JAC Antimicrob Resist
https://doi.org/10.1093/jacamr/dlad147

JAC-Antimicrobial Resistance

French healthcare students and antibiotics: are they ready to promote their appropriate use?

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Received 29 August 2023; accepted 7 December 2023

Objectives: French healthcare students are required to carry out primary prevention interventions as part of the Healthcare Service by Healthcare Students (HSHS). The purpose of this study was to explore students' perceptions of preparedness to address the public's concerns about antibiotic use and how their perceptions changed after implementing their intervention.

Methods: A questionnaire was sent twice during the 2020–2021 academic year to 920 multidisciplinary healthcare students (nursing, medicine, physiotherapy, pharmacy and midwifery students) enrolled in the HSHS in Franche-Comté (HSHS-FC).

Results: This study included 870/920 students (94.6%). Medical and pharmacy students were the most concerned about the issue of antimicrobial resistance. Before enrollment in the HSHS-FC, 463 of the 870 students included (53.2%) reported having sufficient knowledge about antibiotics to lead preventive interventions, reaching 87.9% (58/66) for pharmacy students. Despite this relative lack of knowledge, 77.2% of students felt confident to promote the appropriate use of antibiotics in the healthcare service context. This rate ranged from 68.0% (17/25) for midwifery students to 93.9% (62/66) for pharmacy students. Irrespective of the topic of the intervention, students significantly improved their knowledge and ability to promote antibiotic use after training in the HSHS-FC.

Conclusions: Theoretical prerequisites and a feeling of concern vary widely depending on the curriculum. The HSHS-FC promotes multidisciplinary collaboration and can contribute to improving students' knowledge. The support of an expert in antimicrobial resistance may be necessary to validate the content of the interventions proposed by the students.

Introduction

Antibiotic resistance is a worldwide concern and leads to increased morbidity and mortality.[1] It is largely related to the inappropriate use of antibiotics and a lack of awareness among the general population and healthcare professionals.[2] France is one of Europe's biggest consumers of antibiotics. In 2021 it ranked fourth in Europe, with the highest community consumption of antibiotics: 19.9 DDD per 1000 inhabitants per day (European average: 15.0 DDD per 1000 inhabitants per day).[3] Since the 2000s, France has developed several strategic plans to reduce antibiotic consumption.[4] In a literature review published in 2010 of 22 public campaigns for outpatients in high-income countries, Huttner *et al.*[5] showed that public campaigns contribute to the more careful use of antibiotics among outpatients, at least in countries where prescriptions are high. In 2015, the WHO clearly emphasized the importance of adequate and effective training of healthcare students in the proper prescribing of antibiotics and adopted a global action plan to manage antimicrobial resistance.[6]

In 2018, the Healthcare Service by Healthcare Students (HSHS) was implemented in France on various priority public health themes. The specific year of study for each curriculum covered by the HSHS is defined by national legislation. The HSHS is a national programme that enables healthcare students to lead primary prevention and health promotion interventions aimed at the general public without having to be experts in the field.[7–9] Since the creation of the HSHS in Franche-Comté (HSHS-FC) in 2018, the University of Franche-Comté has offered topics such as 'infectious diseases prevention' (IDP), including vaccination, Lyme disease and the prevention of cross-transmission, and since 2020 antibiotic resistance.

The aim of this study was to explore students' perceptions of preparedness to address general population concerns about antibiotic use and how their perceptions changed after implementation of a primary prevention and health promotion intervention, in general and by curriculum.

Materials and methods

Settings and healthcare students

This study took place in Franche-Comté (1.2 million inhabitants), a region of eastern France, from September 2020 to April 2021. Thus, 920 healthcare students were involved by the HSHS-FC. Among them, 508 (55.2%) were second-year nursing students, 229 (24.9%) were third-year medical students, 91 (9.9%) were fourth-year physiotherapy students, 67 (7.3%) were fifth-year pharmacy students and 25 (2.7%) were fourth-year midwifery students (Table 1). Students were grouped into teams, each assigned a theme and a host structure with specific target audiences (students from primary school to university, nursing home patients, health professionals or the general population). Each team consisted of four to five students, with at least two students from different curricula per team. The planning of regular education related to antibiotics in the different curricula according to the HSHS-FC year is summarized in Table 2.

