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A population survey of public knowledge, attitudes and practices related to antibiotic use and resistance in Singapore

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Abstract

Background
The WHO's Global Action Plan on Antimicrobial Resistance includes increasing overall public awareness of appropriate antibiotic use and antimicrobial resistance as a key priority area. However, little is currently known about the drivers of antibiotic use in primary care and the general population. We aimed to measure public knowledge, attitudes and practices of antibiotics and antibiotic resistance in Singapore, providing baseline data against which to measure the progress of future interventions.

Methods
Between May and June 2019, we conducted a survey via an online panel in Singapore with a total of 706 participants to measure public perceptions of antibiotics and antibiotic resistance as well as their healthcare seeking behaviours for the common cold and flu.

Results
Our findings showed that while respondents indicated high levels of awareness of appropriate antibiotic use, there were common misconceptions surrounding antibiotic effectiveness and mechanisms of antibiotic resistance. In multivariable analyses, better knowledge about antibiotics and antibiotic resistance were associated with more favourable antibiotic attitudes. In addition, more favourable attitude scores were associated with lower odds of both expecting and being prescribed antibiotics by a primary care doctor.

Conclusions
This study presents important information about population perceptions towards antibiotics and antibiotic resistance in Singapore. Results from this study emphasise the importance of effective public communication strategies to promote responsible antibiotic use locally and should be used to inform future implementation of programmes and activities as laid out in Singapore's National Strategic Action Plan on AMR.

Word count: 239

Keywords: antimicrobial resistance, antibiotic use, population survey,

Strengths and limitations of this study

- This is the first population-level study on public knowledge, attitudes and practices of antibiotics and antibiotic resistance in Singapore. Findings from this study provide baseline information against which to measure the progress of future antibiotic interventions.
- Results from this study emphasise the importance of raising population awareness surrounding effective antibiotic use, as well as the mechanisms of antibiotic resistance. Further key resources beneficial to prescribers include standardised clinical practice guidelines, educational resources and diagnostic tools at points of care.
- A potential limitation of our study is that respondents in online surveys may not be fully representative of the general population. This may affect the generalisability of our results.

Introduction

One of five key priority areas highlighted in the World Health Organization's Global Action Plan on Antimicrobial Resistance (AMR) is the improvement of overall public awareness of antibiotics and antimicrobial resistance to promote effective behavioural change population-level antibiotic use.[1] Research on the drivers of antibiotic use in several countries highlights widespread misconceptions among the public regarding appropriate use of antibiotics and the development of antibiotic resistance, showing that less antibiotic knowledge is often associated with unfavourable antibiotic use behaviours, such as self-medication with antibiotics or sharing leftover antibiotics with others.[2] These findings are supported by qualitative studies indicating that the general public is unfamiliar with technical terms such as "antimicrobial resistance", that they feel they "know" when they need antibiotics, and that antibiotic prescription is often viewed as a form of validation for their illness. [3–5]

Singapore is a high-income, city state in Asia with a comprehensive system of hybrid public and private primary, secondary and tertiary health care. Antibiotic resistance is an increasing concern not only in acute care hospitals[6,7] but also in the community[8], an indicator of inappropriate antibiotic consumption. Although antibiotics can be obtained only via prescription by licensed healthcare professionals[9], patients seeking primary health care for upper respiratory tract infections are commonly misinformed about the role of antibiotics in the treatment of viral infections and often seek primary care expecting antibiotics from a medical professional[10].

The development of the WHO's Global Action Plan on AMR and subsequent national action plans[11] serves to complement existing strategies and to prioritise future AMR interventions in both healthcare institutions and the community in preserving antimicrobial effectiveness. To measure the progress of future interventions, as well as to yield evidence-based insights[12] into effective public communication strategies to promote responsible antibiotic use, we conducted an online population survey in Singapore to measure public perceptions of antibiotics and antibiotic resistance.

Methods

Study design + data collection

Survey respondents were participants in an online survey panel recruited and maintained by the Singapore Population Health Improvement Centre (SPHERiC) within the National University Health System. Members of the public are eligible to be part of the online survey panel if they are community-dwelling Singapore Citizens or Permanent Residents, aged 21 and above, English-literate, frequent users of web-based services and if they have a personal email account.

From 23 May to 1 June 2019, 1,001 SPHERiC panel members were invited to participate in the survey via an online link in an email or SMS notification. The survey was available to panel members for 10 days. A reminder notification was sent to panel members who did not respond to the first notification within five days. The self-completed survey was administered in English using RedCap software[13] and took approximately 10-15 minutes to complete. Participants received a reimbursement of SGD5 (~USD3.70) for completing the survey. Survey data were provided by SPHERiC to the research team in an anonymised form for analysis.

