

Article

University students' antibiotic use and knowledge of antimicrobial resistance: what are the common myths?

Nurul Shaheera Shahpawee¹; Li Ling Chaw¹; Siti Hanna Muharram¹; Poh Hui Goh¹; Zahid Hussain²; Long Chiau Ming^{1*}

¹ PAPRSB Institute of Health Sciences, Universiti Brunei Darussalam, Bandar Seri Begawan, Brunei;

² Faculty of Health, University of Canberra, Canberra, Australia

* Correspondence: long.ming@ubd.edu.bn

Abstract: We aimed to assess antibiotic usage and knowledge regarding antibiotics and antimicrobial resistance (AMR) among undergraduate students of Universiti Brunei Darussalam (UBD), public university located in Brunei Darussalam. A cross-sectional study was performed using a self-administered questionnaire. The questionnaire was adapted from the World Health Organization (WHO) Antibiotic Resistance, Multi-country public awareness survey distributed online. Students at UBD were invited to participate in the online survey through internal email. The questionnaire consisted of 5 sections: demographic information, antibiotic usage, knowledge on antibiotics, antibiotic resistance (AMR) and use of antibiotics in agriculture. Data were analyzed descriptively and appropriate inferential statistics was used accordingly. A total of 145 students returned the complete questionnaire. The result of the study found that 50% of the students had good level of knowledge of antibiotic and antimicrobial resistance with a mean total knowledge score of 11.4 out of 14. Of note, 76% of the respondents mistakenly believed that antibiotic resistance is the result of the body becoming resistant to antibiotics. Only 12% of the respondents were found to have poor knowledge in the study. Misconceptions in regards to the use of antibiotics for conditions related to viral illnesses was noticed among the respondents in our study. Thus, improving knowledge on antibiotics is crucial to address those beliefs.

Keywords: Cross-Sectional Survey; Antibiotic use; Antimicrobial Resistance; Knowledge; Brunei;

1. Introduction

The abuse and excessive utilization of antibiotics have led to the rise of antimicrobial resistance (AMR) which possessed a major threat to individual health globally [1]. At least 700,000 deaths globally a year has been caused by drug-resistant diseases and the rate of mortality was predicted to grow to 10 million deaths per year by 2050 [2,3]. In Asia alone, an estimation of 4.73 million deaths annually will be attributed to AMR by 2050 [4].

Antimicrobial can be defined as a group of drugs that is effective against microorganisms that include antibiotics, antifungals, antivirals and antiparasitic whereas antibacterial refers to any agent that is directed against bacteria [5]. Bacterial infections can be prevented and treated with medicines called antibiotics [6]. The antibacterial agent only acts upon bacteria, but antibiotics can work on both bacteria and fungus.

AMR occurs when microorganisms such as bacteria develop resistance to an antimicrobial agent. Due to the emergence of resistance, the ability to treat various infectious diseases become less effective thus causing treatment failure, increasing health care cost and even lead to death [7].

Factors causing the growth of resistance could be due to limited knowledge and awareness on antibiotics, as well as inadequate education regarding antibiotic usage by the prescriber [8]. Inappropriate use such as incomplete antibiotic treatment, reuse of leftover medicines, mistakenly taking antibiotics for the treatment of viral infections, self-medication and skipping of doses have been reported [9]. Indeed, many studies implied that patients sometimes not fully comply with antibiotic regimen [10–12] which may result in the failure of treating the condition as well as resistance [13]. Furthermore, patient-doctor relationship also caused the unnecessary prescribing by the general practitioner. In a survey conducted in United Kingdom which were carried out on 1000 GPs revealed that 55% of them prescribe antibiotics because they felt under pressure [14]. Patients' expectation is also an important factor for inappropriate antibiotic prescribing [15]. This could lead to the rise of antibiotic misprescribing and/or overprescribing further impacting on the development of resistance. Thus, it is important to address one's knowledge and belief on a proper antibiotic usage hence stopping the misconceptions and expectations of using antibiotics to treat minor illnesses [16].

According to the national statistics, the total population in Brunei Darussalam as of 2019 was 459,500 [17]. Brunei has four public hospitals, one each at the four districts: Brunei/Muara, Tutong, Belait and Temburong, with Brunei/Muara district is categorized as urban area. Apart from the hospital, the Ministry of Health and Ministry of Defence also provide fourteen health centres, and eight medical clinics respectively. The private health services comprised of two hospitals, one health centre and thirty three health clinics [18]. The healthcare access and quality index of Brunei was 76.4 in 2016 which was higher than the neighbouring countries Malaysia, and Indonesia but lower than that of Singapore [19]. There are sixteen doctor per 10,000 population in Brunei [18] which is slightly higher when compared to the neighbouring country, Malaysia (11 doctor per 10,000 population) [20].

