and for PrEP

knowledge. Demographic correlates of mean knowledge scores were examined utilizing one-way analyses of variance (ANOVA) models. Multivariable analyses were completed using analysis of covariance (ANCOVA) models adjusting for all demographic and training variables. Analyses were completed utilizing IBM SPSS v27 (Armonk, NY). This study was reviewed and approved by the Institutional Review Board of Rosalind Franklin University.

### 3. Results

A total of 3,964 students indicated interest in participating in the study. Of these students, 2,752 met the inclusion criteria, and 2,353 completed the study (completion rate = 85.5%). This represented an overall response rate of 17.0%, with a rate of 19.5% for allopathic medical students, 14.8% for osteopathic medical students, and 16.5% for pharmacy students.

#### 3.1. Demographics

Approximately half of all respondents were studying allopathic medicine ( $n = 1,175$ , 49.9%). A majority of participants were cisgender women ( $n = 1,423$ , 60.5%) and most were heterosexual ( $n = 2,061$ , 87.6%). Nearly half were studying in the Midwestern U.S. ( $n = 1,093$ , 46.5%) and the largest proportion were in their first-year of training ( $n = 677$ , 28.8%). Mean respondent age was 25.6 ( $SD = 3.1$ ) years. Complete demographic information for the complete sample and individual professions is provided in Table 1.

**Table 1**  
Demographics of Complete Sample and Individual Professions.

Year in Training	Overall ( $N = 2,353$ )		Allopathic Medicine ( $n = 1,175$ )		Osteopathic Medicine ( $n = 984$ )		Pharmacy ( $n = 194$ )	
	<i>N</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
1st year	677	28.8%	354	30.1%	273	27.7%	50	25.8%
2nd year	651	27.7%	328	27.9%	280	28.5%	43	22.2%
3rd year	507	21.5%	235	20.0%	221	22.5%	51	26.3%
4th+ year <sup>a</sup>	518	22.0%	258	22.0%	210	21.3%	50	25.8%
<b>Gender Identity</b>								
Men	905	38.5%	456	38.8%	397	40.3%	52	26.8%
Women	1,423	60.5%	699	59.5%	582	59.1%	142	73.2%
Gender Diverse <sup>b</sup>	25	1.1%	20	1.7%	5	0.5%	0	0.0%
<b>Race/Ethnicity</b>								
White	1,267	53.8%	591	50.3%	565	57.4%	111	57.2%
Black	82	3.5%	48	4.1%	24	2.4%	10	5.2%
Hispanic/Latino	101	4.3%	52	4.4%	38	3.9%	11	5.7%
Asian	734	31.2%	389	33.1%	288	29.3%	57	29.4%
Other Race <sup>c</sup>	169	7.2%	95	8.1%	69	7.0%	5	2.6%
<b>Sexual Orientation</b>								
Heterosexual (straight)	2,061	87.6%	1,020	86.8%	863	87.7%	178	91.8%
Gay/Lesbian	99	4.2%	47	4.0%	47	4.8%	5	2.6%
Bisexual	143	6.1%	77	6.6%	59	6.0%	7	3.6%
Other <sup>d</sup>	50	2.1%	31	2.6%	15	1.5%	4	2.1%
<b>Region<sup>e</sup></b>								
South	215	9.1%	138	11.7%	8	0.8%	69	35.6%
Northeast	512	21.8%	212	18.0%	269	27.3%	31	16.0%
West	533	22.7%	174	14.8%	305	31.0%	54	27.8%
Midwest	1,093	46.5%	651	55.4%	402	40.9%	40	20.6%

a. The year in training numbers also include 14 students who were in combined MD/MBA, MD/MPH, or MD/PhD programs, who were categorized into the year of medical school they indicated currently being enrolled, or the last year of medical school completed before transitioning to graduate coursework.

b. Includes those gender identities other than cisgender identities, including transgender, gender fluid, agender, and gender nonbinary.

c. Includes participants who indicated their race was other than the listed options.

d. Includes sexual orientations other than the listed options, including asexual, demisexual, and pansexual.

e. Northeast: CT, ME, MA, NH, NJ, NY, PA, RI, VT; Midwest: IL, IN, IA, KS, MI, MN, MO, NE, ND, OH, SD, WI; South: AL, AR, DE, DC, FL, GA, KY, LA, MD, MS, NC, OK, SC, TN, TX, VA, WV; West: AK, AZ, CA, CO, HI, ID, MT, NV, NM, OR, UT, WA, WY.