Survey questionnaire

The questionnaire consisted of six sections, eliciting information from respondents about their sociodemographic characteristics (8 questions), knowledge about the effectiveness of antibiotics (5 questions), knowledge about the mechanisms of antibiotic resistance and the spread of antibiotic-resistant infections (12 questions), attitudes toward appropriate antibiotic use (9 questions),

antibiotic practices in relation to the last time they had an acute respiratory illness (11 questions), as well as their healthcare seeking behaviours (17 questions) (**Appendix A**).

The questionnaire was developed by reviewing available questionnaires from previously published surveys[14,15]. Additionally, to enhance cross-country comparability, questions about antibiotic resistance were taken from the WHO country survey[16]. To ensure that questions in the survey were well understood and adapted to the local context, the questionnaire was field tested with 29 individuals over a period of six days.

Ethics approval

This study was approved by the institutional review board of the National University of Singapore (reference number: B-16-269).

Data analysis

We assessed representativeness of the survey sample by comparing respondents' sociodemographic characteristics with the Singapore Census of Population[17]. We then assessed respondents' general awareness toward antibiotics by tabulating variables related to antibiotic effectiveness, resistance and appropriate use. We also tabulated respondents' practices in relation to antibiotic use for common respiratory illnesses.

We assigned each respondent a knowledge and attitude score based on the number of correct or favorable responses in the respective sections (**Appendix B**). All knowledge and attitude questions had three response options: "Agree", "Disagree" or "Not sure". Correct knowledge and favourable attitude responses were assigned 1 point while incorrect or unfavourable responses scored 0 points.

Respondents' antibiotic practice responses during their last consultation with a primary care provider for acute respiratory illness were dichotomised into: 1) whether respondents expected antibiotics from their doctor (yes = 1; no = 0), 2) whether they asked their doctor for antibiotics (yes = 1; no = 0), and 3) whether they were prescribed antibiotics by their doctor (yes = 1; no = 0).

We first investigated the respective relationships between respondents' sociodemographic characteristics and their antibiotic knowledge and attitude scores using a multivariable linear (Gaussian) regression. Sociodemographic explanatory variables included age group, gender, housing type, household income, education, ethnicity and marital status.

In subsequent regression analyses, we investigated the association between antibiotic practices and antibiotic knowledge and attitudes scores using a multivariable linear (Gaussian) regression, controlling for sociodemographic variables. We then conducted separate multivariable logistic regressions to investigate whether respondents' attitudes scores were associated with each of the three antibiotic practices as outcome variables: 1) whether respondents expected antibiotics, 2) whether they asked for antibiotics and 3) whether they were prescribed antibiotics. We summarised associations using adjusted odds ratios and corresponding 95% confidence intervals (CI). Regression residual distributions can be found in **Appendix C.**

All data were analysed using R version 3.6.1.[18]

Results

Of 1,001 eligible panel members, 706 (70.5%) completed the survey. Respondents had a median age of 44 years (range: 22 – 86 years). Four hundred (56.7%) respondents were female and 306 (43.3%)

were male. Most respondents were married (60.8%) and had higher than secondary education (78.0%). The survey sample had a similar gender and ethnic group composition compared to the Singapore Census of Population[17] but had slightly lower proportions of individuals who lived in private housing (i.e. condominium, landed property) and a higher proportion of individuals with a university education (**Table 1**).

Descriptive analysis

Tabulations and frequencies of the descriptive analysis are shown in **Table 2**.

Awareness of antibiotic effectiveness

Almost all the respondents (97.5%) had heard of the term "antibiotics" before. When asked if antibiotics were effective against bacterial infections and viral infections, only about a third of the respondents (35.6%) answered both questions correctly. A large proportion of respondents believed that antibiotics could help to speed up recovery from the common respiratory illness (35.4%), or alleviate serious symptoms associated with these illnesses (45.2%).

Awareness of antibiotic resistance

Among respondents, 60.5% reported having heard of the term "antibiotic resistance", but only 11% had heard of the abbreviation "AMR". About half of the respondents were aware that resistance occurs when bacteria become resistant to the antibiotics. However, many respondents also thought that resistance occurs when our bodies become resistant to antibiotics (62.5%) or when antibiotics become less powerful (48.5%).

There was also lower awareness among respondents about how antibiotic-resistant infections could spread or affect common conditions. More than half (56.1%) either disagreed or were not sure that antibiotic resistance can affect the treatment of common infections such as sore throat and urinary tract infection. More than a third of respondents (39.7%) believed that their own use of antibiotics does not have any impact on other people's chances of acquiring antibiotic-resistant infections, and that they do not have to worry about getting antibiotic-resistant infections as long as they use antibiotics appropriately themselves (44.5%). Overall, respondents agreed that interventions to reduce AMR include implementing better infection control measures in hospitals (76.2%) and using fewer antibiotics (71.9%), although a lower percentage recognized hand hygiene (61.7%) and vaccination (59.5%) as important interventions.

