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Knowledge of antibiotics and antibiotic resistance, antibiotic use and eHealth literacy among nursing students in Thailand: a cross-sectional study

Soontaree Jianvitayakij ,[1] Atsadaporn Niyomyart ,[1] Chuenjit Junsawang ,[2] Wunwisa Bualoy ,[1] Nipaporn Butsing ,[1] Supreeda Monkong ,[1] Joachim G Voss[3]

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[1]Division of Adult and Gerontological Nursing, Ramathibodi School of Nursing, Faculty of Medicine Ramathibodi Hospital, Mahidol University, Bangkok, Thailand
[2]Division of Fundamental Nursing, Ramathibodi School of Nursing, Faculty of Medicine Ramathibodi Hospital, Mahidol University, Bangkok, Thailand
[3]Omaha Division, University of Nebraska Medical Center College of Nursing, Omaha, Nebraska, USA

Correspondence to
Dr Atsadaporn Niyomyart; atsadaporn.niy@mahidol.edu

ABSTRACT

Objectives Antibiotic resistance poses a major global public health threat. However, research on this issue is limited, especially among nursing students. This study aims to examine knowledge of antibiotics and antibiotic resistance, antibiotic use, and eHealth literacy in Thailand.

Design A cross-sectional study was conducted using an online self-administered questionnaire. The WHO Antibiotic Resistance: Multi-Country Public Awareness Survey and the eHealth Literacy Scale were used. Descriptive and multiple regression analyses were performed.

Setting Thailand's North, South, Central and Northeast between January and February 2024.

Participants A total of 1180 nursing students aged 18 or older, from first to fourth year and fluent in Thai, were invited to participate.

Results The participants were mostly female (89.8%), with an average age of 20.64±1.81 years. Over half of the respondents (67.7%) have used antibiotics, mistakenly believing that antibiotics could treat colds and influenza (70.3%), malaria (66.8%), measles (63.6%) and sore throats (60.9%). About 71.5% recognised the impact of antibiotic resistance on themselves and their families, but 93.1% incorrectly believed antibiotic resistance means the body resists antibiotics. Participants scored 35.92±4.21 out of 40 on eHealth literacy. In a multiple regression analysis, three factors predict knowledge of antibiotic resistance: knowledge of antibiotics (B=0.199, p<0.001, 95% CI 0.165 to 0.234), eHealth literacy (B=0.078, p<0.001, 95% CI 0.056 to 0.100) and academic year (B=0.271, p<0.001, 95% CI 0.184 to 0.358), with knowledge of antibiotics being the most impact (β=0.318). These three variables explained 23.7% of the variance in antibiotic resistance knowledge scores.

Conclusions Despite high eHealth literacy, nursing students hold misconceptions about antibiotic treatable conditions and insufficient knowledge of antibiotic resistance. This highlights the need to integrate antibiotic contents into nursing curricular and enhance eHealth literacy for better access and navigate health information.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The study included 1180 participants from four regions with a validated instrument.
⇒ A limitation is that online surveys may exclude respondents without internet access.
⇒ The cross-sectional design limits the ability to establish a causal relationship between the variables.

INTRODUCTION

Antibiotics are medicines to prevent and treat bacterial infections.[1] Despite their benefits, antibiotics are misused and overused, resulting in antibiotic resistance.[2] Antibiotic resistance refers to the ability of bacteria to grow or survive when exposed to antibiotics that typically inhibit or eliminate them, ultimately making the antibiotics ineffective.[3] Approximately, 1.27 million deaths were attributed to antibiotic infections in 2019.[4] Global estimates project that antibiotic resistance will result in $1 trillion in additional healthcare costs and cause up to 50 million deaths annually by 2050 if this trend continues unchecked.[5] For comparison, that is more than the 17.9 million per year who currently die of cardiovascular diseases, 9.3 million who die of cancers, 4.1 million of chronic respiratory diseases and 2.0 million of diabetes including kidney disease caused by diabetes, combined.[6]

In Thailand, around 88 000 infections are related to antibiotic resistance, resulting in 38 000 deaths annually, with direct costs ranging from $70 million to $170 million and indirect costs of $1.1 billion.[7] To address this issue, the Thai government has endorsed its first National Strategic Plan from 2017 to 2021, aiming to raise public awareness and combat antibiotic resistance.[8] The Thai Working Group on Health Policy and Systems Research on Antimicrobial Resistance reported reductions of 7.5%, 5.5% and 15.2% in human antibiotic consumption between

2018 and 2020 compared with a target of a 20% cumulative reduction in antibiotic consumption by 2021.[9] As far as antibiotic knowledge, the results from the working group showed only marginal improvement, with increases of 0.6% from 2017 to 2019 and 0.7% from 2019 to 2020 compared with the goal of a 20% improvement.[9] Recent studies showed that about 30% of Thai adults misuse antibiotics, and over 40% mistakenly believe that antibiotics can treat colds and influenza, sore throat, diarrhoea and fever.[10–13] Accordingly, Thai laws and regulations allow antibiotics to be prescribed not only by physicians but also by pharmacists and other healthcare practitioners, making accessibility without a prescription through various channels, including over-the-counter purchases. Therefore, addressing antibiotic misuse becomes a challenge under these legal provisions.