#### 3.2. HIV knowledge

The overall HIV knowledge scale mean was 79.6% ( $SD = 12.5\%$ ) corresponding to an average of 10.3 items correct out of 13 (median = 11). We found HIV knowledge did not significantly differ between academic programs in the ANCOVA. (Table 2) Compared to first-year students ( $M = 72.6\%$ , 95%CI:[70.5–74.7%]), knowledge of HIV was higher among second ( $M = 75.9\%$ , [73.8–78.0%],  $P < .001$ ), third ( $M = 76.9\%$ , [74.8–79.1%],  $P < .001$ ), and fourth-year and above students ( $M = 78.9\%$ , [76.7–81.0%],  $P < .001$ ). Gay/lesbian participants ( $M = 83.2\%$ , [80.3–86.1%]) reported higher knowledge of HIV compared to heterosexual participants ( $M = 73.2\%$ , [71.3–75.1%],  $P < .001$ ). White participants ( $M = 78.5\%$ , [76.6–80.4%]) reported higher knowledge of HIV compared to Asian participants ( $M = 76.4\%$ , [74.3–78.4%],  $P = .003$ ) and participants identifying as another race ( $M = 73.8\%$ , [71.4–76.2%],  $P < .001$ ). Cisgender male participants reported greater knowledge of HIV ( $M = 79.7\%$ , [78.1–81.4%]) compared to gender-diverse participants ( $M = 68.0$ , [63.1–72.8%],  $P < .001$ ), however there was no significant difference between cisgender men and women. Testing the interaction between gender identity and sexual orientation, we found that cisgender gay men had the highest knowledge of HIV ( $M = 88.4\%$ , [85.4–91.4%]) compared to cisgender heterosexual ( $M = 77.0\%$ , [75.7–78.2%],  $P < .001$ ), bisexual ( $M = 78.7\%$ , [74.1–83.3%],  $P = .002$ ) and cisgender men identifying as another sexual orientation ( $M = 72.1\%$ , [65.3–78.9%],  $P < .001$ ).

The percentage of participants correctly responding to each item is presented in Fig. 1. In early-/late-phase analyses (Table 3), greater percentages of late-phase participants correctly responded to multiple items, including about HIV treatment with single pill regimens (34.0% vs. 29.2%,  $\chi^2_1 = 6.3$ ,  $P = .01$ ), availability of effective medicine to

