Is health literacy associated with antibiotic use, knowledge and awareness of antimicrobial resistance among non-medical university students in Egypt? A cross-sectional study

Aya Mostafa 1, Abdurrahman Abdelzaher 1, Salma Rashed 2, Salma I AlKhawaga 2, Shadwa K Affi 2, Shaimaa AbdelAlim 2, Shaimaa A Mostafa 2, Taha A Zidan 2

ABSTRACT

Objectives Antibiotic resistance is a global public health concern, especially in developing countries, where antibiotic misuse is widespread. However, studies investigating relevant factors, particularly in youth, are limited. This study examined the levels of health literacy (HL) and their association with antibiotic use, knowledge of antibiotics and awareness of antibiotic resistance among university students in Egypt.

Design A cross-sectional study was conducted using self-administered questionnaires during 2018. The Health Literacy Survey (HLS-EU-Q16) and the WHO Antibiotic resistance: Multi-Country Public Awareness Survey were used. Bivariate and multivariable analyses were used to compare responses on use and knowledge of antibiotics, and awareness of antibiotic resistance between the three levels of students’ HL.

Setting University, Cairo, Egypt.

Participants 508 non-medical university students.

Outcomes Students’ HL scores were categorised into sufficient, problematic and inadequate. Students’ knowledge of antibiotics was categorised into good and poor. Students’ awareness of antibiotic resistance was categorised into high, average and poor.

Results 35.1% of students had sufficient HL. 79.7% of students had poor knowledge of antibiotics. 39.9% of students reported having used antibiotics in the past month without a prescription. 92.2% had limited awareness of antibiotic resistance and 30.6% of students heard about the term ‘antimicrobial resistance’. Background characteristics did not significantly differ by HL levels or knowledge scores, except for students’ year of study. Sufficient HL was independently associated with students’ high awareness of antibiotic resistance (adjusted OR=2.8; 95% CI: 1.3 to 5.9).

Conclusions HL was insufficient in this sample of non-medical Egyptian university students. Across all levels of HL, knowledge of antibiotics and awareness of antibiotic resistance were limited, reflecting deficiency in relevant education programmes. Findings suggest that sufficient HL supports high awareness of antibiotic resistance. Incorporating HL and rational antibiotic use awareness raising programmes in university curricula is an urgent necessity to curb antibiotic resistance.

INTRODUCTION

Antimicrobials, including antibiotics, are a shared high-value global asset that is
exploited in developing and developed countries. The worldwide surge in antimicrobial resistance (AMR) threatens public health and derails sustainable development goals. AMR attributes to 700,000 deaths annually, and forces 24 million people into extreme poverty. By 2050, AMR may contribute to 10 million annual deaths, at a global cumulative cost of US$100 trillion. These impacts will unequally affect low/middle-income countries (LMICs). To concert global efforts in tackling AMR, the WHO developed a Global Action Plan in 2015. The first objective of this plan was strategically prioritised to enhance knowledge and awareness of AMR through effective communication and education of the public, policymakers, and health and agriculture professionals. Implementing this objective is particularly important in LMICs, where antibiotics are widely used without prescription.

The 2015 WHO Antibiotic Resistance: Multi-Country Public Awareness Survey reported that levels of awareness of AMR are mixed, reflecting an insufficient understanding of its causes and its management. Responses from the 12 participating countries varied widely. For instance, awareness of the term ‘antibiotic resistance’ was 89% in Mexico and only 22% in Egypt. In Egypt, self-medication is common practice. In 2015, 53.9% of Egyptians used antibiotics without prescriptions. Antibiotic misuse among Egyptian university students was 58.8%.

An in-depth investigation of why younger generations, especially the well-educated, report such high rates of antibiotic misuse is warranted. The association between health literacy (HL) and AMR has been scarcely studied in general, and among youth in particular. To the authors’ knowledge, only one such study has been conducted in 2016 among the general population in Germany, a high-income country (HIC). Antibiotic use was lower in participants with sufficient HL (28%) in comparison to participants with problematic (42%) and inadequate (41%) HL.

Comprehensive HL (CHL) is the ability to obtain health-related knowledge, understand and apply it to improve the quality of life. In this context, antibiotic use and knowledge of AMR are applications of CHL. Studies in migrants and in developing countries, including in Egypt, denoted limited HL was prevalent. Higher education per se without dedicated programmes may not positively impact CHL. Medical students in the USA, an HIC and China reported low rates of HL. Hence, untrained medical and non-medical students might be alike in this sense.

In Egypt, non-medical students form a majority of university students (3.1 million). They can lead community change through raising awareness and correcting misperceptions. Understanding whether university students’ HL affects their awareness of AMR will help identify possible risk factors and tailor interventions to address their specific needs. Furthermore, the scarcity of such studies in HICs and LMICs drives the need to cover this gap of knowledge. To inform future policies in this regard, such as Egypt’s National Action Plan for Antimicrobial Resistance, this study examined levels of HL and their association with antibiotic use, knowledge of antibiotics and awareness of antibiotic resistance among university students in Egypt.

METHODS
Study design and setting
A cross-sectional study was conducted among non-medical students at Ain Shams University (ASU) between February and June 2018 using self-administered questionnaires. ASU is a public university with approximately 200,000 students and encompasses 16 faculties and three institutes with seven campuses that are all located in Cairo, Egypt.