Along with the factors mentioned above, antibiotic misuse and overuse are linked to inadequate knowledge and awareness among community members and healthcare providers regarding their proper usage.[13 14] Inadequate knowledge about antibiotics and antibiotic resistance causes individuals to wrongly believe that antibiotics can treat viral infections and speed up the recovery from common colds.[15 16] Conversely, healthcare providers may prescribe antibiotics improperly due to factors such as their clinical experience, uncertainty in diagnosis, patient demands and fears of unfavourable outcomes.[17–20] In nursing, nurses play a significant role in administering, monitoring and managing antibiotics with other disciplinary teams, as well as educating patients about their usage. In some countries, their roles have expanded to include antibiotic prescription following advanced clinical education.[21 22] Given their potential to mitigate antibiotic resistance, it is therefore crucial to offer a proper education on antibiotics. The proper education should also be extended to nursing students to ensure clinical competence, enhance patient safety and support public health initiatives since they will soon become frontline healthcare providers. By receiving adequate education, nursing students can prevent misuse and reduce the spread of antibiotic resistance effectively.

Today, the internet has emerged as a prevalent and accessible platform for health-related information, providing extensive eHealth resources.[23] Given that many nursing students access health-related information via the internet,[24–26] thus, the ability to find and use accurate information from electronic resources is crucial. eHealth literacy refers to the ability to seek out, find, evaluate and appraise, integrate, and apply electronic health information.[27 28] Having these skills can help individuals accurately understand and apply the right information, thus guiding health-related decisions.[27 28] However, no prior studies have explored the relationship between eHealth literacy and antibiotic usage, as well as the knowledge of antibiotics and antibiotic resistance. Thus, this study aims to examine the knowledge about antibiotics and antibiotic resistance, antibiotic use and eHealth literacy among nursing students in Thailand.

METHODS

Study design and participants

A cross-sectional study was conducted among undergraduate nursing students from the North, South, Central and Northeast regions of Thailand between January and February 2024 using an online self-administered questionnaire. The convenient sampling method was used to recruit subjects via social platforms such as Facebook. The principal investigator (PI) and co-author in Thailand shared a flyer on Facebook to invite potential participants. Friends and colleagues on Facebook were encouraged to share a flyer on other platforms (ie, Twitter, Instagram and LINE) to promote the study project. The flyer was reposted every 2weeks to recruit participants. Google Forms, a web-based survey platform, was used to collect survey data. The participants were not compensated for their time in this study. They were assured that this was an independent research project, not a curricular evaluation from their nursing school. This study followed the STROBE checklist.[29]

The survey opened on 9 January 2024 and closed on 29 February 2024 after receiving sufficient number of responses. Interested participants could click or scan a QR code on a flyer to view the information sheet, which included a summary of the research project, its objectives, estimated survey completion time and contact information for the PI and team in Thailand and outlined the voluntary and anonymous nature of the study. Initially, 1650 individuals clicked or scanned the QR code; of these, 470 chose not to participate, while 1180 consented to the study. The inclusion criteria were: (1) being an undergraduate nursing student; (2) 18 years of age; (3) being enrolled from year one to year four; (4) the institution located in the four regions, that is, North, South, Central and Northeast; (5) being able to read, speak and understand Thai; and (6) agreeing to participate. An exclusion criterion was being a foreign student. The study protocol was approved by the Ethics Committee at the Ramathibodi Hospital, Mahidol University, Thailand, under decision number COA. No. MURA2023/804.