**Table 2**  
HIV and PrEP Knowledge Scale Analyses.

Academic Program	HIV Knowledge Scale				PrEP Knowledge Scale			
	Unadjusted		Adjusted		Unadjusted		Adjusted	
	Mean (95% CI)	P	Mean (95% CI)	P	Mean (95% CI)	P	Mean (95% CI)	P
Allopathic Medicine (MD)	80.1% (79.3, 80.8)	Ref.	76.5% (74.6, 78.4)	Ref.	84.5% (83.7, 85.3)	Ref.	79.3% (77.2, 81.4)	Ref.
Osteopathic Medicine (DO)	79.1% (78.4, 79.9)	.26	75.4% (73.4, 77.4)	.11	83.8% (83.0, 84.7)	.75	78.4% (76.2, 80.6)	.39
Pharmacy	79.3% (77.6, 80.9)	.99	76.3% (73.8, 78.8)	.99	83.0% (81.1, 84.8)	.42	77.8% (75.1, 80.6)	.51
<b>Year in Training</b>								
1st year	76.3% (75.3, 77.2)	Ref.	72.6% (70.5, 74.7)	Ref.	83.2% (82.2, 84.3)	Ref.	77.2% (74.9, 79.5)	Ref.
2nd year	79.8% (78.8, 80.8)	<.001	75.9% (73.8, 78.0)	<.001	84.2% (83.1, 85.4)	.99	78.4% (76.1, 80.7)	.56
3rd year	81.1% (80.1, 82.2)	<.001	76.9% (74.8, 79.1)	<.001	84.1% (82.8, 85.3)	.99	78.1% (75.8, 80.5)	.99
4th+ year	82.3% (81.2, 83.3)	<.001	78.9% (76.7, 81.0)	<.001	85.7% (84.4, 86.9)	.02	80.3% (77.9, 82.6)	<.001
<b>Religiosity</b>								
Not religious at all	80.5% (79.5, 81.4)	Ref.	77.0% (75.0, 79.0)	Ref.	85.5% (84.6, 86.4)	Ref.	80.0% (77.8, 82.2)	Ref.
Somewhat Religious	78.8% (77.3, 80.3)	.61	75.1% (72.8, 77.5)	.28	84.4% (82.7, 86.1)	.99	78.7% (76.1, 81.4)	.99
Neither Religious/Non-Religious	78.9% (77.8, 80.1)	.33	75.6% (73.5, 77.7)	.40	83.3% (81.9, 84.6)	.04	78.1% (75.8, 80.4)	.11
Moderately Religious	80.0% (79.1, 80.9)	.99	76.9% (74.8, 79.0)	.99	83.9% (82.8, 85.0)	.35	78.8% (76.5, 81.1)	.99
Very Religious	78.4% (76.9, 80.0)	.27	75.7% (73.3, 78.2)	.99	81.7% (80.1, 83.4)	<.001	76.9% (74.2, 79.5)	.01
<b>Gender Identity</b>								
Man	79.7% (78.9, 80.5)	Ref.	79.7% (78.1, 81.4)	Ref.	82.8% (81.8, 83.7)	Ref.	81.2% (79.5, 83.0)	Ref.
Woman	79.7% (79.1, 80.4)	.99	80.5% (79.0, 82.0)	.44	85.2% (84.5, 85.8)	<.001	84.2% (82.5, 85.9)	<.001
Gender Diverse	68.0% (55.6, 80.4)	<.001	68.0% (63.1, 72.8)	<.001	71.7% (59.4, 84.1)	<.001	70.1% (64.7, 75.4)	<.001
<b>Race/Ethnicity</b>								
White	81.0% (80.4, 81.6)	Ref.	78.5% (76.6, 80.4)	Ref.	86.4% (85.8, 87.1)	Ref.	82.8% (80.7, 84.9)	Ref.
Black	78.1% (74.1, 82.2)	.42	76.2% (73.0, 79.3)	.89	78.5% (74.0, 82.9)	<.001	75.0% (71.5, 78.4)	<.001
Hispanic/Latino	77.8% (74.8, 80.7)	.11	75.6% (72.6, 78.5)	.19	84.0% (81.2, 86.8)	.86	80.2% (77.0, 83.5)	.62
Asian	78.5% (77.7, 79.4)	<.001	76.4% (74.3, 78.4)	.003	81.9% (81.0, 82.9)	<.001	78.4% (76.1, 80.6)	<.001
Other	75.4% (72.7, 78.1)	<.001	73.8% (71.4, 76.2)	<.001	79.1% (76.3, 81.9)	<.001	76.1% (73.5, 78.8)	<.001
<b>Sexual Orientation</b>								
Heterosexual (straight)	79.2% (78.7, 79.7)	Ref.	73.2% (71.3, 75.1)	Ref.	83.7% (83.2, 84.3)	Ref.	76.2% (74.1, 78.3)	Ref.
Gay/Lesbian	88.0% (85.6, 90.3)	<.001	83.2% (80.3, 86.1)	<.001	89.4% (87.0, 91.8)	<.001	83.0% (79.8, 86.2)	<.001
Bisexual	81.7% (79.5, 83.8)	.12	75.8% (73.1, 78.5)	.08	87.1% (85.2, 89.0)	.03	78.7% (75.7, 81.7)	.17
Other	75.1% (67.5, 82.7)	.13	72.0% (68.5, 75.5)	.99	80.5% (73.0, 88.0)	.60	76.1% (72.3, 80.0)	.99
<b>Region</b>								
South	78.0% (76.1, 80.0)	Ref.	74.5% (72.1, 77.0)	Ref.	83.4% (81.3, 85.4)	Ref.	77.6% (74.9, 80.3)	Ref.
Northeast	79.8% (78.7, 80.8)	.54	76.9% (74.8, 79.1)	.14	83.8% (82.7, 84.9)	.99	78.3% (75.9, 80.7)	.99
West	77.5% (76.3, 78.7)	.99	74.9% (72.8, 77.0)	.99	82.6% (81.3, 83.9)	.99	78.0% (75.7, 80.3)	.99
Midwest	80.9% (80.2, 81.6)	.01	77.9% (75.9, 80.0)	.002	85.2% (84.4, 85.9)	.44	80.1% (77.8, 82.3)	.12