Study sample and data collection
A convenience sample of non-medical students who attended ASU faculties and institutes, except those related to the medical field (Medicine, Pharmacy, Nursing and Dentistry), was sought. A sample size of 456 was calculated at a CI=99%, a margin of error=5%, based on the previously reported level of public awareness of the term ‘antibiotic resistance’ (22%) in Egypt. After pre-testing the questionnaire, a pilot study was done on 50 non-medical students; results were discussed by the research team to: exchange field experiences, ensure data collection was carried out in a consistent manner, confirm clarity of the questions and the answer categories, and agree on standard explanatory phrases for each question. Pilot data were not included in this analysis; based on the pilot results, the authors added approximately 10% (n=52) to accommodate for possible missing data; the target sample size was 508 non-medical students. Questionnaires were distributed by 50 trained medical students at ASU; each of whom approached approximately 10 individuals, one at a time and asked a screening question to identify non-medical students at different ASU campuses. If the individual was a non-medical student, those distributing the questionnaire read aloud a written information sheet (to standardise the information conveyed) introducing the research team, the study aims, its public health benefit and the time needed for completing the questionnaire. Also, it was conveyed that participation was voluntary, withdrawal was free at any time, confidentiality and anonymity were ensured and that data will be published collectively. Research team’s contacts were provided for any inquiries. Non-medical students who were interested to participate provided verbal consent, which was recorded by ticking a box in the questionnaire paper form, before completing the questionnaire. Participants were not provided any incentives for completing the study. Approximately 2% of the approached students refused to participate; reasons for non-response were mainly having no time or no interest in the study. Data were collected until the target sample size was achieved. After completing the survey,
participants were given printed health education material about AMR.

**Study tools**

The 35-item questionnaire was adapted from previous literature and included three sections: demographic characteristics (six items: age, gender, residence, marital status, faculty and academic year); HL (16 items: using the European Health Literacy Survey Questionnaire—modified short version: HLS-EU-Q16); and use of antibiotic, knowledge of antibiotics and awareness of antibiotic resistance (13 items: adapted from the WHO Antibiotic Resistance: Multi-Country Public Awareness Survey).5

The European Health Literacy Survey Questionnaire—modified short version (HLS-EU-Q16)

The modified HLS-EU-Q1620 included 16 closed-ended questions covering three health domains: healthcare (questions 1–7), disease prevention (questions 8–12) and health promotion (questions 13–16), and assessing four dimensions of CHL: participants’ perceived ability to access, comprehend, appraise and apply health information (see online supplemental file 1). The HLS-EU-Q16 was originally developed as part of the European Health Literacy project21; an Arabic version was available and tested previously among Arabic speaking migrants.12 20 The authors used the modified HLS-EU-Q16 because it allowed simple and fast assessment of HL and its Arabic version was used in a previous study in Egypt.13 Its internal consistency reliability using Cronhbach’s alpha in the current study was 0.8. Following the original method of analysing responses to the HLS-EU-Q16,22 the four valid response categories were dichotomised: ‘very easy’ and ‘fairly easy’ responses were assigned a value of ‘1’, where ‘fairly difficult’ and ‘very difficult’ were assigned a value of ‘0’. ‘Don’t know’ responses were treated as missing.20 For each participant, a total score was calculated if they had valid responses for ≥14 out of the 16 questions, per Wångdahl et al score calculation instructions.20 Participants were then categorised into three levels of HL: participants' scores ≥13 were considered ‘sufficient’, 9–12 ‘problematic’ and ≤8 ‘inadequate’ HL.20

The WHO Antibiotic Resistance: Multi-Country Public Awareness Survey

The questions adapted from the WHO’s main survey5 included 13 closed-ended questions (see online supplemental file 1) covering three aspects: self-reported use of antibiotics (three questions: 1–3), knowledge of antibiotics (four questions: 4–7) and awareness of antibiotic resistance (six questions: 8–13). All questions 1–13 were used in the current study. It was conducted previously in 12 countries, including in Egypt.5 The available online version was in English, therefore, it was translated into Arabic; the Arabic version was back translated into English. Face and content validity were assessed by two public health experts. Correct answers were identified from the WHO report.5 Accordingly, each correct answer was assigned a score of ‘1’ and otherwise (ie, not correct or ‘don’t know’ answers) a score of ‘0’. Also, 5-point Likert scale responses were dichotomised: if the correct answers were ‘agree’ or ‘strongly agree’, these were combined and assigned a score of ‘1’ and otherwise a score of ‘0’ and vice versa. A total score for ‘level of knowledge of antibiotics’ was calculated for each participant using questions 4–7 (15 items, as question 7 has 12 subitems). The total score for ‘level of knowledge of antibiotics’ ranged from 0 to 15; percentage scores were calculated for each participant. For subsequent analysis, percentage scores ≤50% were considered ‘poor’ and ≥50% were considered ‘good’ level of knowledge of antibiotics. Similarily, a total score for ‘level of awareness of antibiotic resistance’ was calculated for each participant using questions: 10–12 (22 items, as each of questions 10 and 11 has eight subitems, and question 12 has six subitems). The total score for ‘level of awareness of antibiotic resistance’ ranged from 0 to 22; percentage scores were calculated for each participant. For subsequent analysis, percentage scores <50% were considered ‘poor’, 50% to <75% were considered ‘average’ and ≥75% were considered ‘high’ level of awareness of antibiotic resistance. Additionally, if the participant was aware of any of the terms related to antibiotic resistance under question 8, the participant was considered ‘aware of antibiotic resistance’.

**Statistical analysis**

Anonymously filled questionnaires were assigned serial identification numbers. Data were analysed using SPSS (Statistical Package for the Social Sciences, V.25, SPSS). Descriptive statistics were performed and presented as frequency and percentages for qualitative variables or mean and SD for quantitative variables. Bivariate analyses were performed using the χ² test or the independent samples t-test or the analysis of variance test. For the regression analysis, the following variables were dichotomised: HL into ‘sufficient’ and ‘insufficient’ (combining ‘inadequate’ and ‘problematic’), and level of awareness of antibiotic resistance into ‘high’ and ‘not high’ (combining ‘poor’ and ‘average’). Bivariate and multivariable binary logistic regression analyses were performed to identify factors significantly associated with sufficient HL, good level of knowledge of antibiotics, awareness of antibiotic resistance and high level of awareness of antibiotic resistance. Adjusted odds ratios (adjusted ORs) and 95% CIs are reported. A p value ≤0.05 was considered statistically significant.