The total antibiotic consumption in Brunei ranged from 5.9 DDD per 1000 inhabitants per day but this value is low due to the incomplete coverage and it only represents the use in public health [21]. The most commonly utilized was beta lactam antibiotics which represent 70% of the total consumption [21]. Under the Brunei Medicines Order 2007, all antimicrobials are categorized as prescription-only medicines where they can only be prescribed by registered medical practitioners, dentists or veterinarians [22]. All products containing antibiotics, including eye drop, cream and oral dosage forms required a prescription for dispensing by a pharmacist [22]. Although antibiotics are obtained only by prescription, educating the public on the proper usage of antibiotics is still vital to ensure the successful treatment and as a prevention measure from the spread of resistance. Hence, Good antibiotic prescribing practice (GAPP) is employed as one of the approach in antibiotic stewardship programme. Brunei implemented the guidance document for national antibiotic prescribing practice which was made effective in 2019. Brunei also joined the national action plan which is listed in the Ministry of Health 2019-2023 strategic plan on antimicrobial resistance that aligned with the WHOGAP [23]. The five year strategic plan will ensure that the antimicrobial resistance is decreased while ensuring effective treatment and prevention are in place [23]. The Brunei AMR Action Plan consisted of four strategic objectives which include i) awareness and education, ii) surveillance and research, iii) infection prevention and control, and iv) optimize the use of antimicrobials. These objectives are in line with the WHOGAP action plan and 'One Health' approach to antimicrobial resistance.

In addition, the World Health Organization Global Action Plan (WHOGAP) on antimicrobial resistance has been implemented in 2015 in which the main goal is to ensure the antimicrobial agents are used rationally and to prevent infectious diseases with the use of effective and safe medicines where its quality is assured, used properly and accessible to all who are in need [21].

To the best knowledge of the author, there are no documented Bruneian study assessing the knowledge on and perception of antibiotics. Ministry of Health of Brunei often rely on data of the

neighboring countries as a yardstick in planning public health campaign. Thus, this study is aimed to explore antibiotic usage and knowledge regarding antibiotics and antimicrobial resistance (AMR) among Bruneian population, targeting specifically on undergraduate students. This study could provide a baseline data in future intervention and public health campaigning on antibiotic usage and antimicrobial resistance.

2. Materials and Methods

2.1 Study Design

This was a cross-sectional online survey study conducted from March to April 2020. The study involved undergraduate students from Universiti Brunei Darussalam. The criteria for the eligibility of the study include (i) adult (above 18 years old), and (ii) able to read and understand Malay or English language. Participants who are not willing to participate are excluded from the study.

E-mail invitation was initially mailed to the Academic Registrar at the Institute of Health Sciences then it was forwarded to all Registrar from various faculties in Universiti Brunei Darussalam. Data were collected from an online survey questionnaire. E-mail invitation for participation containing online survey link and the information sheet of participants were disseminated to the targeted participants. To increase the response rate, reminder e-mails were forwarded twice to the contact person following a two weeks interval. Other than reminder emails, the survey was also distributed through whatsapp application among the students as a reminder.

2.2 Sample Size Calculation

Raosoft web site is used to calculate the sample size with a confidence level set to 95% and 5% of margin of error [24]. Assuming a minimum population of 410, a sample of 199 participants will be sought. The number required was calculated based on proportional ratio.

2.3 Study Instrument

The questionnaire was adapted from a questionnaire based on the World Health Organization (WHO) Antibiotic Resistance, Multi-country public awareness survey [25]. This questionnaire is preferred for the study because it has been used previously by WHO and it contains relevant topics which cover the use of antibiotics, knowledge on antibiotics and antimicrobial resistance. Permission for reprinting and reproducing of the survey has been acquired from WHO.

The online questionnaire was displayed in English, which is the medium of instruction in the university and the questions were mostly closed-ended based. The questionnaire consisted of 5 sections comprising of (i) A: basic demographic data of the participants which include age, gender, nationality, years of study and faculty, (ii) B: Antibiotic use: 3 questions on the prior use of antibiotics, advice received and the place obtaining them, (iii) C: Knowledge on antibiotics: 4 questions about the treatment duration, knowledge on sharing of antibiotics, disease conditions which require antibiotics, (iv) D: Knowledge on antibiotic resistance: 5 questions commonly used terms related to AMR; 8 True/False statements regarding knowledge of AMR; 8 statements related to AMR measured using a five-point "Likert scale" of agreement where 1 denotes disagree strongly, 2 for disagree slightly, 3 for neither agree nor disagree, 4 for agree slightly and 5 for agree strongly, (v) E: Antibiotic use in the

community: one question on antibiotic use in agriculture and food products. The questions from the section on knowledge of antibiotic and the True/False statements from knowledge on antibiotic resistance section were scored accordingly; 1 for each correct answer and 0 for incorrect or don't know. The knowledge score which comprised of 12 questions with 14 correct answers were then categorized into "Good" (≥ 10 correct answers), "Moderate" (6-9 correct answers), and "Poor" (< 6 correct answers).