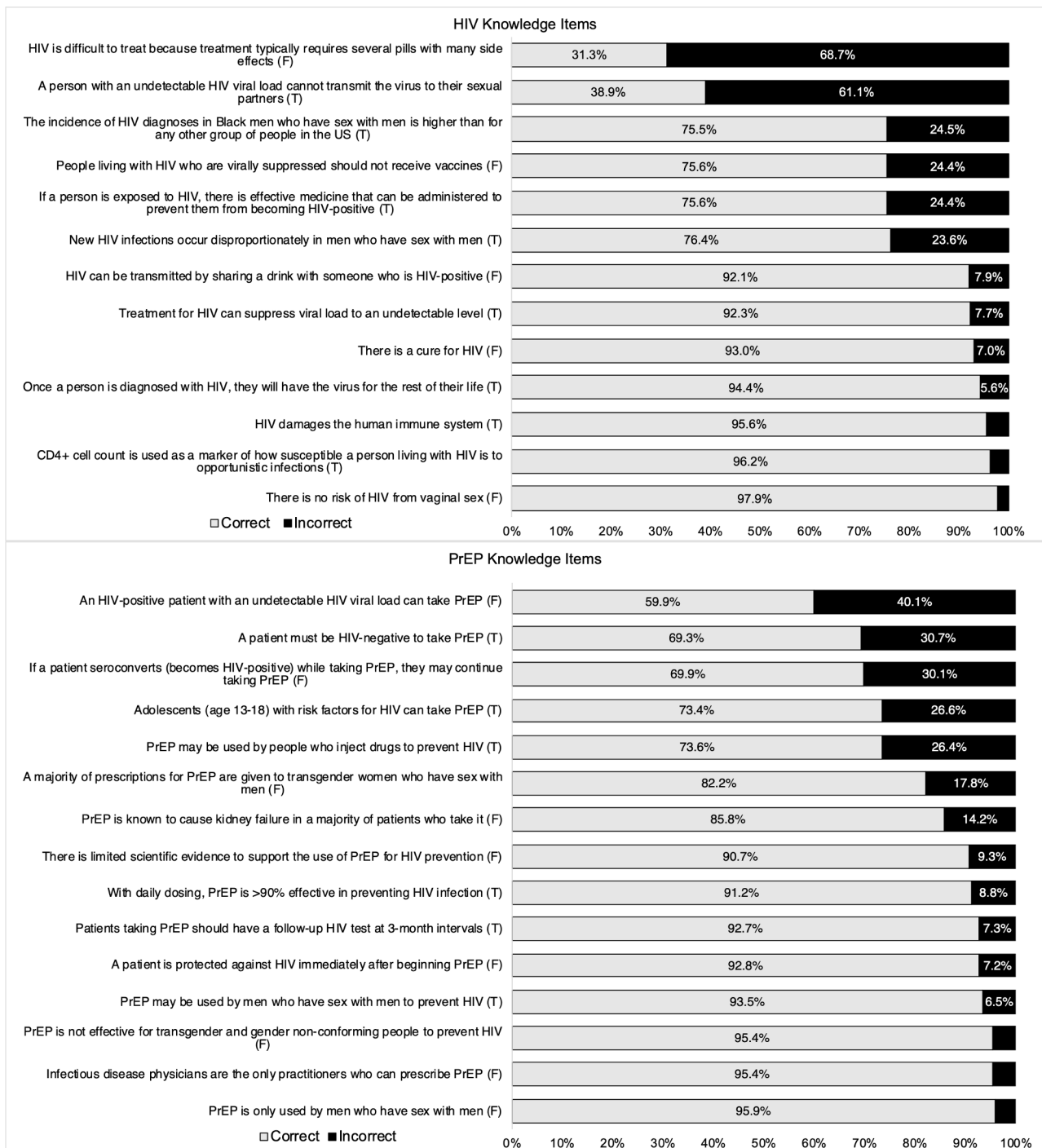
prevent seroconversion following an exposure (82.6% vs. 70.3%,  $\chi^2_1 = 48.1$ ,  $P < .001$ ), and that HIV cannot be transmitted by sharing a drink with an HIV-positive person (94.5% vs. 90.1%,  $\chi^2_1 = 15.3$ ,  $P < .001$ ). We also found that a greater percentage of late-phase participants knew that HIV incidence was highest among Black MSM (73.5% vs. 78.0%,  $\chi^2_1 = 6.48$ ,  $P = .01$ ), and that treatment for HIV can suppress viral load to an undetectable level (94.6% vs. 90.5%,  $\chi^2_1 = 13.8$ ,  $P < .001$ ). In analysis of only final-year students, we found that 39.6% correctly identified that a person with an undetectable HIV viral load could not transmit the virus to their partners, and that HIV treatment *does not* require multiple pills with many side effects.