Regarding the sample size, at the time we conducted this project, there were no studies on knowledge of antibiotic among nursing students in Thailand. Therefore, we calculated the sample size using guidelines for prevalence studies.[30 31] In the Spain study, 91.3% of nursing students agreed that inappropriate antibiotic use leads to antibiotic resistance.[31] However, a precision of 5% (d=0.05) is considered crude if the prevalence is very low (<10%) or very high (>90%). Using the 91% prevalence, we calculated a sample size of 155. We set the expected prevalence among Thai nursing students at 20% (corresponding to a prevalence of 80%) to increase the sample size to 245 for this study. To account for possible missing data, we aimed for a total sample size of 295. Ultimately, by recruiting participants from four regions of Thailand, we achieved a total sample size of 1180, which was adequate for our data analysis.

$$n = \frac{Z^2 P(1-P)}{d^2}$$

n=sample size
Z=Z statistic for a level of confidence
P=expected prevalence or proportion (if 20%, P=0.2)
d=precision (in a proportion of one; if 5%, d=0.05)

Data collection

The study protocol was approved by the Ethics Committee at the Ramathibodi Hospital, Mahidol University, rather than a nursing institution, since we aimed to recruit nursing students nationwide. After approval, data collection was conducted using Google Forms for the questionnaire. To access the online survey, potential participants were asked to provide their consent after reading the information sheet. Those who agreed were directed to complete the survey on Google Forms, while individuals who chose not to consent were automatically redirected and unable to access the survey. The returned questionnaires were treated anonymously. Only the PI could access the participant records. All data were securely kept on a designed data storage device.

Study tools

The questionnaire consisted of three sections as follows: (1) sociodemographic characteristics, (2) Antibiotic Resistance: Multi-Country Public Awareness Survey—the use of antibiotics, antibiotic knowledge and antibiotic resistance knowledge—where these questions examined knowledge based on a 3-point scale (yes, no, uncertain); and (3) the eHealth literacy that was based on a 5-point Likert scale (strongly disagree, disagree, undecided, agree or strongly agree) to evaluate individuals' perceived skills to access health information from electronic sources and apply that knowledge to make decisions on health problems.

The Antibiotic Resistance Survey was originally developed by the WHO in English. The forward-backward translation was performed in 2022; face and content validity were assessed by a panel of four experienced nurses who were knowledgeable about antibiotics.[12] On receiving authorisation from the WHO to use the scale, an infection control nurse, a member of the nursing faculty and a pharmacist knowledgeable about antibiotics later performed the content validity index (CVI). There was a 1.00 CVI for antibiotic use, a 0.83 for antibiotic knowledge and a 0.92 for antibiotic resistance knowledge. To examine knowledge of antibiotics, participants responded to 15 items with options 'true', 'false' and 'I do not know', evaluating their understanding of conditions requiring antibiotic treatment. Correct answers were summed to create a score out of 15, with higher scores indicating higher knowledge about antibiotics. About antibiotic resistance knowledge, participants answered eight questions, indicating whether each statement was correct, incorrect or if they did not know. The total number of correct responses was used to calculate an antibiotic resistance knowledge score, with higher scores indicating greater knowledge about antibiotic resistance.

The eHealth literacy scale (eHEALS) measures e-health literacy. The eHEALS was developed by Norman and Skinner in 2006 to assess people's perceived skills to use information technology and apply it to address a health problem.[28] The eHEALS consists of 8 items with a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree) with total scores ranging from 8 to 40 points. Higher scores indicate higher eHealth literacy.[28] For this study, we used the Thai version of the survey with permission from the Department of Health, Ministry of Public Health. A panel of experts who assessed the CVI for the Antibiotic Resistance Survey also examined the CVI for eHealth, which yielded a score of 1.00.

A pilot study was conducted among 100 nursing students who had graduated within the last 1 to 6 months to evaluate the reliability of the instruments. Most participants found the questions in the questionnaire to be clear, concise, easy to understand and appropriate for use. Based on their feedback, no additional adjustments were needed, so we proceeded without a pretest. Data from these students were not included in the final analysis. The internal consistency and reliability of the survey question were verified using Cronbach's alpha, with a value of 0.88 for antibiotic knowledge, 0.79 for antibiotic resistance knowledge and 0.94 for eHealth literacy.

Statistical analysis

Data from the Google Forms were transferred to Microsoft Excel. Responses to questions about antibiotics and antibiotic resistance knowledge were coded as either correct or incorrect. A score of '1' was given for each correct answer, while incorrect and uncertain responses received a score of '0'. All responses were coded, and any missing data were checked and saved in a comma-separated value file, which was later imported into SPSS, where mean imputation was applied to preserve the sample size for further analysis.

A statistical analysis was performed using IBM SPSS Statistics for Windows V.29.0 (IBM Corp, Armonk, NY). Data on sociodemographic, the use of antibiotics, knowledge of antibiotics and antibiotic resistance and eHealth literacy were put through a descriptive analysis. The median score based on responses was used as the cut-off to dichotomise the continuous variable (knowledge of antibiotics, knowledge of antibiotic resistance, eHealth literacy) for use as the dependent variable in the χ^2 test, which was later used to compare categorical variables between groups.[32–34]

Regarding the cut-off score, it was set at 75% (exceeding the 75th percentile or third quartile). Individuals who score above this threshold are considered to have higher knowledge scores, whereas those scoring below it are categorised as having lower knowledge scores.