2.4 Pilot Test

The questionnaire underwent a preliminary pilot testing with subsequent revisions conducted among 15 respondents for initial validation. Necessary adjustments were made based on the feedback received from the respondents before finalizing the questionnaire. Three questions about obtaining antibiotics from doctor or nurse, vaccination and washing hands were omitted from the original World Health Organization (WHO) Antibiotic Resistance, Multi-country public awareness survey as most antibiotics can only be obtained from medical practitioner and the latter were found to be out of the research topic. The face validity of the online questionnaire was also assessed for readability, length and relevance of the questions amongst two pharmacists with postgraduate qualifications at the Institute of Health Sciences, UBD.

The internal consistency of the survey questions was determined using Cronbach's alpha coefficient. The Cronbach's alpha of the section on antibiotic use and knowledge were 0.66 and 0.86 respectively.

2.5 Data Analysis

The collection of data by the web-based survey's database was exported into Microsoft Excel or appropriate software. Data analysis was done using RStudio Statistical software and Microsoft Excel. The data was summarized using descriptive statistics which include the percentages, frequencies and also mean. Appropriate inferential statistics was also used according to the data distribution.

2.6 Ethical Approval

The study received ethics approval from the Pengiran Anak Puteri Rashidah Institute of Health Sciences Research Ethics Committee, Universiti Brunei Darussalam. All participants were notified about the aims of the study and all data collected were to be remained anonymous and the confidentiality was strictly maintained. Written consent form was provided in the survey by ticking an option placed at the end of cover letter prior to the distribution of questionnaire. The study was on a voluntary basis and respondents had the freedom of not participating in the online survey.

3. Results

3.1 Demographic Data

A total of 145 respondents returned the completed questionnaire yielding a response rate of 35%. The median age of the respondents was 22.1 years (SD=2.8, range between 18 and 35). The majority of the respondents were female (78%) and Bruneian (99%). The proportions of the students in relation to the year of study (year 1- year 4) were 28%, 21%, 26% and 26%. The students were mostly from Faculty of Science (31%), Health Sciences (45%), Arts and Social sciences (8%), School of business and economics (6%) and Institute of Education (10%). The characteristics of the respondents are presented in Table 1.

Table 1 Demographic data of study respondents.

Demographic Data		Frequency (n)	Percentage (%)
Gender	Male	32	22
	Female	113	78
Age	18-21	68	47
	22-25	60	41
	26-29	14	10
	≥ 30	3	2
Nationality	Bruneian	143	99
	International	2	1
Place of resident	Urban	112	78
	Suburban	31	22
Year of Study	Year 1	40	28
	Year 2	30	21
	Year 3	37	26
	Year 4	38	26
Faculty	PAPRSB Institute of Health Sciences (IHS)	65	45
	Faculty of Science (FOS)	45	31
	Sultan Hassanal Bolkiah Institute of Education (SHBIE)	15	10
	Faculty of Arts and Social Sciences (FASS)	12	8
	School of Business and Economics (SBE)	8	6

3.2 Antibiotic Usage

The results obtained for antibiotic use (Table 2) showed that 69% of the students reported the previous use of antibiotic. More than half of the students obtained directions on taking antibiotics from a healthcare professional (82%) and 12% did not get advice. The source of antibiotics were mostly acquired from public (57%) and private hospital (31%) or health clinic as it can only be prescribed by the doctor. However, few of the students reported getting antibiotic from friend or family member (4%), and 3% of them had the antibiotics saved up from the previous use.

Table 2 Experience of study participants in antibiotic usage.

Statements	Frequency (n)	Percentage (%)
When did you last take antibiotics?		
In the last month	25	17
In the last 6 months	26	18
In the last year	16	11
More than a year ago	33	23
Never	9	6
Can't remember	36	25
Did you get advice from a doctor, nurse or pharmacist on how to take them?		
Yes	111	82
No	16	12
Can't remember	9	7
On that occasion, where did you get the antibiotics?		
Public hospital/health clinic	78	57
Private hospital/clinic	42	31
Pharmacy	5	4
The internet	0	0
Friend or family member	5	4
I had them saved up from a previous time	4	3
Somewhere/someone else	0	0
Can't remember	2	1

3.3 Knowledge About Antibiotics and Antimicrobial Resistance

Half of the students (50%) showed a good level of knowledge (score more than 10) on antibiotics and antimicrobial resistance with a mean total knowledge score of 11.4 out of 14. Only 12% of the students scored below 6. Fisher exact test revealed that level of knowledge of the students was significantly different in relation to age ($P=0.003$) but not between gender, nationality, district, year of study and faculty (Table 3). Good knowledge was found in students aged between 18 and 21 years old ($P=0.003$).