The HSHS-FC is divided into four phases spread over 30 days of the academic year:

- The first, in September (4 days), consisted of theoretical training about the project approach, including public health, primary prevention and health promotion, as well as the theme of the intervention; specific e-learning to promote key messages and toolboxes were also available for each theme (oral and dental hygiene and sleep; nutrition and physical activity; prevention of addictive behaviours and infectious diseases prevention). These lessons were compulsory and complementary to the regular courses.
- During the second phase, from October to February (3 days), the students developed their health promotion intervention in three supervised group work sessions. In addition, students dedicated time (16 days) freed up in their schedules at different times of the year to allow them to work in teams on their project.
- The third phase, in March (5 days), consisted of the implementation of their interventions, which consisted of a series of events carried out in the premises of the structures.
- The fourth and final phase, in April (2 days), consisted of a debriefing and an evaluation of the intervention during a final group work session.

To carry out these interventions, healthcare students received three-pronged supervision: (i) by a multidisciplinary pair of group tutors who supported them in the project approach during the four group work sessions, (ii) by a local referent who supported the team in the implementation of the intervention in the structures, and (iii) by thematic referents who shared their expertise with the various actors involved.

Survey questionnaire to explore the perceptions of the students

This questionnaire was developed by the infectiologist and the epidemiologist in charge of the e-learning course, itself linked to the e-Bug programme. The e-Bug programme is an international partnership aiming to respond to each national action plan to contain and control antimicrobial resistance, by promoting context-specific public education on infection prevention and the response to antimicrobial resistance (https://e-bug.eu/fr-fr/home).

Questionnaires were submitted twice to each student, irrespective of the theme of their intervention, through the CleanWeb® platform (Telemedicine Technologies, Boulogne-Billancourt, France). The first (T1) could be completed from September 2020 to November 2020, and the second (T2) after completing the student health promotion interventions in April 2021. Both were completed anonymously but students had to indicate their attended course and the theme of their health promotion intervention during the HSHS-FC (i.e. antibiotic resistance, other infectious diseases prevention or other topics). Students were strongly encouraged to complete the surveys, with no incentive or penalty whether they agreed to participate or not.

The students' perceptions about their feeling of preparedness to address patients' concerns about antibiotic use were evaluated by 19 items detailed in Tables 3 and 4. These items allowed evaluation of the students' ability to promote awareness messages or their self-evaluation about their knowledge. The questionnaires were based on a four-point Likert scale ('strongly agree', 'agree', 'disagree', 'strongly disagree'). Responses were split into two levels depending on the results: 'agree' (grouping 'strongly agree' and 'agree') and 'disagree' (grouping 'disagree' and 'strongly disagree'). A global level of agreement was determined and defined as 'high' when ≥70% of the population interviewed agreed with the statement, 'medium' when 50% to 70% agreed with the statement, and 'low' when ≤50% of the population concerned agreed with the statement.

Statistical analysis

Categorical variables were described by the number and percentage of cases. Differences in qualitative parameters for independent samples were analysed using the chi-squared test. Qualitative parameters for dependent samples, such as agreement before and after the intervention, were compared using the *Z*-test. The evolution of the rate of agreement (Δ) between T1 and T2 was thus calculated. All tests were two-tailed and considered to be significant at the 5% *P* value threshold. The statistical analysis was performed using SAS software, version 9.4 (SAS Institute Inc., Cary, NC, USA).

Table 1. Distribution of students during the HSHS-FC according to their curriculum and the theme of their health promotion action

	TOTAL *n* (%)	MED *n* (%)	PHAR *n* (%)	NURS *n* (%)	PHYS *n* (%)	MIDW *n* (%)
Involved in HSHS-FC	920 (100.0)	229 (24.9)	67 (7.3)	508 (55.2)	91 (9.9)	25 (2.7)
Included in the study	870 (100.0)	217 (24.9)	66 (7.6)	474 (54.5)	88 (10.1)	25 (2.9)
Infectious disease prevention theme	96 (11.0)	36 (16.6)	16 (24.2)	28 (5.9)	13 (14.8)	3 (12.0)
Antibiotic use subtheme	22 (2.5)	9 (4.1)	4 (6.1)	4 (0.8)	3 (3.4)	2 (8.0)

HSHS-FC, Health Service by Healthcare Students in Franche-Comté; MED, medicine; MIDW, midwifery; NURS, nursing; PHAR, pharmacy; PHYS, physiotherapy.