Multiple linear regression was used to determine sociodemographic predictors of antibiotic resistance knowledge. Assumptions were validated. Linearity, independence, homoscedasticity and normality of residuals were confirmed. Collinearity was assessed through

variance inflation factors (VIF), ensuring VIF scores were below 10. A p value of <0.05 was considered statistically significant.

Patient and public involvement

Patients or the public were not involved in the design, conduct, reporting or dissemination plans of our research.

RESULTS

Sociodemographic characteristics

The characteristics of study participants are presented in table 1. The average age of nursing students was 20.64 years (SD=1.81). Among these, 50.4% were aged 20 or younger, while 49.6% were older than 20. Almost all were never married (99.3%; n=1172) and predominantly female (89.8%; n=1059). The majority of participants (97.6%; n=1152) were unemployed at the time of answering the survey. Around three-quarters were 76.2% (n=899) living in student accommodations.

Table 1 Sociodemographic characteristics of nursing students (n=1180)

Variable	Participants n (%) or mean±SD
Age (in years)	20.64±1.81
Age class	
≤20 years	595 (50.4)
>20 years	585 (49.6)
Gender	
Female	1059 (89.8)
Male	96 (8.1)
Transgender/not identify	25 (2.1)
Marital status	
Never married	1172 (99.3)
Married with child	4 (0.3)
Married and without a child	2 (0.2)
Divorced or separated	2 (0.2)
Year of studying	
First year	304 (25.8)
Second year	302 (25.6)
Third year	265 (22.4)
Fourth year	309 (26.2)
Employment status	
Non-employed	1152 (97.6)
Employed	28 (2.4)
Income salary*	
Very adequate	31 (2.6)
Adequate	728 (61.7)
Barely adequate	307 (26.0)
Not adequate	35 (3.0)
Very inadequate	0 (0)
Living accommodation	
Flat public/rental condominium	43 (3.6)
Flat/condominium owner	9 (0.8)
Single-family home/townhouse/shop house	147 (12.5)
Single room	63 (5.3)
Staff/student quarters	899 (76.2)
Others	19 (1.6)

*n=1101.

Antibiotic knowledge

Most participants (90.8%; n=1071) correctly answered that they should stop taking antibiotics once they took them all as prescribed. About 86.4% (n=1020) of participants responded correctly that antibiotics given to a friend or family member should not be used for themselves even though they had the same illness. In addition, 69.7% (n=822) of participants knew they should refrain from purchasing or requesting the same antibiotics even if they have the same symptoms (see figure 1).

Among the disease conditions, only skin/wound infections, gonorrhoea and bladder/urinary tract infections are treatable with antibiotics. A majority of respondents correctly identified bladder/urinary tract infections, skin/wound infections and gonorrhoea as being treatable with antibiotics (88.9%, n=1049; 89.1%, n=1051; and 74.2%, n=876, respectively). Over half of the participants correctly recognised that fever could not be treated with antibiotics (55.4%; n=654), whereas less than half correctly identified that malaria could not be treated (33.4%; n=394). On the contrary, only 29.7% (n=350) of participants correctly identified cold and influenza as untreatable with antibiotics. Also, more than half of participants mistakenly believed that HIV/AIDS, diarrhoea, sore throat and measles were treatable with antibiotics (52.8%, n=623; 55.4%, n=654; 60.9%, n=719; and 63.8%, n=753, respectively) (see figure 2).

The mean score for knowledge of antibiotics was 7.04±2.60 (min=0, max=12), with a median of 8.0 and an IQR of 4.0. The knowledge of antibiotics was normally distributed.

Antibiotic resistance knowledge

Generally, most respondents were familiar with antibiotic resistance (90.3%, n=1065), antibiotic-resistance bacteria (76.7%, n=905), superbugs (75.3%, n=889) and antimicrobial resistance (68.6%, n=810). For details, see online supplemental table S1.