**Patient and public involvement**

Patient and public were not involved in the development of the research question and outcome measures, the design, recruitment and conduct of the study. The results of this study will be disseminated to study participants via newsletters and social media outlets.

**RESULTS**

**Sample characteristics**

Students’ mean age was 20.5±1.3 years old, ranging from 18 to 26 years. Most of students were women (66.3%),
urban residents (61.2%) and unmarried (96.4%). Eighty per cent of students were in years 1–3 of their studies. The most represented faculties were commerce (27.4%) and arts (26.6%) (table 1).

### Health literacy

Approximately one-third (35.1%) of participants had sufficient HL, while 49.3% and 15.6% had problematic and inadequate HL, respectively. There were no statistically significant differences in HL levels by different demographic characteristics (table 1). Details of assessment of HL are presented in online supplemental table 1. Most students (92.0%) found it easy to understand the doctor’s or pharmacists’ instructions on how to take a prescribed medicine, whereas more than half (52.3%) of participants found it difficult to find information about managing mental health problems.

### Use of antibiotics

Approximately two-fifths (38.0%) of students reported having used antibiotics 1 month ago, while 62.3% used antibiotics in the last 12 months. Forty per cent did not get their antibiotics based on a prescription and 33.7% did not get professional medical advice on how to take them (table 2). There were no statistically significant differences in students’ use of antibiotic between the three HL levels (table 2).

### Knowledge of antibiotics

Thirty-eight per cent of students thought they should stop taking antibiotics once they felt better. Thirty-nine per cent believed it is okay to take the same antibiotics that were given to a friend or a family member to treat the same illness. More than half of students (51.8%) stated...
it was ‘okay’ to buy the same antibiotic or request it from a doctor if sick and they helped them get better when they had the same symptoms before (table 3). From a list of medical conditions that were caused by bacteria or viruses, approximately three-quarters of students incorrectly thought antibiotics treat sore throat or cold and influenza. Almost half of students incorrectly thought antibiotics treat fever and diarrhoea. Most students did not know if antibiotics treat gonorrhoea, malaria, measles and HIV (table 3).

Only a fifth (20.3%) of students had a good level of knowledge of antibiotics (table 4). There was no statistically significant difference in good knowledge of antibiotics between the three HL levels or by demographic characteristics, except by students’ year of study. Students in their third to fifth years of study showed a relatively higher proportion of good knowledge of antibiotics compared with younger students in their first or second years of study (table 4).

**Awareness of antibiotic resistance**

Approximately two-fifths (39.5%) of students did not know the term ‘antibiotic resistance’, and less than one-third (30.6%) heard about the term ‘antimicrobial resistance’. More than half (57.4%) of students incorrectly thought antibiotic resistance occurs when their body becomes resistant to antibiotics, 43.3% incorrectly thought antibiotic resistance is only a problem for people who take antibiotics regularly and 53.8% did not know if antibiotics were used in agriculture (table 5).

Most students (55.0%) with sufficient HL agreed that pharmaceutical companies should develop new antibiotics, a proportion significantly higher than students with problematic (48.2%) and inadequate HL (41.1%) (online supplemental table 2). Only 7.8% of students had a high level of awareness of antibiotic resistance. Among those, only 13.2% had sufficient HL (table 6). Older students and those in advanced study years significantly showed a higher level of awareness of antibiotic resistance compared with their counterparts (table 6).

The association between levels of HL, level of knowledge of antibiotics and level of awareness of antibiotic resistance

In the multivariable logistic regression, students’ good level of knowledge of antibiotic resistance was significantly higher in advanced students’ years of study, specifically the third (adjusted OR=4.5; 95% CI: 1.7 to 11.8) and the fourth years (adjusted OR=4.4; 95% CI: 1.4 to 13.5), but was not associated with sufficient HL. Students’ high level of awareness of antibiotic resistance was independently associated with students’ sufficient HL (adjusted OR=2.8; 95% CI: 1.3 to 5.9) and good level of antibiotic knowledge (adjusted OR=4.2; 95% CI: 1.9 to 8.8) (table 7).
### Table 3  Knowledge of antibiotics and health literacy among non-medical students