Table 3 Association of demographic characteristics with level of knowledge

Characteristics	Knowledge Score			P Value Fisher exact test	
	Good n (%)	Moderate n (%)	Poor n (%)		
Gender	Male	17 (24)	9 (16)	6 (33)	0.289
	Female	55 (76)	46 (84)	12 (67)	
Age	18-21	45 (63)	19 (35)	4 (22)	0.003*
	22-25	20 (28)	27 (49)	13 (72)	
	26-29	5 (7)	8 (15)	1 (6)	
	≥ 30	2 (3)	1 (2)	0	
Nationality	Bruneian	70 (97)	55 (100)	18 (100)	0.621
	International	2 (3)	0	0	
Place of Resident	Urban	54 (77)	41 (75)	17 (94)	0.2022
	Suburban	16 (23)	14 (25)	1 (6)	
Year of Study	Year 1	22 (31)	16 (29)	2 (11)	0.116
	Year 2	19 (26)	10 (18)	1 (6)	
	Year 3	16 (22)	13 (24)	8 (44)	
	Year 4	15 (21)	16 (29)	7 (39)	
Faculty	PAPRSB Institute of Health Sciences (IHS)	50 (69)	15 (27)	0	-
	Faculty of Science (FOS)	14 (19)	22 (40)	9 (50)	
	Sultan Hassanal Bolkiah Institute of Education (SHBIE)	6 (8)	9 (16)	0	
	Faculty of Arts and Social Sciences (FASS)	2 (3)	6 (11)	4 (22)	
	School of Business and Economics (SBE)	0	3 (5)	5 (28)	

*Statistically significant *P* value

Almost all students agreed that antibiotic should be taken full course as directed (90%). The frequency and the percentage of students for the statements regarding antibiotic use were presented in Table 4.

Table 4 Knowledge of study participants about antibiotics.

Question/Statements	Frequency (n)	Percentage (%)
When do you think you should stop taking antibiotics once you've begun treatment		
When you feel better	13	9
When you've taken all of the antibiotics as directed	131	90
Don't know	1	1
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		
True	8	6
False	130	90
Don't know	7	5
It's okay to buy the same antibiotics, or request these from a doctor, if you're sick and they helped you get better when you had the same symptoms before		
True	19	20
False	102	70
Don't know	14	10

A greater number of students correctly identified that antibiotics was used to treat bladder or urinary infection (UTI) (72%), skin or wound infection (67%) and gonorrhoea (39%) (Figure 1). Moreover, students incorrectly classified cold and flu (43%) and fever (41%) as conditions that can be treated with antibiotics. Similarly, the use of antibiotics was also reported to be appropriate for sore throat (46%) and diarrhoea (40%).

When asked about the terminology, students recognized with the terms related to antibiotic resistance (89%), drug resistance (79%), antibiotic-resistant bacteria (72%) and antimicrobial resistance (52%). However, the acronym AMR (24%) which stands for 'antimicrobial resistance' and superbugs (28%) were not well known among the students. The most common source of the terminology was from media (44%), followed by family member or friend including social media (40%), doctor (33%), nurse (18%), pharmacist (14%) and other include pre-university and university lectures and secondary schools (64%) (Figure 2).

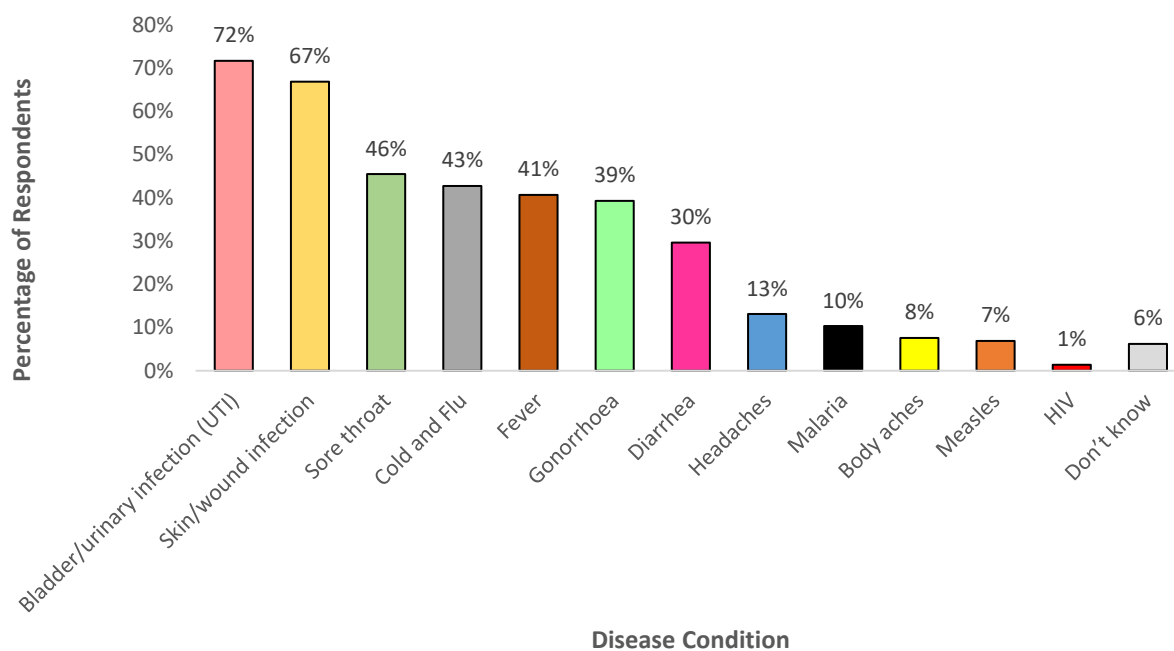


Figure 1 Percentages of respondents reported the appropriate use of antibiotics in the various disease conditions. HIV: Human immunodeficiency virus, UTI: Urinary tract infection