Awareness on how to use antibiotics responsibly

There was generally high awareness about appropriate practices in sharing antibiotics – respondents generally agreed that it is inappropriate to share antibiotics with family and friends when they are sick with either same (84.3%) or different (92.4%) symptoms. Respondents were also reluctant to share antibiotics with their household pets – only 1% thought it was appropriate to do so.

Less than 10% of the respondents said that they felt comfortable keeping leftover antibiotics for future use. While over 90% of the respondents agreed that it is important to always finish the course of antibiotics prescribed, a small proportion of respondents believed that they do not have to finish a prescribed course of antibiotics when they feel better (7.9%) or when they have an alternative remedy (8.2%).

Cold/flu practices

We asked respondents what they did the last time they had symptoms of the common cold or flu (**Figure 1**). Of the 706 respondents, 50.6% chose to see a doctor. The rest chose to take extra rest (29.7%), over-the-counter medication (20.1%), traditional Chinese medicine (6.2%) or do nothing about the symptoms (6.4%). Only 1.4% of respondents used leftover antibiotics (1.4%).

Of the 350 respondents who chose to see a doctor for their cold and flu symptoms, 12.6% expected an antibiotic prescription and 11.4% explicitly asked their doctor for antibiotics. Despite this, nearly half (49.7%) of the respondents who visited the doctor for cold or flu symptoms reported that their doctor prescribed them antibiotics, regardless of whether they asked for them explicitly or not.

For respondents who were prescribed antibiotics, 71.1% said that the doctor explained to them why they needed antibiotics, but only a minority stated that their doctor talked to them about possible side-effects of antibiotics (28.3%), or about antibiotic resistance (18.1%). For respondents who were not prescribed antibiotics, 44.6% of them said that the doctor explained why they did not need them.

Multivariable analysis

Respondents' knowledge & attitude scores

Respondents' median knowledge score was 8 (range: 0 – 14) and median attitude score was 7 (range 0 – 11).

Compared to female respondents, males scored better in terms of antibiotic knowledge (β: 0.68; 95% CI – 0.15 – 1.22) but scored worse for attitudes (β: -0.40; 95% CI: -0.77 – -0.03). Malays had lower knowledge (β: -0.69; 95% CI: -1.81 – -0.43) and attitude scores (β: -1.04; 95% CI: -1.76 – -0.33) relative to their Chinese counterparts. Respondents with secondary education also scored lower for both knowledge (β: -1.64; 95% CI: -2.53 – -0.75) and attitudes (β: -1.16; 95% CI: - 1.71 – -0.60) compared to respondents with a university education. Respondents in 3 room HDB (public housing) flat scored lower for both knowledge (β: -1.01; 95% CI: -1.90 – -0.13) and attitudes (β: -0.83; 95% CI: -1.42 – -0.24) compared to respondents in 5-room HDB and executive flats (**Table 3**).

Attitude scores increased by 0.29 (95% CI: 0.20 – 0.37) for every unit increase in antibiotic knowledge score (**Table 4**).

Respondents' knowledge & attitude scores with practice variables

We found that more favourable antibiotic attitude scores were associated with lower odds of expecting antibiotics (OR: 0.84, 95% CI: 0.72 – 0.99) per unit increase in score. Antibiotic knowledge and attitude scores were not associated with whether participants asked their doctors for antibiotics. However, higher scores on knowledge of antibiotic resistance (OR: 0.90, 95% CI: 0.79 – 1.05) and attitude (OR: 0.76, 95% CI: 0.63 – 0.90) were associated with lower odds of being prescribed antibiotics by the doctor (**Table 4**).

Discussion

Our cross-sectional study of 706 participants in Singapore showed that there is a high level of awareness towards appropriate antibiotic use among the Singapore general population, but greater knowledge and awareness can be beneficial for curbing expectation and receipt of antibiotics during primary care consultations.

While most of the respondents said that they had heard of the term antibiotics before, only about a third of the respondents could correctly identify that antibiotics are effective towards bacterial and not viral infections. Comparable to previously published surveys in other countries [15,19,20], almost half of the respondents believed that antibiotics could be used for speeding up recovery or alleviating symptoms from conditions like the common cold and the flu, indicating knowledge gaps in the appropriate use of antibiotics.