Table 2. Planning of regular teaching related to antibiotics in the different curricula according to the HSHS-FC (France)

	MED	PHAR	NURS	PHYS	MIDW
Year of studies during HSHS-FC (total year of studies)	3 (6)	5 (6)	2 (3)	4 (5)	4 (5)
Courses prior to the HSHS-FC year	Infectious disease prevention	Bacteriology, antibiotic resistance, antibiotics, infectious disease prevention	Bacteriology, infectious disease prevention	None	Infectious disease specifically associated with pregnancy
Courses during the HSHS-FC year	Bacteriology, antibiotic resistance	None	Antibiotics, antibiotic resistance	Infectious diseases specifically associated with cutaneous, pulmonary and osteoarticular contexts	None
Courses after the HSHS-FC year	Infectious disease diagnosis, antibiotics	None	None	None	None

HSHS-FC, Health Service by Healthcare Students in Franche-Comté; MED, medicine; MIDW, midwifery; NURS, nursing; PHAR, pharmacy; PHYS, physiotherapy.

Results

Participation

During the study period, 870 of the 920 students (94.6%) completed both the T1 and T2 questionnaires and were included. The distribution of students according to their curriculum and the theme of their health promotion action is detailed in the Table 1.

Students' perceptions according to the curricula

Before the HSHS-FC, among the 870 students, 670 (77.0%) felt concerned about antimicrobial resistance, with a statistically significant difference between curricula ($P<10^{-4}$) (Table 3). Medical and pharmacy students were the most concerned, regardless of the period of study (from 86.6% to 91.2% for medical students, and from 92.4% to 98.5% for pharmacy students). Conversely, physiotherapists were the least concerned (from 59.1% to 63.6%). Overall, students appeared to feel more involved after the programme (from 77.0% to 78.4%), but this trend was not significant (Table 3).

Before the HSHS-FC, 463 of the 870 students (53.2%) reported having sufficient knowledge about antibiotics to carry out preventive interventions, but there was significant variability depending on the curriculum before and after the intervention ($P<10^{-4}$) (Table 3).

Despite this relative lack of knowledge at T1, 672 of the 870 students (77.2%) felt confident about promoting antibiotic use in the HSHS-FC setting, ranging from 68.0% for midwifery students to 93.9% for pharmacy students (Table 3).

The self-assessment of nursing and medical students significantly improved for 14 and 11 of the 19 criteria, respectively. The biggest changes were observed among medical students. Their global level of agreement changed from low to high for knowledge of an association between antibiotic resistance and antibiotic prescriptions in veterinary medicine (from 46.5% to 90.2%, $P<10^{-4}$), and with the environment (from 48.4% to 86.6%, $P<10^{-4}$) (Table 3).

Students' perceptions according to the theme of the health promotion intervention

At baseline (T1), students' sense of concern about antibiotic resistance, such as their ability to promote antibiotic stewardship or to provide education to patients, did not differ according to

the theme of the health promotion intervention (Table 4). However, after the activity (T2), there were significant differences depending on the theme. Indeed, students working on a health promotion intervention on the prevention of infectious diseases were more inclined to promote antibiotic stewardship (82.3% versus 78.8%, $P=0.04$). After the intervention, 84 of the 96 students (87.5%) in the IDP groups knew that antibiotics are not necessary for viral infections versus 77.7% in the other groups ($P=4x10^{-3}$) (Table 4).

Regardless of the health promotion intervention topic, students reported improved knowledge after the HSHS-FC intervention. Indeed, agreement increased from 54.2% to 72.9% ($P=2x10^{-3}$) and from 53.1% to 68.0% ($P<10^{-4}$) for the 'Infectious Disease Prevention' and 'Other' groups, respectively (Table 4).

Discussion

The HSHS programme aims to raise public awareness of healthcare issues, such as the proper use of antibiotics and antibiotic resistance, through healthcare students. Because healthcare students must lead interventions for the general population without having completed their curricula, we decided to evaluate their perception of preparedness through the HSHS-FC.