Online supplemental figure 1 shows the proportion of participants who answered correctly regarding their knowledge about antibiotic resistance. Out of the eight

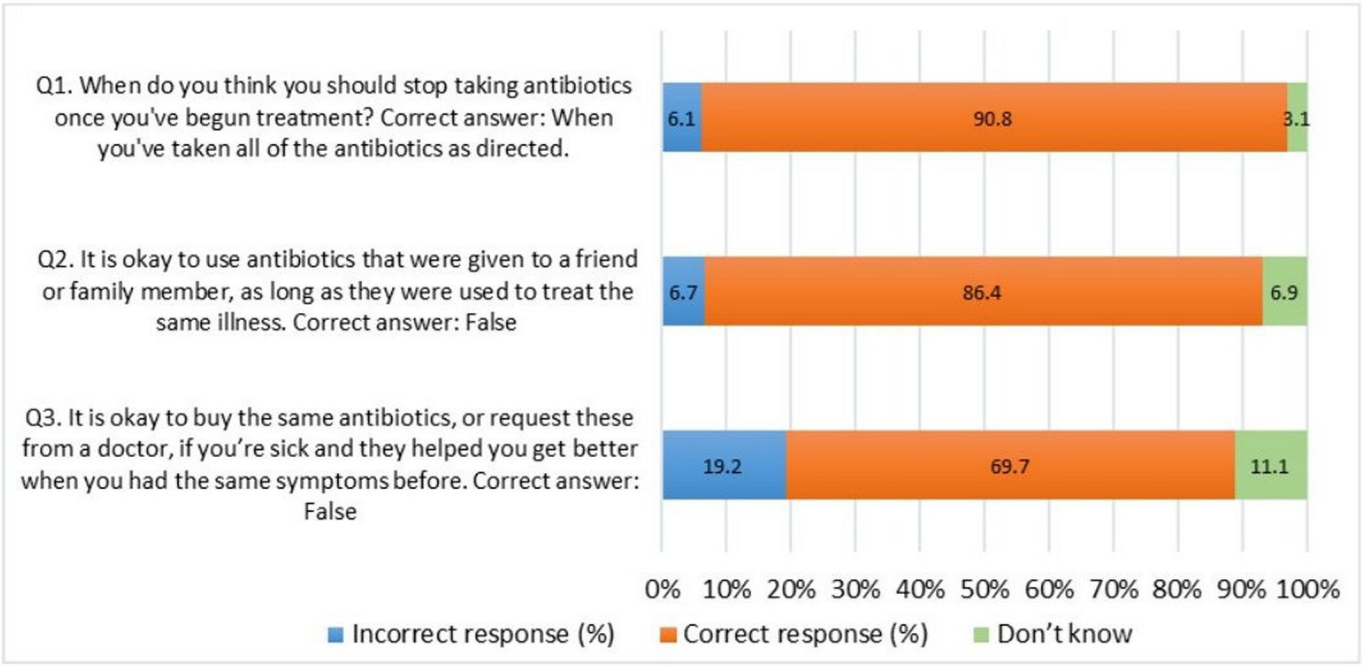

Figure 1 Antibiotic knowledge

questions, items 2, 3, 4, 7 and 8 were true, while the rest were false.

The proportion of participants correctly identifying that 'antibiotic-resistant infections could make medical procedures like surgery, organ transplants, and cancer treatment much more dangerous' is 77.5% (n=914). Further, 71.5% (n=844) provided the correct response that 'antibiotic resistance is an issue that could affect me or my family'. Despite this, 93.1% of participants (n=1099) believe that 'antibiotic resistance occurs when your body becomes resistant to antibiotics' is a true statement, when it is not. In addition, the statements commonly answered incorrectly are 'antibiotic resistance is only a problem for people who take antibiotics regularly' (55.2%; n=651) and 'if bacteria are resistant to antibiotics, it can be very difficult or impossible to treat the infections they cause' (51.4%; n=607).

The mean score for knowledge of antibiotics resistance was 4.44±1.81 (min=0, max=8) with a median of 5.0 and an IQR of 2.0. The knowledge of antibiotic resistance was normally distributed.

Antibiotic use

Study participants have used antibiotics as follows: 24.7% (n=291) in the last 6 months, 18.1% (n=213) in the last 30 days, 14.3% (n=169) in the last year and 10.6% (n=125)