In terms of awareness of antibiotic resistance, only about a tenth of the respondents were able to correctly identify the mechanisms of resistance, suggesting a need for increased public education in this area. These misconceptions are also mirrored in the WHO multi-country antibiotic resistance public awareness survey in 12 countries.[16] Similar to our findings, a majority of respondents in all countries surveyed thought that antibiotic resistance occurs when our bodies become resistant to antibiotics, while approximately half of the respondents thought that antibiotic resistance is only a problem for people who take antibiotics regularly.

Approximately half of the respondents went to a medical doctor when they experienced symptoms of the cold or flu, and a tenth of these respondents expressed that they explicitly asked for antibiotics. These results are congruent with a previously published study on Singaporean adult patients seeking medical care for upper respiratory tract infection symptoms, where a third of patients said that they would ask the doctor for antibiotics or see another doctor if antibiotics were not prescribed[10]. While the studies looked at different target populations, this could indicate favourable population-level changes in antibiotic seeking behaviours over time.

While only a small proportion of respondents who sought care for their symptoms of the cold or flu said that they expected antibiotics, close to half of them left the clinic with antibiotics whether they asked for them or not. While respondents with higher attitude scores were less likely to expect antibiotics and to leave the clinic with an antibiotic prescription, this discrepancy between patient expectation and prescription is an indication of sub-optimal antibiotic prescribing. As respondents' antibiotic prescribing information was self-reported, we were unable to verify whether they actually received antibiotics, or if those who knew more about antibiotics were less likely to take any form of prescription. We also do not know from our study if there are significant differences in patient antibiotic seeking behaviours or clinician prescribing practices between public and private healthcare sectors. However, previous research in other countries indicates the effectiveness of potential strategies such as delayed prescription[21,22] and shared decision-making[23,24] to reduce inappropriate antibiotic use especially for acute respiratory infections.

These findings also highlight the importance of disseminating clear information about antibiotics and antibiotic resistance not only to the public, but also providing resources such as clinical practice guidelines [25] on antibiotic use in acute upper respiratory infections and diagnostic tools in upskilling primary care healthcare professionals. Further, while public campaign messages have focused on antibiotic effectiveness towards specific medical conditions, our findings suggest that more should be done with regard to how people can use antibiotics more effectively and how health professionals can communicate that information. Future research should further explore where people usually get information about antibiotics and how this influences their antibiotic seeking behaviours.

A potential limitation of our study is that respondents in online surveys may not be fully representative of the general population. Although our survey sample was compared to the Singapore census population in terms of gender and ethnic group, there was a pronounced over-representation of respondents with at least a university education and those living in private accommodation. This

may affect the generalisability of our results as these sociodemographic characteristics might be associated with greater awareness about health-related issues as well as knowledge relating to AMR.

Conclusion

This is the first study on public knowledge, attitudes and practices of antibiotics and antibiotic resistance in Singapore, providing baseline information against which to measure the progress of future interventions. Results from this study serve to emphasise the importance of raising awareness surrounding effective antibiotic use, as well as the mechanisms of antibiotic resistance. They also highlight the benefit of clinical practice guidelines on antibiotic prescribing, educational resources and clinical diagnostic tools for providers. These recommendations should be used to inform future implementation of programmes and activities as laid out in Singapore's National Strategic Action Plan on Antimicrobial Resistance.

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Authors' contributions

All authors attest they meet the ICMJE criteria for authorship. JL, DMC and CCT conceived the research study and developed the questionnaire. JL and CCT analysed the data and drafted the manuscript. All authors provided critical feedback on the manuscript.

Availability of data and materials

All data generated or analysed during this study are included in this published article and its supplementary information files.

Competing interests

The authors declare that they have no competing interests.

Patient and public involvement

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

Figure caption

Figure 1. Participants' cold/flu practices

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Table 1 Demographic and socioeconomic characteristics of survey participants compared with Singapore Census of Population (2010)

	Survey respondents n (%)	**Census (2010) (%)**
Gender*		
Male	306 (43.3)	49.3
Female	400 (56.7)	50.7
Age		
Median age	44	37.4
Ethnicity		
Chinese	549 (77.8)	74.1
Malay	82 (11.6)	13.4
Indian	51 (7.2)	9.2
Other	24 (3.4)	3.3
Education		
Below secondary	13 (1.8)	32.4
Secondary	138 (19.5)	18.9
Post-secondary	243 (34.5)	11.1
Diploma & Professional qualification		14.8
University	308 (43.6)	11.7
Prefer not to say	4 (0.6)	-
Housing		
1-2 room	19 (2.7)	2.1
3-4 room	393 (55.7)	38.1
5-room & Exec	247 (35.0)	21.5
Private housing	36 (5.1)	36.5
Others	11(1.5)	1.4
Household income		
< $2,000	81 (11.5)	21
$2,000 - $3,999	148 (21.0)	16.5
$4,000 - $5,999	141 (20.0)	15.3
$5,000 - $9,999	178 (25.2)	21.7
$10,000 +	79 (11.2)	25.5
Do not know	35 (5.0)	-
Prefer not to say	44 (6.1)	-