| Knowledge of antibiotics                                                                 | Total       | Inadequate | Problematic | Sufficient | χ²   | P value† |
|------------------------------------------------------------------------------------------|-------------|------------|-------------|------------|------|----------|
| **When do you think you should stop taking antibiotics once you’ve begun treatment? n=497** |             |            |             |            |      |          |
| When you feel better                                                                    | n=497      | n=73       | n=229       | n=160      |      |          |
|                                                                                         | 188(37.8%)  | 22(30.1%)  | 80(35.1%)   | 70(43.8%)  | 10.663 | 0.031    |
| When you’ve taken all of the antibiotics as directed in the prescription                 | n=497      | n=73       | n=229       | n=160      |      |          |
|                                                                                         | 267(53.7%)  | 40(54.8%)  | 129(56.6%)  | 83(51.9%)  |      |          |
| Don’t know                                                                              | n=497      | n=73       | n=229       | n=160      |      |          |
|                                                                                         | 42(8.5%)    | 11(15.1%)  | 19(8.3%)    | 7(4.4%)    |      |          |
| **Do you think this statement is ‘true’ or ‘false’? ‘It’s okay to use antibiotics that were given to a friend or family member, as long as they were used to treat the same illness’ n=500** |             |            |             |            |      |          |
| True                                                                                    | n=500      | n=73       | n=229       | n=163      |      |          |
|                                                                                         | 259(51.8%)  | 41(56.2%)  | 112(49.1%)  | 87(53.4%)  | 1.757 | 0.78     |
| False                                                                                   | n=500      | n=73       | n=229       | n=163      |      |          |
|                                                                                         | 188(37.6%)  | 26(35.6%)  | 92(40.4%)   | 58(35.6%)  |      |          |
| Don’t know                                                                              | n=500      | n=73       | n=229       | n=163      |      |          |
|                                                                                         | 53(10.6%)   | 9(12.3%)   | 24(10.5%)   | 18(11%)    |      |          |
| **Do you think these conditions can be treated with antibiotics?**                       |             |            |             |            |      |          |
| HIV/AIDS                                                                               | n=500      | n=72       | n=228       | n=163      |      |          |
| No                                                                                     | n=500      | n=72       | n=228       | n=163      |      |          |
|                                                                                         | 96(17.2%)   | 6(9.6%)    | 34(14.9%)   | 39(23.9%)  | 4.907 | 0.297    |
| Yes                                                                                    | n=500      | n=72       | n=228       | n=163      |      |          |
|                                                                                         | 67(13.4%)   | 9(12.5%)   | 39(17.1%)   | 17(10.4%)  |      |          |
| Don’t know                                                                             | n=500      | n=72       | n=228       | n=163      |      |          |
|                                                                                         | 347(69.4%)  | 58(80.6%)  | 105(47.4%)  | 107(65.6%) |      |          |
| Gonorrhoea                                                                             | n=500      | n=72       | n=228       | n=163      |      |          |
| No                                                                                     | n=500      | n=72       | n=228       | n=163      |      |          |
|                                                                                         | 86(17.2%)   | 5(6.9%)    | 34(14.9%)   | 39(23.9%)  | 14.398 | 0.006    |
| Yes                                                                                    | n=500      | n=72       | n=228       | n=163      |      |          |
|                                                                                         | 67(13.4%)   | 9(12.5%)   | 39(17.1%)   | 17(10.4%)  |      |          |
| Don’t know                                                                             | n=500      | n=72       | n=228       | n=163      |      |          |
|                                                                                         | 347(69.4%)  | 58(80.6%)  | 105(47.4%)  | 107(65.6%) |      |          |
| Bladder or urinary tract infection                                                      | n=500      | n=72       | n=228       | n=163      |      |          |
| No                                                                                     | n=500      | n=72       | n=228       | n=163      |      |          |
|                                                                                         | 95(19%)     | 11(15.3%)  | 49(21.5%)   | 30(18.4%)  | 3.209 | 0.523    |
| Yes                                                                                    | n=500      | n=72       | n=228       | n=163      |      |          |
|                                                                                         | 164(32.8%)  | 25(34.7%)  | 69(30.3%)   | 61(37.4%)  |      |          |
| Don’t know                                                                             | n=500      | n=72       | n=228       | n=163      |      |          |
|                                                                                         | 241(48.2%)  | 36(50%)    | 110(48.2%)  | 72(44.2%)  |      |          |
| Diarrhoea                                                                              | n=500      | n=72       | n=228       | n=162      |      |          |
| No                                                                                     | n=500      | n=72       | n=228       | n=162      |      |          |
|                                                                                         | 151(30.2%)  | 13(17.8%)  | 82(36%)     | 49(30.2%)  | 9.513 | 0.049    |
| Yes                                                                                    | n=500      | n=72       | n=228       | n=162      |      |          |
|                                                                                         | 207(41.4%)  | 33(45.2%)  | 88(38.6%)   | 70(43.2%)  |      |          |
| Don’t know                                                                             | n=500      | n=72       | n=228       | n=162      |      |          |
|                                                                                         | 142(28.4%)  | 27(37%)    | 58(25.4%)   | 43(26.5%)  |      |          |
| Cold and influenza                                                                     | n=500      | n=72       | n=228       | n=162      |      |          |
| No                                                                                     | n=500      | n=72       | n=228       | n=162      |      |          |
|                                                                                         | 90(18%)     | 10(13.7%)  | 38(16.7%)   | 37(22.8%)  | 12.897 | 0.012    |
| Yes                                                                                    | n=500      | n=72       | n=228       | n=162      |      |          |
|                                                                                         | 364(72.8%)  | 50(68.5%)  | 176(77.2%)  | 112(69.1%) |      |          |
| Don’t know                                                                             | n=500      | n=72       | n=228       | n=162      |      |          |
|                                                                                         | 46(9.2%)    | 13(17.8%)  | 14(6.1%)    | 13(8%)    |      |          |
| Fever                                                                                  | n=499      | n=463      | n=463       | n=463      |      |          |

Continued
DISCUSSION

This study is one the first attempts to assess CHL levels among non-medical university students and compare these with students’ use of antibiotics, knowledge of antibiotics and awareness of AMR in LMICs. Only one-third of students had sufficient HL. Approximately two-fifths of students reported having used antibiotics in the past month without a prescription. Only a fifth of students had a good level of knowledge of antibiotics. Less than one-third of students heard about the term ‘antimicrobial resistance’ and less than a tenth had a high level of awareness of antibiotic resistance. Sufficient HL was an independent determinant of students’ high level of awareness of antibiotic resistance.

Nearly half of the participating students (49.5%) had problematic HL, a proportion similar to that reported in a study among outpatient clinics attendees at ASU Hospitals (46.7%). However, levels of sufficient HL among students in this study (35.1%) were higher than levels reported in outpatient clinic attendees (18.9%). These
The misuse of antibiotics for self-diagnosed symptoms or conditions. Self-medication of antibiotics was common (39.9%) in all students regardless of their level of HL. A similar rate (39.5%) was reported recently among university students in the UAE (38.2%). Sri Lanka (38.6%), China (33.0%) and in an earlier household study in Jordan (39.5%). The rate of self-medication of antibiotics among students in this study was 1.5 times higher than that reported for Egypt in the WHO survey (26%). This observation entails a further wider investigation in different HICs and LMICs on why individuals with higher educational levels practice self-medication of antibiotics.