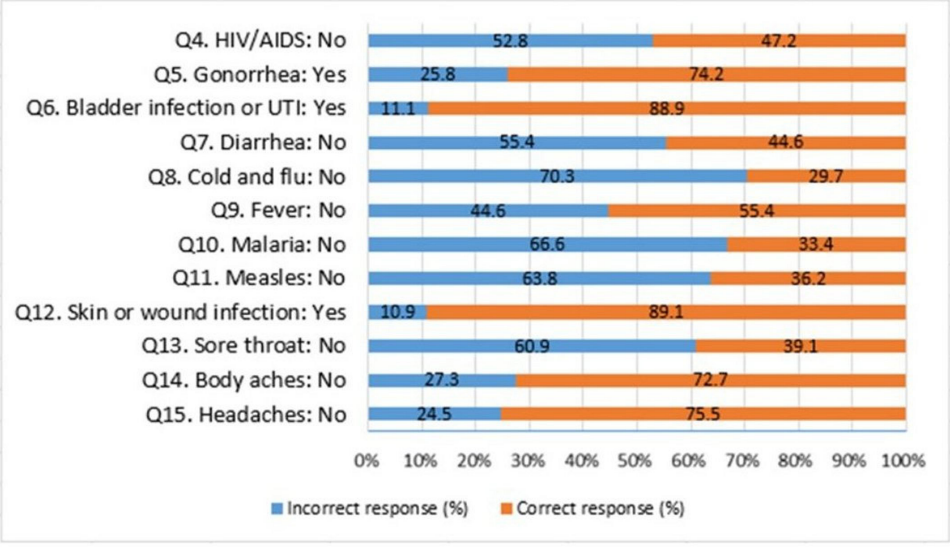

Figure 2 Conditions to be treated with antibiotics. AIDS, acquired immunodeficiency syndrome; HIV, human immunodeficiency virus; UTI, urinary tract infection.

more than a year. Only 6.9% (n=82) of respondents reported never using antibiotics, and 25.4% (n=300) could not recall when they last used them. Please refer to online supplemental figure S2 for details.

eHealth literacy

The overall mean score for eHealth literacy was 35.92±4.21 (min=16, max=40) with a median of 37 and an IQR of 8.0. In this study, more than 90% of the participants demonstrated a high level of eHealth literacy. Among them, fourth-year students (99.4%, n=307) and those over 20 (98.30%, n=575) were found to have higher eHealth literacy compared with students in other academic years and those under 20.

Antibiotic knowledge, antibiotic resistance knowledge, eHealth literacy and antibiotic use

Antibiotic knowledge, antibiotic resistance knowledge, eHealth literacy and antibiotic use were significantly associated with participants' ages. Among participants over the age of 20, there were higher levels of knowledge about antibiotics, antibiotic resistance and eHealth literacy (χ^2= 84.610, p<0.001; χ^2= 28.012, p<0.001; χ^2= 8.498, p=0.004). However, they used more antibiotics than those under 20 (χ^2= 47.493, p<0.001). A significant association was also found between these variables and academic years (χ^2= 122.063, p<0.001; χ^2= 66.093, p<0.001; χ^2= 13.104, p=0.004; χ^2= 57.327, p<0.001). Female students appeared to have better eHealth literacy (χ^2= 4.975, p=0.049). Income did not show any significant relationship with these variables. For details, see online supplemental table S2.

Predictors of antibiotic resistance knowledge

A multiple linear regression was carried out to identify the predictors of antibiotic resistance knowledge. The dependent variable was the total number of correct items on antibiotic resistance, while the independent variables were gender, age, year of study, income, total scores of antibiotic knowledge and eHealth literacy scores.

All the above variables were included in the regression analysis using a stepwise elimination procedure to remove insignificant variables. In the final model, three variables remained. When examining the collinearity between knowledge of antibiotics and eHealth literacy, we found their VIFs to be 1.057 and 1.190, respectively. Since these VIF values are below 10, it indicates that there is no significant correlation between the two independent variables. Also, the correlation coefficient was 0.219, which is below the 0.70 threshold for strong correlation, indicating a weak correlation. Thus, there is no collinearity issues between the two independent variables. The model showed that the factors predicting knowledge of antibiotic resistance included (i) knowledge of antibiotics (B=0.199, p<0.001, 95% CI 0.165 to 0.234), (ii) eHealth literacy (B=0.078, p<0.001, 95% CI 0.056 to 0.100) and (iii) academic years (B=0.271, p<0.001, 95% CI 0.184 to 0.358). This means that for every one-point increase in antibiotic knowledge, there is a corresponding 0.199-point increase in knowledge of antibiotic resistance score. Similarly, for each one-point increase in eHealth literacy, there is a 0.078-point rise in knowledge of antibiotic resistance score. Moreover, for every additional year of study, knowledge of antibiotic resistance increases by 0.271 points. Knowledge of antibiotics had the most substantial impact on knowledge of antibiotic resistance (β=0.318), followed by eHealth literacy (β=0.181). All three variables accounted for 23.7% of the variance in antibiotic resistance knowledge scores ($F_{3,\ 1176}$ <0.001). Please refer to table 2 for details.

DISCUSSION

Antibiotic resistance poses a significant public health concern. Investigating knowledge of antibiotics and antibiotic resistance, antibiotic usage and eHealth literacy among nursing students shed light on the challenges related to antibiotic resistance and potentially uncover strategies to mitigate these issues. This study represents the first extensive examination among nursing students in Thailand.