Table 2 Participants' responses on antibiotic knowledge, attitudes and antibiotic resistance

Antibiotic knowledge	**Response**	**n = 706** n (%)
Have you ever heard of a type of medication called 'antibiotics'?	Yes	688 (97.5)
	No	18 (2.5)
		n = 688 n (%)
Antibiotics can help me recover from bacterial infections	Agree	574 (83.4)
	Disagree	43 (6.2)
	Not sure	71 (10.3)
Antibiotics can help me recover from viral infections	Agree	314 (45.6)
	Disagree	266 (38.7)
	Not sure	108 (15.7)
Antibiotics can help me recover from the common cold and flu	Agree	228 (33.1)
	Disagree	364 (52.9)
	Not sure	96 (14.0)
Antibiotics can help me recover from serious symptoms of cold and flu	Agree	319 (46.4)
	Disagree	256 (37.2)
	Not sure	113 (16.4)
Antibiotics can speed up my recovery from the common cold and flu	Agree	250 (36.3)
	Disagree	315 (45.8)
	Not sure	123 (17.9)
Antibiotic attitudes	**Response**	**n = 688** n (%)
It is okay to share my antibiotics with family and friends when they are sick with the same symptoms	Agree	50 (7.3)
	Disagree	595 (86.5)
	Not sure	43 (6.2)
It is okay to share my antibiotics with family and friends when they are sick with different symptoms	Agree	9 (1.3)
	Disagree	652 (94.8)
	Not sure	27 (9.3)
It is okay to share my antibiotics with my pets when they are sick	Agree	7 (1.0)
	Disagree	661 (96.1)
	Not sure	20 (2.9)
It is okay to keep leftover antibiotics and use them again when I fall sick in the future	Agree	39 (5.7)
	Disagree	604 (87.8)
	Not sure	45 (6.5)
It is okay for me to use my leftover antibiotics when I have the same symptoms as before	Agree	59 (8.6)
	Disagree	590 (85.8)
	Not sure	39 (5.7)
It is important to always finish the course of antibiotics prescribed to me	Agree	642 (93.3)
	Disagree	28 (4.1)
	Not sure	18 (2.6)
It is okay not to finish the course of antibiotics prescribed to me when I feel better	Agree	56 (8.4)
	Disagree	592 (86.0)
	Not sure	67 (9.7)
It is okay not to finish the course of antibiotics prescribed to me when I have an alternative remedy	Agree	58 (8.4)
	Disagree	563 (81.8)
	Not sure	67 (9.7)
It is okay to miss a dose during the course of	Agree	139 (20.2)

antibiotics prescribed to me	Disagree	433 (62.9)
	Not sure	116 (16.9)
Antibiotic resistance knowledge	**Response**	**n = 706** n (%)
Have you ever heard of the abbreviation 'AMR'?	Yes	78 (11.0)
	No	628 (89.0)
Have you ever heard of the term 'antibiotic resistance'?	Yes	427 (60.5)
	No	279 (39.5)
		n = 427 n (%)
Antibiotic resistance occurs when antibiotics become less powerful so they don't work as well	Agree	207 (48.5)
	Disagree	177 (41.4)
	Not sure	43 (10.1)
Antibiotic resistance occurs when your body becomes resistant to the antibiotics and they no longer work as well	Agree	266 (62.3)
	Disagree	127 (29.7)
	Not sure	34 (8.0)
Antibiotic resistance occurs when bacteria become resistant to the antibiotics so they are more difficult to kill	Agree	382 (89.5)
	Disagree	18 (4.2)
	Not sure	27 (6.3)
Antibiotic resistance only affects people with serious infections in hospitals	Agree	31 (7.3)
	Disagree	334 (78.2)
	Not sure	62 (14.5)
Antibiotic resistance affects common infections such as sore throats and urinary tract infections	Agree	188 (44.0)
	Disagree	100 (23.4)
	Not sure	139 (32.6)
If I use antibiotics appropriately, I don't have to worry about getting antibiotic resistant infections	Agree	190 (44.5)
	Disagree	141 (33.0)
	Not sure	96 (22.5)
How other people use antibiotics doesn't affect my chance of getting antibiotic resistant infections	Agree	157 (36.8)
	Disagree	183 (42.9)
	Not sure	87 (20.4)
How I use antibiotics doesn't affect other's peoples' chances of getting antibiotic resistant infections	Agree	169 (39.6)
	Disagree	176 (41.2)
	Not sure	82 (19.2)