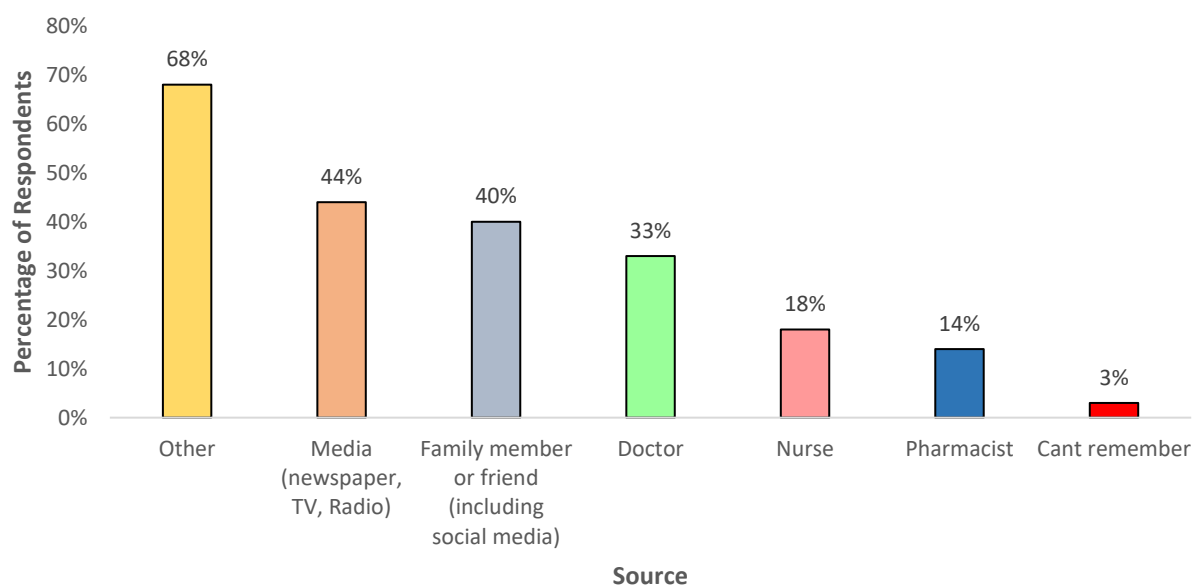


Figure 2 Percentages of respondents reported the sources of terminology

In terms of knowledge about antimicrobial resistance (Table 5), 76% of the students mistakenly considered that antibiotic resistance occurs when the body becomes resistant to antibiotics. Moreover, more than half of the respondents (84%) agreed that when bacteria are resistant to antibiotics, treatment of infections can be very difficult or impossible. Some disagreed (54%) with the statement 'antibiotic resistance is only a problem for people who take antibiotics regularly' but 15% of the respondents were not sure about it.

Table 5 Responses to various statements on antimicrobial resistance

Statement	Correct n (%)	Incorrect n (%)	Unsure n (%)
Antibiotic resistance occurs when your body becomes resistant to antibiotics and they no longer work as well	30 (21)	110 (76)	5 (3)
Many infections are becoming increasingly resistant to treatment by antibiotics	102 (70)	11 (8)	32 (22)
If bacteria are resistant to antibiotics, it can be very difficult or impossible to treat the infections they cause	122 (84)	10 (7)	13 (9)
Antibiotic resistance is an issue that could affect me or my family	109 (75)	17 (12)	19 (13)
Antibiotic resistance is an issue in other countries but not here	98 (68)	11 (8)	36 (25)
Antibiotic resistance is only a problem for people who take antibiotics regularly	78 (54)	45 (31)	22 (15)
Bacteria which are resistant to antibiotics can be spread from person to person	57 (39)	45 (31)	43 (30)
Antibiotic-resistant infections could make medical procedures like surgery, organ transplants and cancer treatment much more dangerous	97 (67)	7 (5)	41 (28)

3.4 Knowledge About Antibiotics Use in Agriculture and Food Producing Animals

Only few of the students (27%) reported that they were aware about the use of antibiotics in agriculture and food products in the country, and more than half (66%) of them were unsure about it.

4. Discussion

This study assessed the knowledge of antibiotics and antimicrobial resistance of the students. To the extent of author's knowledge, this is the first study carried out among Brunei university students.

A quite high degree of antibiotic consumption was evident in the study. Sources of antibiotics were mostly obtained from public and private hospital or health clinics as all antimicrobials in Brunei are classified as prescription only medicine unlike in many developing countries where antibiotics can be acquired without valid prescription which is commonly practiced among university students in China, India and Nigeria [22,26,27]. The greater antibiotic consumption could be due to the easy access of healthcare in Brunei which may cause excessive prescribing of antibiotics and this correlates with a study in Malaysia where the rates of antibiotic prescribing were indeed high in both public and private primary care setting [28]. Thus, the first National Antibiotic Prescribing published in 2019

was hope to minimize the unnecessary prescribing of antibiotics and to be adopted as a standard practice among all healthcare providers. This is in part in the shares of the principles of WHO's systematic approach to good prescribing practice in general which can help minimize poor-quality and incorrect prescribing [29]. This can also be used as a referral for the prescribers to practice and ensure the appropriateness of antimicrobial use. Further, Brunei also initiated a national strategic plan between 2019 and 2023 in tackling antimicrobial resistance which follow the World Organization (WHO). This was implemented to ensure appropriate education and awareness is provided to the public and reduce the growth of resistance in the country.