The misuse of antibiotics for self-limiting illnesses, such as cold and influenza, sore throat, and diarrhoea, is the most important contributing factor for rising AMR. Overall, only one in five students in this study had good knowledge of antibiotics, which is lower than rates among non-medical students (one in three) in Nigeria, another LMIC. However, in line with the current study results, the year of study was associated with knowledge of antibiotics use, while most students’ demographic characteristics were not significantly associated with knowledge scores of the Nigerian students. Although students with sufficient HL in the current study reported significantly higher rates of correct answers than students with lower HL levels for conditions treatable with antibiotics, particularly cold, influenza and fever, this was not true for other conditions, such as gonorrhoea. This indicates that students have mixed perceptions and incomplete knowledge of antibiotics, even among students with sufficient HL.

Approximately, 4 in 10 students knew the term ‘antibiotic resistance’, which is about half the average reported for all participating countries (7 in 10) in the WHO survey. Despite this, the rate detected among students in this study was twice as high as that reported for Egyptians in the WHO survey (one in five). Respondents in the WHO survey with a higher educational level were more
| Awareness of antibiotic resistance | Level of health literacy, n=467 |  |  |  | \( \chi^2 \) | P value† |
|-----------------------------------|---------------------------------|--|--|--|--|---------|
| Have you heard of any of the following terms | Total n=496 | Inadequate n=462 | Problematic n=228 | Sufficient n=162 |  |  |
| Antibiotic resistance |  |  |  |  |  |  |
| No | n=72 | n=228 | n=162 |  |  |  |
| Yes |  |  |  |  |  |  |
| Don’t know |  |  |  |  |  |  |
| Superbugs |  |  |  |  |  |  |
| No | n=72 | n=228 | n=161 |  |  |  |
| Yes |  |  |  |  |  |  |
| Don’t know |  |  |  |  |  |  |
| Antimicrobial resistance |  |  |  |  |  |  |
| No | n=73 | n=228 | n=160 |  |  |  |
| Yes |  |  |  |  |  |  |
| Don’t know |  |  |  |  |  |  |
| Drug resistance |  |  |  |  |  |  |
| No | n=73 | n=228 | n=161 |  |  |  |
| Yes |  |  |  |  |  |  |
| Don’t know |  |  |  |  |  |  |
| Antibiotic-resistant bacteria |  |  |  |  |  |  |
| No | n=73 | n=224 | n=158 |  |  |  |
| Yes |  |  |  |  |  |  |
| Don’t know |  |  |  |  |  |  |
| Please indicate whether you think the following statements are ‘true’ or ‘false’ |  |  |  |  |  |  |
| Antibiotic resistance occurs when your body becomes resistant to antibiotics and they no longer work as well | n=491 | n=457 | n=491 | n=73 | n=224 | n=160 |  |  |
| False | 55 | 11.2 | 8 | 11 | 27 | 12.1 | 15 | 9.4 | 3.966 | 0.411 |
| True | 282 | 57.4 | 42 | 57.5 | 120 | 53.6 | 102 | 63.7 |  |  |
| Don’t know | 154 | 31.4 | 23 | 31.5 | 77 | 34.4 | 43 | 26.9 |  |  |
| Many infections are becoming increasingly resistant to treatment by antibiotics | n=490 | n=455 |  |  |  |  |
| False | 65 | 13.3 | 10 | 13.7 | 24 | 10.8 | 24 | 15.1 | 2.082 | 0.721 |
| True | 249 | 50.8 | 35 | 47.9 | 120 | 53.8 | 80 | 50.3 |  |  |
| Don’t know | 176 | 35.9 | 28 | 38.4 | 79 | 35.4 | 55 | 34.6 |  |  |
| If bacteria are resistant to antibiotics, it can be very difficult or impossible to treat the infections they cause | n=492 | n=457 |  |  |  |  |
| False | 108 | 22 | 16 | 21.9 | 54 | 24.1 | 33 | 20.6 | 0.931 | 0.92 |
| True | 222 | 45.1 | 32 | 43.8 | 102 | 45.5 | 75 | 46.9 |  |  |
| Don’t know | 162 | 32.9 | 25 | 34.2 | 68 | 30.4 | 52 | 32.5 |  |  |

*Continued*
likely to have heard of the term ‘antibiotic resistance’ compared with those with lower educational levels, consistent with the current study results.

Only 11.2% of students in this study correctly responded to the question on whether the following statement was true or false: ‘antibiotic resistance occurs when your body becomes resistant to antibiotics and they no longer work as well’ and identified it as a false statement. This is compared with 22% of university students in Italy and 28.7% of survey respondents in Germany. This suggests a high level of misunderstanding concerning this particular aspect of antibiotic resistance.

Awareness of AMR among Egyptian medical students/professionals was satisfactory in 39.3%, 48.3% and 60.5% of respondents, while it was 47.4% among non-medical students in the current study. However, there were still some misconceptions and malpractices reported among medical students/professionals. Regarding self-medication with antibiotics, 62.2%, 65.9% and 77.7% of medical students reported such practice. These rates are higher than that observed among non-medical students in the current study (39.9%). Such findings require a more in-depth systematic investigation into the reasons behind the discrepancies in knowledge and practice among medical students/professionals.

The current study finding that sufficient HL and good antibiotic knowledge were significantly associated with students’ high level of awareness of AMR should be

### Table 5

| Awareness of antibiotic resistance | Level of health literacy, n=467 |       |       |       |       |
|-----------------------------------|---------------------------------|-------|-------|-------|-------|
|                                   | Total                          | Inadequate | Problematic | Sufficient |       |
|                                   | N*     | %  | n*     | %  | n*     | %  | n*     | %  | χ²   | P value† |
| False                             | 55     | 11.2 | 5      | 6.8 | 27     | 12.1 | 19     | 1.9 | 5.824 | 0.213    |
| True                              | 313    | 63.6 | 52     | 71.2 | 148    | 66.1 | 93     | 58.1 |       |          |
| Don’t know                        | 124    | 25.2 | 16     | 21.9 | 49     | 21.9 | 48     | 30  |       |          |