### 3.3. PrEP knowledge

The overall PrEP knowledge scale mean was 84.1% ( $SD = 13.7\%$ ) corresponding to an average of 12.6 items correct out of 15 (median = 13). PrEP knowledge did not significantly differ between academic programs. (Table 2) Participants with more training reported higher knowledge of PrEP; however, only the comparison between first-year ( $M = 77.2\%$ , [74.9–79.5%]) and fourth-year and above participants ( $M = 80.3\%$ , [77.9–82.6%],  $P < .001$ ) was significant. Regarding race, White participants reported the highest knowledge of PrEP ( $M = 82.8\%$ , [80.7–84.9%]) as compared to Black ( $M = 75.0\%$ , [71.5–78.4%],  $P < .001$ ), Asian ( $M = 78.4\%$ , [76.1–80.6%],  $P < .001$ ), and participants identifying as another race ( $M = 76.1\%$ , [73.5–78.8%],  $P < .001$ ). Gay/lesbian participants ( $M = 83.0\%$ , [79.8–86.2%]) reported higher knowledge of PrEP compared to heterosexual participants ( $M = 76.2\%$ ,

[74.1–78.3%],  $P < .001$ ). Bisexual participants also reported higher knowledge of PrEP ( $M = 87.1\%$ , [85.2–89.0%]) compared to heterosexual participants ( $M = 83.7\%$ , [83.2–84.3%],  $P = .03$ ) in the ANOVA, however the difference was not significant in the ANCOVA. Cisgender male participants reported greater knowledge of PrEP compared to cisgender female participants ( $M = 84.2\%$ , [82.5–85.9%],  $P < .001$ ) and gender-diverse participants ( $M = 70.1\%$ , [64.7–75.4%],  $P < .001$ ). As with HIV knowledge, cisgender gay men participants reported the highest knowledge of PrEP ( $M = 87.7\%$ , [84.4–91.0%],  $P < .001$ ) when testing the interaction term of gender identity and sexual orientation, however only the comparison to cisgender heterosexual men was statistically significant ( $M = 78.8\%$ , [77.4–80.1%],  $P < .001$ ).

We found that greater percentages of late-phase students correctly indicated that adolescents could receive PrEP (78.7% vs. 69.2%,  $\chi^2_1 = 26.9$ ,  $P < .001$ ), that PrEP does *not* cause kidney failure in a majority of patients (90.0% vs. 82.5%,  $\chi^2_1 = 26.9$ ,  $P < .001$ ), and that PrEP is > 90% effective with daily dosing (92.8% vs. 90.0%,  $\chi^2_1 = 5.6$ ,  $P = .02$ ). (Table 3) Furthermore, a greater percentage of late-phase participants were aware of the evidence supporting PrEP (93.0% vs. 89.0%,  $\chi^2_1 = 10.8$ ,  $P = .001$ ), and that a majority of prescriptions are *not* given to transgender women who have sex with men (84.2% vs. 80.7%,  $\chi^2_1 = 4.77$ ,  $P = .03$ ). Finally, a lower percentage of late-phase participants identified the need for HIV testing at 3-month intervals for patients taking PrEP (91.0% vs. 94.1%,  $\chi^2_1 = 7.86$ ,  $P = .005$ ). Analysis of only final-year students revealed that 71.0% correctly indicated that a patient must be HIV-negative in order to take PrEP and 63.5% responded that a patient with an undetectable HIV viral load *could not* take PrEP.