Moreover, a low number of the respondents were found not receiving advice on how to take antibiotics and the need to complete it full course. Those who did not obtain advice are more likely to stop taking antibiotics when they feel better which eventually leads to the growth of resistance in the community. Respondents also reported obtaining antibiotics from the previous use but the rate was lower than previous study in Malaysia (46/204), Qatar (161/596), China (1965/11,192), and Saudi Arabia (165/347) [30–33]. There were more female students than male in this study which is comparable to that in many other research [8,30,34]. Similarly, a few proportion of respondents shared antibiotic with their friends or family member which was also reported in Nigeria (5/400), UK (3/242), and Jordan (76/1158) [27,35,36]. The use of leftover and antibiotic sharing by the respondents portrayed the non-compliance with antibiotic therapy and this showed that knowledge on antibiotic use is still lacking. Hence, it is important for the healthcare provider to highlight the importance of taking antibiotic full course and advise them not to stop taking antibiotic when the condition is better. The healthcare professionals can also recommend the public to return the leftover antibiotics to prevent for future use, which is unsafe and hence, should be hindered. Pharmacist too can play a role in counselling the patients on the possible risk if the course of antibiotic therapy is incomplete.

Furthermore, most of the students demonstrated a good knowledge on antibiotics and antimicrobial resistance. Majority correctly identified conditions that can be treated with antibiotics namely bladder or urinary infection, skin or wound infection and gonorrhoea as suggested by the WHO in the antibiotic resistance survey. However, the misconceptions regarding the use of antibiotics for viral infection was also noted in the study which was consistent with findings from other study. The proportion was lower than in Jordan (527/1158), and Jatinangor, Indonesia (145/250), but higher than Italy (210/1050) [36–38]. Sore throat and diarrhoea were also reported appropriate for antibiotic use. Sore throat is a self-limiting viral illnesses which do not need the use of antibiotics and usually, it can be managed easily [39]. Lack of understanding on the difference between bacterial and viral infection could be the reason for the choices and this inappropriate choice can cause the development of resistance if their erroneous belief is not addressed. In addition, respondents were aware of the terminology used related to antimicrobial resistance but not the acronym AMR and superbug. The reason for this is not known but most likely because the acronym is rarely used to describe antibiotic or antimicrobial resistance in Brunei and the word “bug” is also not commonly used to portray the term like germs, bacteria or virus. Pre-university and university lectures were the main source where they heard about the term because most of the respondents in this study were mostly from science background. As for knowledge on antimicrobial resistance, more than half of the respondents mistakenly viewed that antibiotic resistance occur due to the body becomes resistant to antibiotics

while in fact, it is the bacteria that is resistant to the antibiotic and this was also seen in a study in Sri Lanka [40].

This study has several limitations. The study response rate was 35% which was quite low despite sending the reminder emails twice to achieve a good response rate. Thus, respondents may not be representative of the population surveyed. Other limitations of the study include the potential of response bias as the findings of the survey was solely based on self-reported data.

5. Conclusions

Although good level of knowledge was found in this study, there are still gaps in areas on antibiotic use, especially the part on the appropriate antibiotic use for certain disease condition as some mistakenly considered antibiotic therapy for viral conditions. Awareness of the proper use of antibiotics among the students is greatly required to correct their misconceptions and prevent the rise of antimicrobial resistance.

Author Contributions: Conceptualization, Siti Hanna Muharram and Long Chiau Ming; Data curation, Nurul Shaheera Shahpawee; Formal analysis, Li Ling Chaw; Funding acquisition, Nurul Shaheera Shahpawee; Methodology, Li Ling Chaw, Siti Hanna Muharram and Poh Hui Goh; Supervision, Li Ling Chaw, Siti Hanna Muharram, Poh Hui Goh and Long Chiau Ming; Writing – original draft, Nurul Shaheera Shahpawee; Writing – review & editing, Li Ling Chaw, Siti Hanna Muharram, Poh Hui Goh, Zahid Hussain and Long Chiau Ming.

Funding: This research received no external funding

Acknowledgments: The authors would like to acknowledge the Faculty Registrar of FOS, PAPRSBIHS, FASS, SHBIE and SBE for disseminating the survey and thank all the students for returning the completed questionnaire.