Table 3 Univariate analysis: Participant characteristics associated with knowledge and attitude scores

	Knowledge score		Attitude score	
	Coefficient	**95% CI**	**Coefficient**	**95% CI**
Estimate	10.99	7.80 – 11.35	8.19	6.99 – 9.38
Sex				
Female[#]				
Male	0.68*	0.15 – 1.22	-0.40*	-0.77 – -0.03
Ethnicity				
Chinese[#]				
Malay	-0.69	-1.81 – -0.43	-1.04**	-1.76 – -0.33
Indian	0.23	-0.62 – 1.08	-0.32	-0.89 – 0.25
Other	-0.13	-1.61 – 1.35	0.25	-0.73 – 1.22
Age	-0.03*	-0.06 – -0.01	0.01	-0.00 – 0.03
Education				
University[#]				
Primary (PSLE)	-0.47	-4.48 – 3.53	-1.10	-3.06 – 0.86
Secondary ('O'/'N' Level)	-1.64***	-2.53 – -0.75	-1.16***	-1.71 – -0.60
'A' Level/Polytechnic/Diploma	0.33	-0.26 – 0.94	-0.50*	-0.94 – -0.06
ITE/NTC	0.06	-1.92 – 2.04	-0.13	-1.17 – 0.91
Housing				
5 – room HDB/executive flat[#]				
1 – 2 room HDB[+]	0.23	-2.13 – 2.59	-0.59	-1.79 – 0.62
3 – room HDB	-1.01*	-1.90 – -0.13	-0.83**	-1.42 – -0.24
4 – room HDB	-0.24	-0.81 – 0.34	-0.37	-0.78 – 0.05
Condominium	0.22	-1.13 – 1.56	-0.56	-1.56 – 0.44
Landed house	-1.02	-2.79 – 0.74	0.78	-0.73 – 2.28
Income				
< $2000[#]				
$2000 - $3999	-0.80	-1.91 – 0.31	-0.26	-0.95 – 0.42
$4000 - $5999	-0.49	-1.63 – 0.65	-0.24	-0.95 – 0.48
$6000 - $10000	-0.21	-1.35 – 0.94	-0.12	-0.84 – 0.60
> $10000	0.40	-0.83 – 1.62	-0.17	-1.01 – 0.68
Marital status				
Married[#]				
Divorced	-0.34	-1.97 – 1.29	0.04	-0.88 – 0.96
Never married	0.23	-0.44 – 0.91	-0.32	-0.79 – 0.14
Widowed	-0.71	-3.50 – 2.19	-0.34	-1.95 – 1.29
Separated but not divorced	2.02	-1.80 – 5.83	0.85	-1.85 – 3.56
	Adjusted R-squared = 0.12		Adjusted R-squared = 0.05	

[#]Reference groups

*p ≤ 0.05, **p ≤ 0.01, ***p ≤ 0.001

[+]Public housing in Singapore managed by the Housing and Development Board (HDB)

Table 4 Multivariable regression analysis

	Multivariable linear regression		Multivariable logistic regression					
	Attitudes		**Expected antibiotics**		**Asked for antibiotics**		**Prescribed antibiotics**	
	Coefficient	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Estimate	7.49	5.80 – 9.18	-	-	-	-	-	-
Knowledge score	0.29***	0.20 – 0.37	0.90	0.77 – 1.04	0.96	0.79 – 1.16	0.90	0.79 – 1.05
Attitude score	-	-	0.84*	0.72 – 0.99	0.78	0.71 – 1.07	0.76	0.63 – 0.90
All regression results are adjusted for sociodemographic variables (i.e. gender, income, housing, education, ethnicity, marital status and age)								
*p ≤ 0.05, **p ≤ 0.01, ***p ≤ 0.001								