To our knowledge, this study is the first to evaluate the impact of a multidisciplinary health promotion programme on healthcare students' perception of antibiotic resistance. Fifty-three percent of healthcare students reported having sufficient knowledge at the beginning of the HSHS-FC. Paradoxically, at the same time, 77% of healthcare students declared themselves ready to promote the use of antibiotics. Although our study showed a global improvement (from 53.2% to 68.5%, $P<10^{-4}$) in the students' knowledge after the HSHS-FC, especially for nursing and medical students (from 54.6% to 71.7%, $P<10^{-4}$; and from 45.2% to 69.6%, $P<10^{-4}$, respectively), the level of knowledge remained low after the programme. For example, only 50% of the pharmacy students knew that the duration of prescription can reduce the selection of MDR bacteria. Among nursing students, almost 53% agreed that there is a risk of cross-transmission of MDR bacteria. Lack of knowledge was also found among midwives, where only almost one in eight knew that antibiotics were not necessary for viral infections. Overall students' level of concern by the subject of antimicrobial resistance did not significantly change (from 77% to 78%) after the HSHS-FC. Concern about antibiotic resistance also differed by curriculum. In fact, medical and pharmacy students were the most concerned, whereas non-medical prescribers (nurses or physiotherapists) were the least concerned.

Comparisons between different categories of healthcare students on their knowledge of antibiotic resistance and proper antibiotic use have been little studied in the literature. In addition, the results of the few studies available may be difficult to compare because of differences in training programmes between and even within countries in Europe.[10] In Croatia, a survey on attitudes and knowledge regarding antibiotic use and resistance was conducted among final-year medical and pharmacy school students.[11] No differences were found for the average knowledge scores of the students concerning antimicrobial resistance. However, some differences were reported on the students' attitudes. Rusic *et al.*[11] suggested that the attitudes of students

Table 3. Rate of agreement relative to the students' ability to promote awareness messages relative to antibiotic resistance at the beginning of the HSHS-FC and its evolution (Δ) according to their curriculum

	MED			PHAR			NURS			PHYS			MIDW				
	$n=217$			$n=66$			$n=474$			$n=88$			$n=25$				
Item	T1	Δ[a]	P^b	T1	Δ[a]	P^b	T1	Δ[a]	P^b	T1	Δ[a]	P^b	T1	Δ[a]	P^b	P^c_{T1}	P^d_{T2}
I feel concerned by the subject of antibiotic resistance	86.6	+4.6	*NS*	98.5	−6.1	*0.0455*	72.2	+1.6	*NS*	63.6	−4.5	*NS*	76.0	+4.5	*NS*	$<10^{-4}$	$<10^{-4}$
I have sufficient knowledge to lead preventive actions	**45.2**	+24.4	$<10^{-4}$	87.9	+4.5	*NS*	54.6	+17.1	$<10^{-4}$	**43.2**	**−6.8**	*NS*	**40.0**	**+8.0**	*NS*	$<10^{-4}$	$<10^{-4}$
I feel able to promote antibiotic stewardship	74.7	+6.4	*NS*	92.4	+3.1	*NS*	74.1	+6.5	$4x10^{-3}$	68.2	−10.2	*NS*	68.0	+0.0	*NS*	$2x10^{-3}$	$<10^{-4}$
I feel able to help patients to think critically about antibiotic prescriptions	82.5	+4.6	*NS*	90.9	+1.5	*NS*	74.1	+11.6	$<10^{-4}$	75.0	−1.1	*NS*	80.0	−4.0	*NS*	$9x10^{-3}$	10^{-3}
I feel able to help patients to think critically about not prescribing antibiotics	82.0	+6.9	*0.03*	90.9	+7.6	*NS*	67.1	+14.1	$<10^{-4}$	79.6	−2.3	*NS*	76.0	−4.0	*NS*	$<10^{-4}$	$<10^{-4}$
I feel able to explain what an antibiotic is to patients	85.3	+10.6	$2x10^{-4}$	100.0	−1.5	*NS*	95.6	+2.3	*0.04*	80.7	+6.8	*NS*	84.0	+0.0	*NS*	$<10^{-4}$	$<10^{-4}$
I feel able to explain to patients why antibiotics are unnecessary against viruses	85.3	+11.5	$<10^{-4}$	100.0	−1.5	*NS*	77.9	+8.8	$<10^{-4}$	87.5	−4.5	*NS*	92.0	−4.0	*NS*	$<10^{-4}$	$<10^{-4}$