The percentage of respondents who responded correctly or incorrectly to each item in the HIV or PrEP knowledge domain. The correct response to each item is indicated in parentheses after the item text.

Fig. 1. Percent correct and incorrect for all PrEP/HIV knowledge items.

4. Discussion

Low clinician knowledge of PrEP is a barrier to PrEP scale-up efforts (Mayer et al., 2020; Pleuhs et al., 2020). This makes training about HIV and PrEP in health professions education an important component of ongoing public health efforts to eliminate HIV, including the federal *Ending the HIV Epidemic* plan (Health Resources and Services Administration, 2019). To the best of our knowledge, the current study represents the largest study to date of PrEP and HIV knowledge among health

professionals in training, and our findings may be used to inform specific targets for improving health professions education about HIV and PrEP.

In the analyses of individual knowledge items, we identified a pattern of apparent misunderstanding about the basic requirement of patient HIV-negative status in order to be a potential candidate for PrEP. These findings indicate that additional health professions education is required about the role of PrEP as primary prevention for HIV-negative people with HIV risk-factors. Correcting this misunderstanding through education is essential, as prescribing PrEP to patients living with HIV

**Table 3**  
Knowledge item comparisons by phase of training.

HIV Knowledge Items	Percent Correct				
	Early-Phase		Late-Phase		Early vs. Late P
	n	%	n	%	
Treatment for HIV can suppress viral load to an undetectable level (T)	1,202	90.5%	970	94.6%	<.001
A person with an undetectable HIV viral load cannot transmit the virus to their sexual partners (T)	495	37.3%	420	41.0%	.07
HIV is difficult to treat because treatment typically requires several pills with many side effects (F)	388	29.2%	349	34.0%	.01
There is a cure for HIV (F)	1,244	93.7%	944	92.1%	.14
HIV can be transmitted by sharing a drink with someone who is HIV-positive (F)	1,197	90.1%	969	94.5%	<.001
Once a person is diagnosed with HIV, they will have the virus for the rest of their life (T)	1,258	94.7%	964	94.0%	.48
If a person is exposed to HIV, there is effective medicine that can be administered to prevent them from becoming HIV-positive (T)	933	70.3%	847	82.6%	<.001
There is no risk of HIV from vaginal sex (F)	1,298	97.7%	1,006	98.1%	.50
CD4+ cell count is used as a marker of how susceptible a person living with HIV is to opportunistic infections (T)	1,271	95.7%	992	96.8%	.18
HIV damages the human immune system (T)	1,268	95.5%	981	95.7%	.79
People living with HIV who are virally suppressed should not receive vaccines (F)	917	69.1%	863	84.2%	<.001
New HIV infections occur disproportionately in men who have sex with men (T)	1,015	76.4%	783	76.4%	.98
The incidence of HIV diagnoses in Black men who have sex with men is higher than for any other group of people in the U.S. (T)	976	73.5%	800	78.0%	.01
<b>PrEP Knowledge Items</b>					
A patient must be HIV-negative to take PrEP (T)	928	69.9%	702	68.5%	.47
Patients taking PrEP should have a follow-up HIV test at 3-month intervals (T)	1,249	94.1%	933	91.0%	.005
If a patient seroconverts (becomes HIV-positive) while taking PrEP, they may continue taking PrEP (F)	941	70.9%	703	68.6%	.23
Infectious disease physicians are the only practitioners who can prescribe PrEP (F)	1,263	95.1%	981	95.7%	.49
With daily dosing, PrEP is >90% effective in preventing HIV infection (T)	1,195	90.0%	951	92.8%	.02
There is limited scientific evidence to support the use of PrEP for HIV prevention (F)	1,182	89.0%	953	93.0%	.001
An HIV-positive patient with an undetectable HIV viral load can take PrEP (F)	781	58.8%	629	61.4%	.21
PrEP is known to cause kidney failure in a majority of patients who take it (F)	1,096	82.5%	923	90.0%	<.001
A patient is protected against HIV immediately after beginning PrEP (F)	1,237	93.1%	946	92.3%	.43