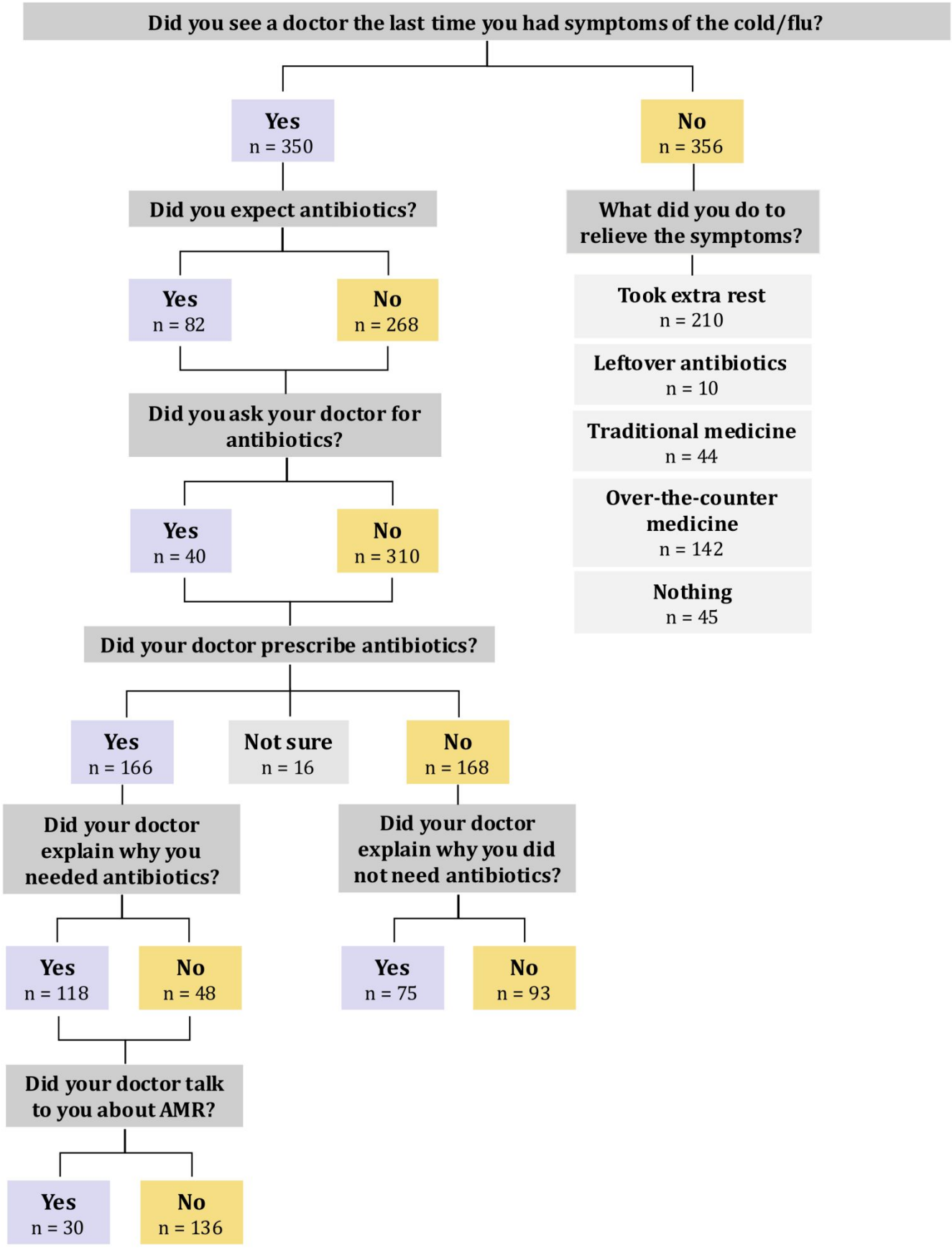


Figure 1 Participants' cold/flu practices

APPENDIX C

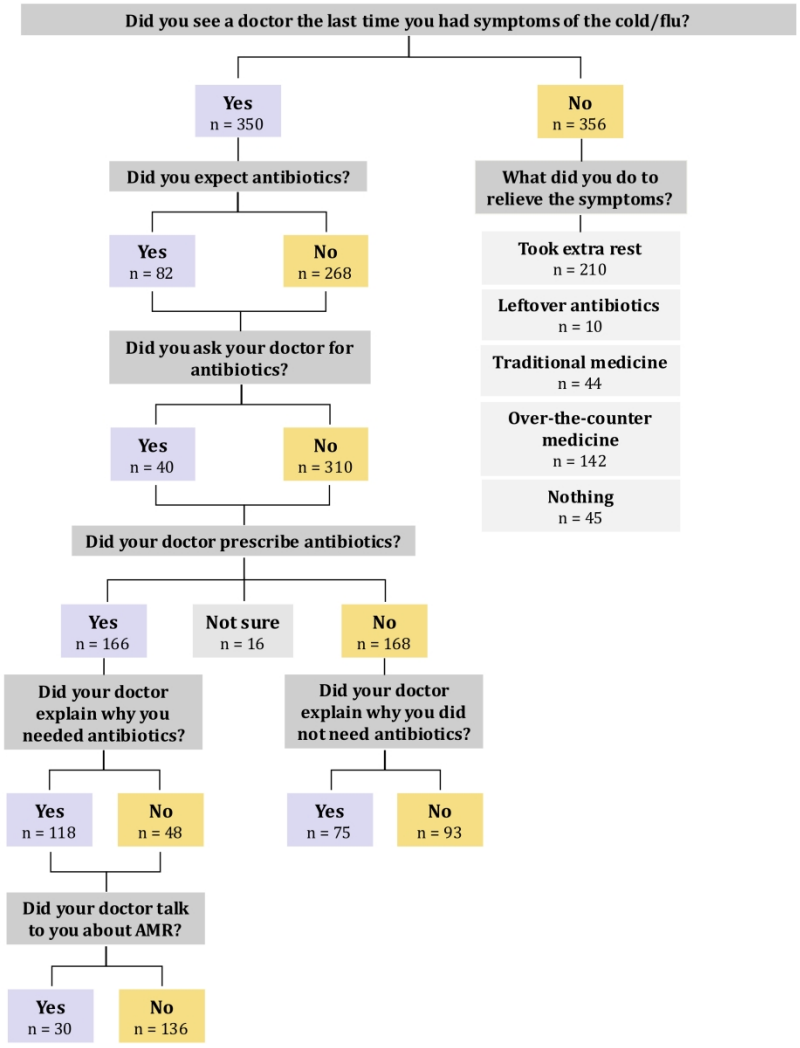


Figure 1 Participants' cold/flu practices

Figure 1

Survey title: A survey of knowledge, attitudes and practices surrounding antibiotics and vaccines in Singapore

Section 1 - Knowledge and attitudes regarding antibiotics

First, I'd like to ask you some questions about antibiotic medications		
1.1	Have you ever heard of a type of medication called 'antibiotics'? *If necessary, prompt: "Antibiotics are a type of medication used to treat certain types of infections. Some examples of antibiotics are Augmentin, Zithromax, amoxycillin, clarithromycin, streptomycin"*	□ Yes (go to 1.2) □ No (go to Section 2)
Now I will tell you a few statements regarding antibiotics. For each statement, please let me know if you ***agree, disagree or not sure***		
1.2	Antibiotics can help you recover from bacterial infections	□ Agree □ Disagree □ Not sure
1.3	Antibiotics can help you recover from viral infections	□ Agree □ Disagree □ Not sure
1.4	Antibiotics can help you recover from the common cold and flu	□ Agree □ Disagree □ Not sure
1.5	Antibiotics can help you recover from serious symptoms of cold and flu	□ Agree □ Disagree □ Not sure
1.6	Antibiotics can speed up your recovery from the common cold and flu	□ Agree □ Disagree □ Not sure
1.7	It is okay to share my antibiotics with family and friends when they are sick with the same symptoms	□ Agree □ Disagree □ Not sure
1.8	It is okay to share my antibitoics with family and friends when they are sick with different symptoms	□ Agree □ Disagree □ Not sure