I feel able to explain the individual risks associated with antibiotic therapy	71.9	+16.1	$<10^{-4}$	93.9	+1.6	NS	75.7	+14.0	$<10^{-4}$	59.1	+10.2	NS	68.0	+4.0	NS	$<10^{-4}$	$<10^{-4}$
I feel able to explain the collective risks associated with antibiotic therapy	64.5	+24.4	$<10^{-4}$	89.4	+4.5	NS	61.8	+15.2	$<10^{-4}$	61.4	−2.3	NS	64.0	−12.0	NS	$6x10^{-4}$	$<10^{-4}$
I feel able to explain the risk of antibiotic overprescription	81.6	+8.7	$4x10^{-3}$	97.0	+1.5	NS	82.5	+8.9	$<10^{-4}$	76.1	+3.5	NS	84.0	−4.0	NS	0.02	$5x10^{-4}$
I feel able to promote antibiotic use in the HSHS-FC context	72.4	+5.9	NS	93.9	−1.5	NS	78.9	+5.1	0.02	70.5	−10.3	NS	68.0	−16.0	NS	$4x10^{-4}$	$<10^{-4}$
Antibiotics are unnecessary in case of viral infection	91.2	+2.8	NS	95.5	−4.5	NS	61.2	+7.1	$3x10^{-3}$	87.5	−2.3	NS	**0.0**	**+12.0**	NS	$<10^{-4}$	$<10^{-4}$
Antibiotics have different selection pressures	88.9	−3.2	NS	86.4	−7.6	NS	65.0	−4.0	NS	86.4	−1.2	NS	**8.0**	**+12.0**	NS	$<10^{-4}$	$<10^{-4}$
Multidrug-resistant bacteria selection can be reduced by the duration of prescription	55.8	+14.3	$3x10^{-4}$	**50.0**	**−3.0**	NS	58.4	+10.8	$<10^{-4}$	69.3	−5.7	NS	56.0	−4.0	NS	NS	0.003
Antibiotic resistance is due to antibiotic prescriptions in human medicine	88.0	+10.2	$<10^{-4}$	87.9	+7.6	NS	64.8	+8.8	$5x10^{-4}$	76.1	+12.5	0.02	88.0	+0.0	NS	$<10^{-4}$	$<10^{-4}$
Antibiotic resistance is due to antibiotic prescriptions in veterinary medicine	**46.5**	+43.7	$<10^{-4}$	77.3	+3.0	NS	**36.7**	**+8.7**	$2x10^{-3}$	**33.0**	**+9.0**	NS	**28.0**	**+8.0**	NS	$<10^{-4}$	$<10^{-4}$
Antibiotic resistance implies the environment	**48.4**	+38.2	$<10^{-4}$	**47.0**	+9.1	NS	**46.8**	+6.2	0.03	51.1	+13.6	NS	56.0	+8.0	NS	NS	$<10^{-4}$
Antibiotic resistance is associated with cross transmission	65.9	+17.1	$<10^{-4}$	62.1	+3.1	NS	**50.0**	+2.5	NS	62.5	+6.8	NS	**24.0**	+44.0	$9x10^{-4}$	$<10^{-4}$	$<10^{-4}$
New antibiotics will not be available soon	50.7	+7.8	NS	66.7	−1.6	NS	**46.2**	**−5.3**	NS	**38.6**	**+9.1**	NS	**48.0**	**+0.0**	NS	$9x10^{-3}$	$<10^{-4}$

Level of agreement: light roman typography: high (70% or more of students agree with the statement); italic typography: medium (50% to 70% of students agree with the statement); bold roman typography: low (50% or less of students agree with the statement). HSHS-FC, Health Service by Health Students in Franche-Comté; MED, medicine; NS, non-significant; NURS, nursing; PHAR, pharmacy; PHYS, physiotherapy; T1, at the beginning of the HSHS-FC.

[a] Δ denotes evolution of the rate of agreement between September 2021 and April 2022.

[b] P denotes comparison between the beginning and the end of the HSHS-FC.

[c] P_{T1} is the comparison between curricula at the beginning of the HSHS-FC.

[d] P_{T2} is the comparison between curricula at the end of the HSHS-FC.