**Table 3 (continued)**

HIV Knowledge Items	Percent Correct				
	Early-Phase		Late-Phase		Early vs. Late P
	n	%	n	%	
PrEP may be used by men who have sex with men to prevent HIV (T)	1,247	93.9%	952	92.9%	.32
PrEP may be used by people who inject drugs to prevent HIV (T)	982	73.9%	750	73.2%	.67
PrEP is not effective for transgender and gender non-conforming people to prevent HIV (F)	1,267	95.4%	977	95.3%	.92
PrEP is only used by men who have sex with men (F)	1,266	95.3%	991	96.7%	.10
Adolescents (age 13–18) with risk-factors for HIV can take PrEP (T)	919	69.2%	807	78.7%	<.001
A majority of prescriptions for PrEP are given to transgender women who have sex with men (F)	1,072	80.7%	863	84.2%	.03

represents a serious public health concern and could cause direct patient harm given risk of antiretroviral resistance (Elliott et al., 2019).

Participants did appear to understand that follow-up HIV testing at 3-month intervals is required for patients taking PrEP. However, coupled with the identified misunderstanding regarding the need for HIV-negative status to be a PrEP candidate, additional training about the rationale for the required HIV-negative status to continue PrEP is needed. Research with clinicians has also identified a need for training on management of PrEP, follow-up laboratory testing, and follow-up counseling (Bleasdale et al., 2020). Medical and pharmacy educators should consider our findings, in conjunction with prior work with clinicians, when designing curriculum about PrEP.

Overall, we did not identify differences in knowledge scale scores between academic programs. This contrasts with a previous study which found that pharmacy students had greater knowledge of PrEP compared to allopathic medical students (Przybyla et al., 2021). Students in later-phases of training reported progressively higher HIV knowledge scores while only those students in the final-year of training reported higher PrEP knowledge relative to first-year students. However, we found that large proportions of late-phase and final-year students were misinformed regarding the requirement of HIV-negative status for PrEP candidacy, U = U (undetectable = untransmittable), and modern, single-tablet HIV treatment regimens. This indicates that this critical content about modern HIV prevention and treatment is likely missing from current medical and pharmacy education curricula.

We found several, interesting demographic trends regarding HIV and PrEP knowledge scales. First, gay/lesbian participants reported higher knowledge of HIV and PrEP compared to heterosexual participants. This may be explained by the historical and present disparities in HIV incidence among MSM as well as public health campaigns about HIV and PrEP specifically targeting this population (Centers for Disease Control Prevention, 2018). Gay/lesbian participants may also be more likely to have personal experience with PrEP, or with others taking PrEP.

Knowledge discrepancies regarding PrEP and HIV were also identified between participants of different races, such that White participants reported the highest knowledge, while Black participants reported the lowest knowledge of PrEP and HIV. Previous studies have also shown that Black people have less access to information about PrEP for HIV prevention (Philbin et al., 2016; Friedman et al., 2019; Ojikutu et al., 2018). Our findings here suggest that these issues of access to education are not being corrected by education, again highlighting the need for accurate and comprehensive training about HIV risk and PrEP in medical and pharmacy education. Additional work is needed to better understand reasons for these demographic differences in HIV and PrEP

knowledge. It may relate to differences in exposure to information prior to graduate training or differences in educational experiences.

#### 4.1. Implications

Our findings have multiple implications for health professions education regarding PrEP for HIV prevention. Of note, there were no identified differences in either knowledge scale between the three professional programs, suggesting that curriculum gaps are systemic and present among all disciplines. Specifically related to HIV knowledge, our findings suggest that medical and pharmacy education may require additional content about modern HIV treatment. Many participants believed HIV treatment was difficult because treatment required many pills with serious side effects. However, the vast majority of people living with HIV are on single-tablet regimens, and many single-tablet regimens are recommended as initial treatment for newly diagnosed HIV (Department of Health and Human Services, 2019). Finally, it is also apparent that medical and pharmacy education needs additional training regarding the concept of U = U (Rodger et al., 2019). The PARTNER-1 and 2 studies showed no HIV transmission between serodifferent couples when the partner living with HIV has an undetectable HIV viral load (Rodger et al., 2019). This represents a major breakthrough in HIV prevention and highlights the importance of treatment as prevention (TasP). Correcting this misinformation before practice is crucial, as patients living with an undetectable HIV viral-load may still perceive themselves as infectious to their partners (Rj et al., 2016). Based on our findings, health professions education requires additional training dedicated to modern HIV preventive strategies, including PrEP, TasP, and U = U.