*Antibiotic resistance is an issue in other countries but not here* n=492

|                                    |       |       |       |       |       |
|-----------------------------------|-------|-------|-------|-------|-------|
|                                   | n=492 | n=73  | n=225 | n=199 |       |
| False                             | 161   | 32.7  | 31    | 42.5  | 72    | 32   | 47    | 29.6 | 8.127 | 0.087    |
| True                              | 132   | 26.8  | 12    | 16.4  | 69    | 30.7 | 41    | 25.8 |       |          |
| Don’t know                        | 199   | 40.4  | 30    | 41.1  | 84    | 37.3 | 71    | 44.7 |       |          |

*Antibiotic resistance is only a problem for people who take antibiotics regularly* n=492

|                                    |       |       |       |       |       |
|-----------------------------------|-------|-------|-------|-------|-------|
|                                   | n=492 | n=73  | n=225 | n=199 |       |
| False                             | 101   | 20.5  | 16    | 31.9  | 37    | 16.4 | 42    | 26.4 | 7.678 | 0.104    |
| True                              | 213   | 43.3  | 35    | 47.9  | 106   | 47.1 | 59    | 37.1 |       |          |
| Don’t know                        | 178   | 36.2  | 22    | 30.1  | 82    | 36.4 | 58    | 36.5 |       |          |

*Bacteria which are resistant to antibiotics can be spread from person to person* n=492

|                                    |       |       |       |       |       |
|-----------------------------------|-------|-------|-------|-------|-------|
|                                   | n=492 | n=73  | n=225 | n=199 |       |
| False                             | 85    | 17.3  | 20    | 37.4  | 35    | 15.6 | 23    | 14.5 | 8.482 | 0.075    |
| True                              | 180   | 36.6  | 23    | 31.5  | 78    | 34.7 | 66    | 41.5 |       |          |
| Don’t know                        | 227   | 46.1  | 30    | 41.1  | 112   | 49.8 | 70    | 44   |       |          |

*Antibiotic-resistant infections could make medical procedures like surgery, organ transplants and cancer treatment much more dangerous* n=481

|                                    |       |       |       |       |       |
|-----------------------------------|-------|-------|-------|-------|-------|
|                                   | n=481 | n=73  | n=225 | n=156 |       |
| False                             | 36    | 7.5   | 8     | 11    | 15    | 6.9  | 11    | 7.1  | 7.558 | 0.109    |
| True                              | 234   | 48.6  | 43    | 58.9  | 104   | 47.9 | 69    | 44.2 |       |          |
| Don’t know                        | 211   | 43.9  | 22    | 30.1  | 98    | 45.2 | 76    | 48.7 |       |          |

Do you think antibiotics are widely used in agriculture (including in food-producing animals) in your country? n=483

|                                    |       |       |       |       |       |
|-----------------------------------|-------|-------|-------|-------|-------|
|                                   | n=483 | n=69  | n=222 | n=160 |       |
| Yes                               | 186   | 38.5  | 27    | 39.1  | 85    | 38.3 | 60    | 37.5 | 2.609 | 0.125    |
| No                                | 37    | 7.7   | 3     | 4.3   | 15    | 6.8  | 16    | 10   |       |          |
| Don’t know                        | 260   | 53.8  | 39    | 56.5  | 122   | 55   | 84    | 52.5 |       |          |

Correct answers are italicised.

Students’ responses to questions about antibiotic resistance are presented in figures 1 and 2.

Statistically significant P-values ≤0.05 are in bold.

*Some values are missing, missing data not included.

†χ² test.
interpreted with caution, given the mixed conceptions about antibiotics among students with sufficient HL. The population-based study in Germany that examined the association between HL and knowledge of antibiotics reported supporting results.9 However, their survey was limited to only four questions, thus did not fully investigate antibiotic use, knowledge of antibiotics and awareness of AMR. More evidence is needed to examine the association between HL and correct knowledge and behaviour towards antibiotics use in HICs and LMICs. Improvements in HL, considering its several determinants, may achieve broader advancements in health, a progress that is greatly needed in Egypt and similar LMICs.

**Strengths and limitations**

The cross-sectional nature of the study cannot allow causal associations between students’ HL and use of antibiotics, knowledge of antibiotics and awareness of AMR. Convenience sampling may have introduced selection bias, thus may not accurately represent the wider views of private and public university students in Egypt. However, the target sample size has been achieved and non-response and missing values have been taken into account, thus the minimal missing data and possible differences between responders and non-responders have unlikely biased the current study findings. The self-administered method
| Characteristics                  | N* | Mean (SD) | Poor  | Average | High |
|-------------------------------|----|-----------|-------|---------|------|
|                               |    |           | n* (%)| n* (%)  | n* (%)|
| **Total**                     | 463| 56.2 (13.6)| 115 (24.8) | 312 (67.4) | 36 (7.8) |
| **Age (years)**               |    |           |       |         |      |
| 18–20                         | 230| 54.2 (13.5)| 68 (29.6)  | 147 (63.9) | 15 (6.5)  |
| ≥21                           | 233| 58.2 (13.4)| 47 (20.2)  | 165 (70.8) | 21 (9.0)  |
| **Gender**                    |    |           |       |         |      |
| Males                         | 149| 54.4 (12.9)| 39 (26.2)  | 104 (69.8) | 6 (4.0)   |
| Females                       | 311| 57.2 (13.9)| 75 (24.1)  | 206 (66.2) | 30 (9.6)  |
| **Residence**                 |    |           |       |         |      |
| Urban                         | 60 | 54.1 (14.2)| 22 (36.7)  | 35 (58.3)  | 3 (5.0)   |
| Suburban                      | 119| 57.7 (13.0)| 20 (16.8)  | 88 (73.9)  | 11 (9.2)  |
| Rural                         | 284| 56.1 (13.7)| 73 (25.7)  | 189 (66.5) | 22 (7.7)  |
| **Marital status**            |    |           |       |         |      |
| Not married                   | 447| 56.0 (13.6)| 113 (25.3) | 299 (66.9) | 35 (7.8)  |
| Married                       | 15 | 61.2 (12.4)| 2 (13.3)   | 12 (80.0)  | 1 (6.7)   |
| **Academic year**             |    |           |       |         |      |
| 1                             | 85 | 53.4 (12.9)| 28 (32.9)  | 51 (60.0)  | 6 (7.1)   |
| 2                             | 127| 55.3 (13.4)| 31 (24.4)  | 90 (70.9)  | 6 (4.7)   |
| 3                             | 158| 56.2 (12.9)| 37 (23.4)  | 110 (69.6) | 11 (7.0)  |
| 4                             | 86 | 60.4 (14.7)| 17 (19.8)  | 57 (66.3)  | 12 (14.0) |
| 5                             | 7  | 57.1 (17.2)| 2 (28.6)   | 4 (57.1)   | 1 (14.3)  |
| **Health literacy**           |    |           |       |         |      |
| Inadequate                    | 71 | 54.4 (15.7)| 24 (33.8)  | 44 (62.0)  | 3 (4.2)   |
| Problematic                   | 208| 56.7 (12.3)| 48 (23.1)  | 148 (71.2) | 12 (5.8)  |
| Sufficient                    | 152| 57.9 (13.7)| 29 (19.1)  | 103 (67.8) | 20 (13.2) |