Conflicts of Interest: The authors declare no conflict of interest

References

1. Shallcross, L.J.; Howard, S.J.; Fowler, T.; Davies, S.C. Tackling the threat of antimicrobial resistance: From policy to sustainable action. *Philos. Trans. R. Soc. B Biol. Sci.* **2015**, *370*, doi:10.1098/rstb.2014.0082.
2. O'Neill, J. *Tackling Drug-Resistant Infections Globally: Final Report And Recommendations*; 2016.
3. Interagency Coordination Group on Antimicrobial Resistance. No time to wait: Securing the Future fro Drug-Resistant Infections. **2019**.
4. O'Neill, J. *Antimicrobial Resistance: Tackling a crisis for the health and wealth of nations*; 2014.
5. WHO. What is the difference between antibiotic and antimicrobial resistance? Available online: <http://www.emro.who.int/health-topics/drug-resistance/what-is-the-difference-between-antibiotic-and-antimicrobial-resistance.html> (accessed on Dec 17, 2019).
6. CDC. How Antibiotic Resistance Happens Available online: <https://www.cdc.gov/drugresistance/about/how-resistance-happens.html> (accessed on Feb 5,

- 2020).
7. WHO. *Global Antimicrobial Resistance Surveillance System (GLASS) Report*; 2017; ISBN 9789241513449.
 8. Hassali, M.A.; Arief, M.; Saleem, F.; Khan, M.U.; Ahmad, A.; Mariam, W.; Bheemavarapu, H.; Syed, I.A. Assessment of attitudes and practices of young Malaysian adults about antibiotics use: A cross-sectional study. *Pharm. Pract. (Granada)*. **2017**, *15*, 1–7, doi:10.18549/PharmPract.2017.02.929.
 9. Ayele, Y.; Jifar, Al. Assessment of Knowledge, Attitude, and Practice toward Antibiotic Use among Harar City and Its Surrounding Community, Eastern Ethiopia. *Interdiscip. Perspect. Infect. Dis.* **2018**, doi:10.1186/s40545-018-0155-9.
 10. Tong, S.; Pan, J.; Lu, S.; Tang, J. Patient compliance with antimicrobial drugs: A Chinese survey. *Am. J. Infect. Control* **2018**, *46*, e25–e29, doi:10.1016/j.ajic.2018.01.008.
 11. Ss, G.; Macit, C.; Mercanoglu, G.; Taner, N.; Pm, C. A Cross-Sectional Study from Turkey : The Impact of Community Pharmacist Let Educational Intervention on Adherence to Antibiotic Therapy. *Res. Rev. J. Pharm. Pharm. Sci.* **2016**, *5*, 29–37.
 12. Kardas, P. Noncompliance in current antibiotic practice. *Infect. Dis. Clin. Pract.* **2006**, *14*, 11–14, doi:10.1097/01.idc.0000230544.11499.8b.
 13. Grosso, G.; Marventano, S.; Ferranti, R.; Mistretta, A. Pattern of antibiotic use in the community: Non-adherence and self-prescription rates in an Italian urban population. *Mol. Med. Rep.* **2012**, *5*, 1305–1310, doi:10.3892/mmr.2012.818.
 14. Machowska, A.; Lundborg, C.S. Drivers of irrational use of antibiotics in Europe. *Int. J. Environ. Res. Public Health* **2019**, *16*, doi:10.3390/ijerph16010027.
 15. Gaarslev, C.; Yee, M.; Chan, G.; Fletcher-Lartey, S.; Khan, R. A mixed methods study to understand patient expectations for antibiotics for an upper respiratory tract infection. *Antimicrob. Resist. Infect. Control* **2016**, *5*, 1–9, doi:10.1186/s13756-016-0134-3.
 16. Choo, S.J.; Chang, C.T.; Lee, J.C.Y.; Munisamy, V.; Tan, C.K.; Raj, J.D.; Mat Taib, R.I.; Thong, K.S.; Shafie, A.A. A cross-sectional study on public belief, knowledge and practice towards antibiotic use in the state of Perak, Malaysia. *J. Infect. Dev. Countries* **2018**, *12*, 960–969, doi:10.5001/omj.2013.95.
 17. Ministry of Finance and Economy Brunei Darussalam. Department of Economic Planning and Statistics - National Statistics Available online: <http://www.deps.gov.bn/SitePages/NationalStatistics.aspx> (accessed on May 7, 2020).
 18. Ministry of Health Brunei Darussalam. *Health Information Booklet 2017*; 2017.
 19. GBD Healthcare Access and Quality Collaborators Measuring performance on the Healthcare