The specific items we employed in our knowledge assessment, which were developed based on the essential PrEP information from the CDC guidelines, may be used to formulate curriculum innovation within medical and pharmacy education for training about HIV and PrEP. Including training about the items incorrectly answered by a large percentage of participants, such as PrEP indications, the rationale for requirement of documented and continued HIV-negative status, U = U, and disparities in HIV incidence, would ensure that medical and pharmacy education is providing quality training about PrEP for HIV prevention. Querying and updating curriculum to address these topics would also ensure that training is addressing the identified knowledge deficiencies.

There are published resources describing PrEP training interventions, including a case-based training module for clinicians about HIV risk assessment, PrEP prescription, and management for an MSM patient as well as a guide for development of interprofessional, clinician training about PrEP (Bunting et al., 2019; Perucho et al., 2020). These resources may be directly adapted to medical or pharmacy education. Previously described training for internal medicine resident physicians about PrEP may also be adapted for medical and pharmacy students (Frasca et al., 2019). Finally, there are many educational resources about PrEP and HIV risk that may be readily adapted for medical and pharmacy education, including from the Fenway Institute, the CDC, the National HIV Curriculum, and the national network of AIDS Education and Training Centers (The Fenway Institute, 2021; Centers for Disease Control Prevention, 2021; The University of Washington, 2020; Education Training Center Program National Coordinating Resource, 2021). Additionally, it will be important for educators to continue updating training about PrEP as new modalities become available, such as the anticipated approval of long-acting injectable cabotegravir as PrEP (Clement et al., 2020).

#### 5. Limitations

There are several limitations that should be acknowledged when interpreting the findings of the present study. First, although our knowledge assessment was more comprehensive than prior studies, all

of the items were phrased as true/false statements. This phrasing, which did not include an ‘unsure’ option, may have led some participants to guess an answer for some items. However, no response was required for any item in the study, and the consequence of the limitation would be that our data may actually overestimate knowledge of HIV and PrEP. A second limitation is the demographic composition of our study sample. When comparing the demographic composition of our sample to that of health professionals in training nationally, our sample is over-representative of students who identified as lesbian, gay, and bisexual (LGB), contains a higher percentage of cisgender women compared to the national gender distribution, and contains a relatively low number of participants who identified as people of color (American Association of Colleges of Osteopathic Medicine, 2020; Association of American Medical Colleges, 2019; American Association of Colleges of Pharmacy, 2019). We also likely over-represented gender-diverse students, however these data are not nationally available. However, it is important to note that the number of LGB, gender-diverse, and students of color in the health professions are low overall, and subsequently are low in our sample. This makes comparisons in knowledge between these demographic groups challenging. As such, findings should be interpreted with caution. Our sample is also over-representative of students training in the Midwestern U.S. This over-representation is due to a majority of the schools that participated in this study being located in the Midwestern U.S. For this reason, we included region as a covariate. A future study may benefit from targeted investigation of PrEP/HIV knowledge in the Southern U.S. given the region’s high HIV burden and previous work showing sub-optimal health professions education about PrEP in the Southern U.S (Bunting et al., 2020). We were unable to compare the demographics of our sample to the demographic composition of the students who did not respond as we did not have access to the demographic details of the student bodies at all participating institutions.

#### 6. Conclusion

In order to ensure that PrEP reaches all patient groups at risk for HIV, health professions education must prepare future clinicians to incorporate PrEP into their clinical practice. While much work has focused on the training needs of clinicians, the present study provides an evidence base for design of health professions education regarding PrEP for HIV prevention. We found that many medical and pharmacy students were incorrect in their knowledge of basic tenants of PrEP, including the requirement that a patient be HIV-negative to be considered a candidate. Many also were uninformed regarding modern HIV treatment regimens, and the principle of U = U. These findings suggest innovation with respect to health professions education on PrEP and HIV is critical to ending the HIV epidemic.

#### CRedit authorship contribution statement

**Samuel R. Bunting:** Writing - original draft, Funding acquisition, Visualization. **Brian A. Feinstein:** Writing - review & editing, Funding acquisition. **Aniruddha Hazra:** Writing - review & editing. **Neeral K. Sheth:** Writing - review & editing. **Sarah S. Garber:** Writing - review & editing, Supervision, Project administration, Funding acquisition.

#### Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## Appendix A. Supplementary data

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