Table 4. Rate of agreement relative to the students' ability to promote awareness messages relative to antibiotic resistance at the beginning (T1) of the HSHS-FC and its evolution (Δ) according to the theme of the action

				Infectious disease prevention theme							
	TOTAL			YES			NO[a]				
	N = 870			*n* = 96			*n* = 774				
Item	T1	Δ[b]	*P*	T1	Δ[b]	*P*	T1	Δ[b]	*P*	P_{T1}[c]	P_{T2}[d]
I feel concerned by the subject of antibiotic resistance	77.0	+1.4	*NS*	77.1	+3.1	*NS*	77.0	+1.2	*NS*	*NS*	*NS*
I have sufficient knowledge to drive preventive actions	*53.2*	*+15.3*	*<10⁻⁴*	*54.2*	+18.7	*2x10⁻³*	*53.1*	*+14.9*	*<10⁻⁴*	*NS*	*NS*
I feel able to promote antibiotic stewardship	74.8	+4.4	*0.009*	79.2	+3.1	*NS*	74.3	+4.5	*0.01*	*NS*	*0.04*
I feel able to help patients to think critically about antibiotic prescription	77.7	+7.4	*<10⁻⁴*	79.2	+2.1	*NS*	77.5	+8.0	*<10⁻⁴*	*NS*	*NS*
I feel able to help patients to think critically about antibiotic consumption	74.1	+9.7	*<10⁻⁴*	81.3	+1.0	*NS*	73.3	+10.7	*<10⁻⁴*	*NS*	*NS*
I feel able to explain what an antibiotic is to patients	91.5	+4.5	*<10⁻⁴*	91.7	+2.1	*NS*	91.5	+4.8	*<10⁻⁴*	*NS*	*5.10⁻³*
I feel able to explain to patients why antibiotics are unnecessary against viruses	82.8	+7.0	*<10⁻⁴*	83.3	+9.4	*0.01*	82.7	+6.7	*<10⁻⁴*	*NS*	*NS*
I feel able to explain the individual risks associated with antibiotic therapy	74.3	+12.8	*<10⁻⁴*	71.9	+8.3	*NS*	74.6	+13.4	*<10⁻⁴*	*NS*	*NS*
I feel able to explain the collective risks associated with antibiotic therapy	*64.6*	+14.1	*<10⁻⁴*	*63.5*	+16.7	*2x10⁻³*	*64.7*	+13.9	*<10⁻⁴*	*NS*	*NS*
I feel able to explain the risk of antibiotic overprescription to patients	82.8	+7.3	*<10⁻⁴*	77.1	+12.5	*7x10⁻³*	83.5	+6.7	*<10⁻⁴*	*NS*	*NS*
I feel able to promote antibiotic use in the health service context	77.2	+2.7	*NS*	79.2	+1.0	*NS*	77.0	+2.8	*NS*	*NS*	*NS*
Antibiotics are unnecessary in case of viral infections	75.1	+3.7	*0.02*	83.3	+4.2	*NS*	74.0	+3.7	*0.03*	*0.0462*	*4.10⁻³*
Antibiotics have different selection pressures	75.5	−4.0	*0.02*	86.5	−9.4	*0.04*	74.2	−3.4	*NS*	*7.10⁻³*	*NS*
Multidrug-resistant bacteria selection can be reduced by the duration of prescription	*58.2*	*+8.5*	*<10⁻⁴*	*58.3*	*+1.0*	*NS*	*58.1*	*+9.7*	*<10⁻⁴*	*NS*	*NS*
Antibiotic resistance is due to antibiotic prescriptions in human medicine	74.1	+9.2	*<10⁻⁴*	*68.8*	+21.9	*2.10⁻⁴*	74.8	+7.6	*<10⁻⁴*	*NS*	*<10⁻⁴*
Antibiotic resistance is due to antibiotic prescriptions in veterinary medicine	**41.6**	*+17.0*	*<10⁻⁴*	**38.5**	*+31.3*	*<10⁻⁴*	**42.0**	*+15.2*	*<10⁻⁴*	*NS*	*10⁻³*
Antibiotic resistance implies the environment	**47.9**	*+15.2*	*<10⁻⁴*	**43.8**	*+25.0*	*<10⁻⁴*	**48.5**	*+13.9*	*<10⁻⁴*	*NS*	*4.10⁻³*
Antibiotic resistance is associated with cross-transmission	*55.4*	*+7.8*	*<10⁻⁴*	*58.3*	+13.6	*0.02*	*55.0*	*+7.1*	*10⁻³*	*NS*	*NS*
New antibiotics will not be available soon	**48.2**	**−0.2**	*NS*	**49.4**	*+5.7*	*NS*	**47.4**	**−3.7**	*NS*	*NS*	*NS*

Level of agreement: light roman typography: high (70% or more of students agree with the statement); italic typography: medium (50% to 70% of students agree with the statement); bold roman typography: low (50% or less of students agree with the statement). HSHS-FC, Health Service by Health Students in Franche-Comté; NS, non-significant; T1, denotes the beginning of the HSHS-FC.