Overall, the nursing students in our study had relatively good knowledge of antibiotics. Students over 20 and in their fourth year of the programme had better knowledge compared with those under 20 and in lower academic years. However, most of them had limited understanding of the conditions that require antibiotic treatment. Specifically, only 29.7% of nursing students correctly identified that colds and influenza should not be treated with antibiotics. Our findings were consistent with a study conducted in China, where 30.0% of nursing students showed a similar lack of understanding of this matter.[35] Despite this, Thai nursing students demonstrated a significantly lower level of antibiotic knowledge regarding colds and influenza than nursing students from Spain (94.5%), Nigeria

Table 2 Regression analysis for antibiotic resistance knowledge

Independent variables	B	SE	β	P value	95% CI	R-squared	Adjusted R-squared
Constant	−0.404	0.399					
Antibiotic knowledge	0.199	0.018	0.318	<0.001	0.165 to 0.234	0.237	0.235
eHealth literacy	0.078	0.011	0.181	<0.001	0.056 to 0.100		
Academic years	0.271	0.044	0.170	<0.001	0.184 to 0.358		

B, unstandardised coefficient; β, standardised coefficient.

(74.2%) and Sri Lanka (59.8%).[31 36 37] As indicated by prior studies, the variation in the content and depth of antibiotic knowledge taught in nursing curricula and training programmes across institutions and countries remains unclear compared with pharmacy and medical students.[38–41] Indeed, certain nursing programmes may place greater emphasis on pharmacology and antimicrobial knowledge, integrating them comprehensively into both theoretical coursework and clinical practice, while others may cover these subjects superficially.[38 40] This variation applies even to nursing schools in Thailand, where the lack of knowledge about antibiotic indications highlights the need to incorporate this topic into the current nursing curricula.

When it comes to knowledge about antibiotic resistance, fourth-year nursing students and individuals over 20 years old demonstrated better understanding. In addition, a majority of nursing students were familiar with antibiotic resistance terminologies. They were aware that antibiotic resistance can increase the danger of medical procedures (77.5%) and can affect them and their family (71.5%). However, they were unaware that antibiotic resistance can occur when bacteria became resistant to antibiotics (93.1%). Similar to those reported by the WHO in 12 countries, 76.0% of participants had misconceptions about it.[42] Our findings were also consistent with previous studies, indicating that 63.2% of Canadian and 76.0% of Bruneian university students and 74.9% of medical students in Ecuador held this misconception.[43–45] Despite earlier studies highlighting a lack of comprehensive understanding of the severity of antibiotic resistance among the general public, university students and healthcare students, Thai nursing students exhibit the highest level of misconceptions in this study. This indicates a significant gap in knowledge of antibiotic resistance that needs to be addressed. Similar to those observed in the UK, there are concerns about educational deficiencies in antibiotic resistance, as only two-thirds of undergraduate nursing programmes incorporate antibiotic resistance teaching, and only 12.0% cover its principles.[45] As with Thai nursing programmes, although nursing students are introduced to pharmacology in the first year, they are not exposed to antibiotic principles until their initial clinical placements. These placements allow them to gain hands-on experience administering medication, including antibiotics, under supervision, which requires prior pharmacological knowledge to be able to grasp the concept of antibiotic resistance. Pharmacology is therefore crucial for nursing students; however, it must be tailored to their needs, especially in the area of antibiotic resistance, to ensure a comprehensive understanding.

Regarding antibiotic use, over half of Thai nursing students had used antibiotics at some point, with only a small proportion either never using antibiotics or unable to recall their last intake. Compared with nursing students under 20 and in different academic years, nursing students over 20 and enrolled in their fourth year of nursing school used more antibiotics. A high prevalence of antibiotic use in our study is similar to nursing and medical students in India, as well as universities in Malaysia (78.7%, 70.0% and 89.0%, respectively).[46–48] This highlights the need to examine whether various education methods (ie, traditional classrooms, presentations, webinars, online learning, patient rounds, bedside teaching and simulations) in nursing programmes can provide students with a comprehensive understanding of antibiotics and antibiotic resistance, thereby preventing antibiotic overuse. Another important consideration is the legal right to dispense antibiotics. In Thailand, pharmacists can legally dispense antibiotics, and the legislation that authorises this, combined with the extensive presence of 23 804 drugstores nationwide, may pose a substantial threat to the general public to access antibiotics without a prescription or store them for later use.[49–51] Therefore, national regulatory authorities should enhance inspection protocols and enforce more stringent policies to reduce the excessive distribution and use of antibiotics.