- Access and Quality Index for 195 countries and territories and selected subnational locations : a systematic analysis from the Global Burden of Disease Study 2016. *Lancet* **2018**, 391, doi:10.1016/S0140-6736(18)30994-2.
20. Ministry of Health Malaysia Annual Report 2017. **2017**.
 21. Geneva: World Health Organization *WHO report on surveillance of antibiotic consumption: 2016-2018 early implementation.*; 2018; ISBN 9789241514880.
 22. Brunei Ministry of Health; Ministry of Primary Resources and Tourism. *Brunei Darussalam Antimicrobial Resistance National Action Plan*; 2019.
 23. Brunei Ministry of Health. *Strategic Plan 2019-2023*; 2019.
 24. Raosoft Inc. Raosoft Sample Size Calculator Available online: http://www.raosoft.com/sample_size.html (accessed on May 14, 2020).
 25. WHO. *Antibiotic Resistance: Multi-Country Public Awareness Survey*; 2015.
 26. Pan, H.; Cui, B.; Zhang, D.; Farrar, J.; Law, F.; Ba-Thein, W. Prior knowledge, older age, and higher allowance are risk factors for self-medication with antibiotics among University students in Southern China. *PLoS One* **2012**, 7, doi:10.1371/journal.pone.0041314.
 27. Sanya, T.E.; Fakeye, T.O.; Adisa, R.; Segun, J.S. Use of antibiotics among non-medical students in a Nigerian University. *Afr. Health Sci.* **2013**, 13, 1149–1155, doi:10.4314/ahs.v13i4.41.
 28. Ab Rahman, N.; Teng, C.L.; Sivasampu, S. Antibiotic prescribing in public and private practice: A cross-sectional study in primary care clinics in Malaysia. *BMC Infect. Dis.* **2016**, 16, 1–8, doi:10.1186/s12879-016-1530-2.
 29. Brunei Ministry of Health. National Best Practice Guidance For Good Antibiotic Prescribing Practice (GAPP). **2019**.
 30. Aljayyousi, G.F.; Abdel-Rahman, M.E.; El- Heneidy, A.; Kurdi, R.; Faisal, E. Public practices on antibiotic use: A cross-sectional study among Qatar University students and their family members. *PLoS One* **2019**, 14, 1–22, doi:10.1371/journal.pone.0225499.
 31. Haque, M.; Rahman, N.A.A.; McKimm, J.; Sartelli, M.; Kibria, G.M.; Islam, M.Z.; Lutfi, S.N.N.B.; Othman, N.S.A.B.; Abdullah, S.L.B. Antibiotic use: A cross-sectional study evaluating the understanding, usage and perspectives of medical students and pathfinders of a public defence university in Malaysia. *Antibiotics* **2019**, 8, 154, doi:10.3390/antibiotics8030154.
 32. Wang, X.; Lin, L.; Xuan, Z.; Li, L.; Zhou, X. Keeping Antibiotics at Home Promotes Self-Medication with Antibiotics among Chinese University Students. *Int. J. Environ. Res. Public Heal. Artic.* **2018**, 1–13, doi:10.3390/ijerph15040687.
 33. Zaidi, S.F.; Alotaibi, R.; Nagro, A.; Alsalmi, M.; Almansouri, H.; Khan, M.A.; Khan, A.; Memon,

- I. Knowledge and Attitude Towards Antibiotic Usage: A Questionnaire-Based Survey Among Pre-Professional Students at King Saud bin Abdulaziz University for Health Sciences on Jeddah Campus, Saudi Arabia. *Pharmacy* **2020**, *8*, 5, doi:10.3390/pharmacy8010005.
34. Sakeena, M.H.F.; Bennett, A.A.; Carter, S.J.; McLachlan, A.J. A comparative study regarding antibiotic consumption and knowledge of antimicrobial resistance among pharmacy students in Australia and Sri Lanka. *PLoS One* **2019**, *14*, 1–14, doi:10.1371/journal.pone.0213520.
35. Dyar, O.J.; Hills, H.; Seitz, L.T.; Perry, A.; Ashiru-Oredope, D. Assessing the knowledge, attitudes and behaviors of human and animal health students towards antibiotic use and resistance: a pilot cross-sectional study in the UK. *Antibiotics* **2018**, *7*, 1–8, doi:10.3390/antibiotics7010010.
36. Abu-Helalah, M.; Alshraideh, H.; Hijazeen, J.; Al-Zu, A.; Abu Hassan, W.; Al-Sbou, M. Antibiotics Use and Misuse among University Students in Jordan. *Bull. Env.Pharmacol. Life Sci* **2015**, *4*, 62–71.
37. Fimanggara, B.; Istriati, I.; Diposarosa, R. Knowledge and Attitude towards Antibiotic Use among College Students in Jatinangor. *Althea Med. J.* **2016**, *3*, 269–274, doi:10.15850/amj.v3n2.792.
38. Scaioli, G.; Gualano, M.R.; Gili, R.; Masucci, S.; Bert, F.; Siliquini, R. Antibiotic Use: A cross-sectional survey assessing the knowledge, attitudes and practices amongst students of a school of medicine in Italy. *PLoS One* **2015**, *10*, 1–12, doi:10.1371/journal.pone.0122476.
39. Kumar, S.; Little, P.; Britten, N. Why do general practitioners prescribe antibiotics for sore throat? Grounded theory interview study. *Br. Med. J.* **2003**, *326*, 138–141, doi:10.1136/bmj.326.7381.138.
40. Sakeena, M.H.F.; Bennett, A.A.; Jamshed, S.; Mohamed, F.; Herath, D.R.; Gawarammana, I.; McLachlan, A.J. Investigating knowledge regarding antibiotics and antimicrobial resistance among pharmacy students in Sri Lankan universities. *BMC Infect. Dis.* **2018**, *18*, 1–11, doi:10.1186/s12879-018-3107-8.