[a]Other themes: oral and dental hygiene, sleep, nutrition and physical activity, prevention of addictive behaviours.

[b]Δ denotes evolution of the rate of agreement between September 2021 and April 2022.

[c]P_{T1}: is the comparison between the themes of actions at the beginning and end of the HSHS-FC.

[d]P_{T2} is the comparison between the themes of health promotion actions at the end of the HSHS-FC.

are partly formed before college education or that they are not solely influenced by their medical education. In our study, we were unable to distinguish between the contribution of regular course-related knowledge and that of the HSHS-FC. Indeed, the improvement in students' knowledge of antibiotics was observed in the groups working on the other topics as well. This may be due to the low proportion of students (22/870) who worked specifically on the topic of 'antimicrobial resistance', which did not allow comparisons for this group. However, the choice of the topics was left to the host structures and reflects a lack of interest in this topic on the part of the structures, particularly schools. However, a recruitment bias cannot be excluded due to the heterogeneity of the distribution of the curricula within the groups. Nevertheless, the assignment of topics to the students was random. Furthermore, pharmacy students may be a strong indicator because they were in their fifth year of study and had completed the entire infectious disease programme and did not receive any other instruction on antibiotic resistance other than that of the HSHS-FC during the fifth year. However, their high level of agreement from the beginning of the HSHS-FC did not allow a significant change to appreciate the specific impact of the HSHS-FC on students' knowledge.

The lack of knowledge concerning antimicrobial resistance, observed in our study, has also been noted in other studies. Indeed, medical students declared they did not feel capable of prescribing appropriate antibiotics and that they lacked knowledge about antimicrobial resistance.[12,13] Because the knowledge and skills of the students examined were self-reported, we can assume that their evaluation may have been overestimated.[14,15] Further studies are needed to assess students' level of knowledge and skills according to a reference framework to be defined for each curriculum. In addition, to better understand students' perception of antibiotic resistance, qualitative studies should be conducted. We did not specifically explore the satisfaction of the public or the structure where the primary prevention interventions took place. However, the local referents were satisfied and are continuing the collaboration.

More efforts are needed to evaluate public health strategies and their meaningful and effective communication with the public, professionals and patients. Misconceptions about the use of antibiotics are similar in different countries, regardless of the socioeconomic level. Public education is necessary to combat antibiotic resistance.[16,17] Healthcare students should contribute to the dissemination of information and education of the population.[18] Although the objectives of the HSHS are to introduce future professionals to health promotion and primary prevention, they are not to make them experts in the field. The low level of knowledge perceived by the students suggests that they should systematically have their projects validated by a specialist before presenting them to the public. Moreover, this result may reflect the need to develop courses on antibiotic resistance for healthcare students in two perspectives: first, the One-Health approach, with the relationship between animals, the environment and humans on the risk of the selection and spread of resistant bacteria, and second, the risk of returning to the pre-antibiotic era and the need to prevent the emergence and spread of resistance, which implies better use of antibiotics when necessary and the promotion of infection control prevention measures.

The promotion of the prevention and control of antibiotic resistance involves a multidisciplinary approach that includes physicians, biologists, pharmacists, nurses and hygienists. This justified the addition of the topic of antibiotic resistance to the HSHS-FC.

Conclusion

The HSHS-FC promotes multidisciplinary collaboration, which is particularly important in the context of antimicrobial resistance. This study showed that it can contribute to improving students' knowledge, but the theoretical prerequisites are very heterogeneous depending on the curriculum. The support of an expert in antimicrobial resistance may be necessary to validate the content of the interventions proposed by the students.

Funding

This study was carried out as part of our routine work.

Transparency declarations

All authors declare that they have no competing interests.

Author contributions

K.B. and C.S. created the questionnaire and wrote the article. V.N. analysed the data. All authors reviewed the article. All the collaborators were implied in the HSHS-FC study group.

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