**Table 6** Mean total percentage scores and awareness of antibiotic resistance among non-medical students by background characteristics and levels of health literacy

| Characteristics                  | N* | Mean (SD) | Poor  | Average | High |
|-------------------------------|----|-----------|-------|---------|------|
|                               |    |           | n* (%)| n* (%)  | n* (%)|
| Statistic†                    | F=0.000 | χ²=5.854 |       |         |      |
| P value                       | 0.001 | 0.021     |       |         |      |
| Gender                        |    |           |       |         |      |
| Males                         | 149| 54.4 (12.9)| 39 (26.2)  | 104 (69.8) | 6 (4.0)   |
| Females                       | 311| 57.2 (13.9)| 75 (24.1)  | 206 (66.2) | 30 (9.6)  |
| Statistic†                    | F=1.819 | χ²=4.427 |       |         |      |
| P value                       | 0.037 | 0.11      |       |         |      |
| Residence                     |    |           |       |         |      |
| Urban                         | 60 | 54.1 (14.2)| 22 (36.7)  | 35 (58.3)  | 3 (5.0)   |
| Suburban                      | 119| 57.7 (13.0)| 20 (16.8)  | 88 (73.9)  | 11 (9.2)  |
| Rural                         | 284| 56.1 (13.7)| 73 (25.7)  | 189 (66.5) | 22 (7.7)  |
| Statistic†                    | F=1.442 | χ²=9.001 |       |         |      |
| P value                       | 0.238 | 0.06      |       |         |      |
| Marital status                |    |           |       |         |      |
| Not married                   | 447| 56.0 (13.6)| 113 (25.3) | 299 (66.9) | 35 (7.8)  |
| Married                       | 15 | 61.2 (12.4)| 2 (13.3)   | 12 (80.0)  | 1 (6.7)   |
| Statistic†                    | F=0.111 | χ²=1.228 |       |         |      |
| P value                       | 0.739 | 0.653     |       |         |      |
| Academic year                 |    |           |       |         |      |
| 1                             | 85 | 53.4 (12.9)| 28 (32.9)  | 51 (60.0)  | 6 (7.1)   |
| 2                             | 127| 55.3 (13.4)| 31 (24.4)  | 90 (70.9)  | 6 (4.7)   |
| 3                             | 158| 56.2 (12.9)| 37 (23.4)  | 110 (69.6) | 11 (7.0)  |
| 4                             | 86 | 60.4 (14.7)| 17 (19.8)  | 57 (66.3)  | 12 (14.0) |
| 5                             | 7  | 57.1 (17.2)| 2 (28.6)   | 4 (57.1)   | 1 (14.3)  |
| Statistic†                    | F=3.133 | χ²=10.787 |       |         |      |
| P value                       | 0.015 | 0.021     |       |         |      |
| Health literacy               |    |           |       |         |      |
| Inadequate                    | 71 | 54.4 (15.7)| 24 (33.8)  | 44 (62.0)  | 3 (4.2)   |
| Problematic                   | 208| 56.7 (12.3)| 48 (23.1)  | 148 (71.2) | 12 (5.8)  |
| Sufficient                    | 152| 57.9 (13.7)| 29 (19.1)  | 103 (67.8) | 20 (13.2) |
| Statistic†                    | F=1.728 | χ²=9.790 |       |         |      |
| P value                       | 0.179 | 0.002     |       |         |      |

Statistically significant P-values ≤0.05 are in bold.

*Some values are missing, missing data not included.
†χ² test or independent samples t-test or one-way analysis of variance.
minimised interviewer bias and avoided social desirability in respondents’ answers. Although self-reporting may have introduced recall bias in some answers, the survey items were adapted from previously tested questionnaires in different populations and in Egypt. Despite these limitations, considering this subpopulation’s perceptions are important because the dynamic engagement of well-educated youth in this issue is vital to progress in containing AMR, specifically in a country where more than half of people report self-medication with antibiotics. Also, this study investigated in-depth several aspects in students’ knowledge of antibiotic use that other studies on university students recommended addressing. Future studies using analytical designs such as longitudinal, or case-control studies could help provide robust evidence for causal associations.

**CONCLUSIONS**

HL was insufficient in this sample of non-medical Egyptian university students. A considerable proportion used antibiotics without prescription and believed antibiotics could treat self-limiting illnesses. Knowledge and awareness of antibiotic resistance were poor among these well-educated young adults and across all levels of HL, reflecting a profound deficiency in relevant education and communication programmes. However, findings suggest that sufficient HL is independently associated with students’ high level of awareness of antibiotic resistance. Therefore, incorporating awareness raising curricula and public health education campaigns are an urgent necessity. In addition, public health awareness programmes on antibiotic use, coupled with national policies for controlling access and prescription of antibiotics are strongly recommended.