To use antibiotics properly and understand the danger of antibiotic resistance, eHealth literacy is crucial since it gives individuals access to accurate antibiotic information, enables them to analyse and comprehend data from digital sources, and gives them the ability to make informed decisions.[52] In this study, more than 90% of the nursing students were labelled as having a high level of eHealth literacy. Nursing students who were over 20 years old and in their fourth year had higher eHealth literacy compared with those in lower academic years and below 20 years old. There was no association between eHealth literacy level and income. The average eHealth literacy level, determined by the eHEALS, was 35.92 out of 40. This is higher than the scores of nursing students in Ethiopia (25.23), Sri Lanka (28.02) and medical and health science students in Ethiopia (28.70).[23 25 53] In addition, Thai nursing students also showed higher eHealth literacy levels compared with general university students in the USA (30.1) and Portugal (28.8).[54 55] However, the average eHEALS score of our study is in line with medical students in Thailand (33.45),[56] where the policy landscape has highlighted electronic health through the initiation of the Digital Health Strategy from 2021 to 2025, encouraging both public and private sectors to embrace digital technologies.[57] Prior studies indicate that individuals with higher eHealth literacy levels can potentially navigate through online information more effectively and use a greater variety of health professional websites.[54 56] Conversely, a study conducted among immigrants found that lower eHealth literacy levels have affected an individual's ability to access reliable health information and led to improper use of medicines and antibiotics.[52] In our study, eHealth literacy level is one of the factors linked to knowledge of antibiotic resistance.

Our regression analysis showed the importance of the academic year of study, antibiotic knowledge score and eHealth literacy score in predicting knowledge of antibiotic resistance score. Knowledge of antibiotics is the strongest predictor of knowledge of antibiotic resistance,

followed by eHealth literacy and academic year of study. However, knowledge of antibiotics, eHealth literacy and academic year of study explain only 23.7% of the variance in knowledge of antibiotic resistance scores. Therefore, we need to consider other factors that may have a greater impact, such as attitude toward antibiotics and personal experiences with their use. As this is the first study to examine these variables on antibiotic resistance knowledge among nursing students, we could not compare our findings to other literature. However, the requirement for third- and fourth-year nursing students to spend more hours on clinical rotations across various settings serves as a valuable opportunity for them to encounter antibiotics and antibiotic resistance in their daily nursing floor duties. This highlights that, despite not having a specific course on antibiotic resistance, their exposure to antibiotics through clinical rotations may enable them to answer questions on antibiotic resistance more accurately. Additionally, the students have exhibited strong eHealth literacy compared with other studies, which suggests their capability to access trustworthy sources and respond to antibiotic resistance questions accurately. This evidence is supported by previous studies indicating that individuals with high eHealth literacy can effectively access reliable health-related information, whereas those with low eHealth literacy often struggle.[58 59]

Strength and limitations

Our findings underscore the need of incorporating antibiotics and antibiotic resistance topics into nursing curricula at the baccalaureate level, as most nursing school in Thailand currently lack such courses. Additionally, our findings highlight the importance of eHealth literacy for nursing students to access and navigate health-related information effectively. Future research should explore what interventions would promote the best outcomes in improving knowledge of antibiotics, knowledge of antibiotic resistance and antibiotic use when eHealth literacy is incorporated. A longitudinal study should be implemented to monitor changes in nursing students' knowledge and practices related to antibiotics and antibiotic resistance throughout their education and practice.

This study has some limitations. First, a cross-sectional design does not allow for causal inferences. Second, the reliance on self-report questionnaires may introduce social desirability bias. Third, the multiple linear regression model accounts for only 23.7% of the variability in antibiotic resistance, indicating that other factors might have a greater influence. Lastly, the use of online questionnaires may exclude nursing students without internet access. These limitations should be taken into account when interpreting the results and designing future research in this area.

Conclusion

This study provides fundamental data on nursing students' knowledge of antibiotics, antibiotic resistance, antibiotic use and eHealth literacy in Thailand. The findings reveal misconceptions about conditions requiring antibiotic treatment and inadequate knowledge about antibiotic resistance among nursing students, despite their high eHealth literacy levels. These results underscore the need of enhancing nursing education with a focus on antibiotic resistance ensuring that nursing students gain better knowledge and awareness, ultimately benefiting patients and the community. Future studies should explore whether integrating antibiotic resistance and antibiotic-related topics into nursing curricula can improve students' knowledge.

X Atsadaporn Niyomyart @Papa Niyomyart and Chuenjit Junsawang @Chuenjit_koy

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ORCID iDs
Soontaree Jianvitayakij http://orcid.org/0009-0003-4793-437X
Atsadaporn Niyomyart http://orcid.org/0000-0002-5460-2934
Chuenjit Junsawang http://orcid.org/0000-0001-5625-354X
Wunwisa Bualoy http://orcid.org/0009-0009-8125-7089
Nipaporn Butsing http://orcid.org/0000-0002-2065-3207
Supreeda Monkong http://orcid.org/0000-0002-3720-124X

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