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**Table 7** Logistic regression analyses results of factors associated with good level of knowledge of antibiotics and high level of awareness of antibiotic resistance

| Characteristic       | Good level of knowledge of antibiotics (vs poor level of knowledge) | High level of awareness of antibiotic resistance (vs not high level of awareness) |
|----------------------|---------------------------------------------------------------------|---------------------------------------------------------------------------------|
|                      | Unadjusted OR (95% CI) | P value | Adjusted OR (95% CI) | P value | Unadjusted OR (95% CI) | P value | Adjusted OR (95% CI) | P value |
| Age (years)          |                        |         |                      |         |                        |         |                      |         |
| 18–20                | 1                      | 0.057   | 1                    | 0.219   | 1                      | 0.319   | 1                    | 0.507   |
| ≥21                  | 1.5 (1.0 to 2.4)       | 0.6 (0.3 to 1.3) |                      |         | 1.4 (0.7 to 2.8)       | 0.7 (0.2 to 2.3) |                      |         |
| Gender               |                        |         |                      |         |                        |         |                      |         |
| Male                 | 1                      | 0.061   | 1                    | 0.064   | 1                      | 0.042   | 1                    | 0.095   |
| Female               | 1.6 (1.0 to 2.7)       | 1.6 (1.0 to 2.8) |                      |         | 2.5 (1.0 to 6.3)       | 2.2 (0.9 to 5.8) |                      |         |
| Residence            |                        |         |                      |         |                        |         |                      |         |
| Rural                | 1                      | 1       | 1                    |         | 1                      | 1       | 1                    |         |
| Suburban             | 1.2 (0.6 to 2.6)       | 0.645   | 1.1 (0.5 to 2.6)     | 0.8     | 1.9 (0.5 to 7.2)       | 0.326   | 1.7 (0.4 to 6.6)     | 0.483   |
| Urban                | 1.1 (0.5 to 2.1)       | 0.882   | 1.1 (0.5 to 2.3)     | 0.873   | 1.6 (0.5 to 5.5)       | 0.46    | 1.4 (0.4 to 5.1)     | 0.633   |
| Marital status       |                        |         |                      |         |                        |         |                      |         |
| Not married          | 1                      | 0.17    | 1                    | 0.31    | 1                      | 0.869   | 1                    | 0.178   |
| Married              | 2.0 (0.7 to 5.5)       | 1.7 (0.6 to 5.1) |                      |         | 0.8 (0.1 to 6.9)       | 0.2 (0.0 to 2.0) |                      |         |
| Academic year        |                        |         |                      |         |                        |         |                      |         |
| 1                    | 1                      | 1       | 1                    | 1       | 1                      | 1       | 1                    | 1       |
| 2                    | 1.7 (0.8 to 3.8)       | 0.181   | 1.8 (0.8 to 4.1)     | 0.186   | 0.7 (0.2 to 2.1)       | 0.474   | 0.5 (0.2 to 1.7)     | 0.278   |
| 3                    | 2.8 (1.3 to 5.8)       | 0.008   | 4.5 (1.7 to 11.8)    | 0.003   | 0.9 (0.4 to 2.8)       | 0.977   | 0.9 (0.2 to 4.1)     | 0.968   |
| 4                    | 3.0 (1.4 to 6.7)       | 0.007   | 4.4 (1.4 to 13.5)    | 0.009   | 2.1 (0.8 to 5.9)       | 0.149   | 2.6 (0.5 to 13.6)    | 0.245   |
| 5                    | 2.8 (0.5 to 5.8)       | 0.243   | 4.7 (0.7 to 31.4)    | 0.114   | 2.2 (0.2 to 21.3)      | 0.498   | 3.4 (0.2 to 50.9)    | 0.371   |
| Health literacy      |                        |         |                      |         |                        |         |                      |         |
| Insufficient         | 1                      | 1       | 1                    | 1       | 1                      | 1       | 1                    | 1       |
| Sufficient           | 1.2 (0.8 to 1.9)       | 0.444   | 1.2 (0.7 to 1.9)     | 0.55    | 2.7 (1.3 to 5.4)       | 0.006   | 2.8 (1.3 to 5.9)     | 0.008   |
| Antibiotic knowledge |                        |         |                      |         |                        |         |                      |         |
| Poor                 | 1                      | 1       | 1                    |         | 1                      |         | 1                    |         |
| Good                 | 4.2 (2.1 to 8.6)       | <0.001  | 4.2 (1.9 to 8.8)     | <0.001  | 1                      |         | 1                    |         |

Statistically significant P-values ≤0.05 are in bold.
Contributors AM conceptualised and designed the study, performed literature search, adapted the study tools, overseen pre-testing of the questionnaire, supervised study conduction, advised on data management, performed formal statistical data analysis, prepared the tables and figures, interpreted the data, wrote the final draft of the manuscript, and critically reviewed and edited it. The following authors have contributed equally in data collection and in searching the literature, in addition to their individual contributions: AA participated in conceptualisation of the study, participated in writing the first draft of results and in preliminary data analysis. SR participated in preliminary data analysis and writing the first draft of the introduction. SA participated in writing the first draft of the methods and discussion. SKA participated in writing the first draft of the discussion. SA participated in writing the first draft of the introduction. SAM participated in writing the first draft of the introduction and references.

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ORCID iDs
Aya Mostafa http://orcid.org/0000-0002-2803-2608
Abdurrahman Abdelzaher http://orcid.org/0000-0003-0721-4506
Salma Rashid http://orcid.org/0000-0002-5067-4412
Salma I Alkhawaga http://orcid.org/0000-0002-4993-2381
Shadwa K Alfli http://orcid.org/0000-0003-3481-3766
Shaimaa AbdelAlim http://orcid.org/0000-0001-6099-4287
Shaimaa A Mostafa http://orcid.org/0000-0003-1943-5453
Taha A Zidan http://orcid.org/0000-0001-5707-7285

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