1.9	It is okay to share my antibiotics with my pets when they are sick	□ Agree □ Disagree □ Not sure
1.10	It is okay to keep leftover antibiotics and use them again when I fall sick in the future	□ Agree □ Disagree □ Not sure

1.11	It is okay for me to use my leftover antibiotics when I have the same symptoms as before	□ Agree □ Disagree □ Not sure
1.12	It is important to always finish the course of antibiotics prescribed to me	□ Agree □ Disagree □ Not sure
1.13	It is okay not to finish the course of antibiotics prescribed to me when I feel better	□ Agree □ Disagree □ Not sure
1.14	It is okay not to finish the course of antibiotics prescribed to me when I have an alternative remedy	□ Agree □ Disagree □ Not sure
1.15	It is okay to miss a dose during the course of antibiotics prescribed to me	□ Agree □ Disagree □ Not sure

Section 2 - Knowledge and attitude regarding antibiotic resistance

Thanks a lot. We will now move on to questions about antibiotic resistance.		
2.1	Have you ever heard of the term 'antibiotic resistance'?	□ Yes (go to 2.2) □ No (go to Section 3)
I will now state a few statements regarding antibiotic resistance. Please tell me if you ***agree, disagree or not sure***		
2.2	Antibiotic resistance occurs when antibiotics become less powerful so they don't work as well	□ Agree □ Disagree □ Not sure
2.3	Antibiotic resistance occurs when your body becomes resistant to the antibiotics and they no longer work as well	□ Agree □ Disagree □ Not sure
2.4	Antibiotic resistance occurs when bacteria become resistant to the antibiotics so they are more difficult to kill	□ Agree □ Disagree □ Not sure
2.5	If I use antibiotics appropriately, I don't have to worry about getting antibiotic resistant infections	□ Agree □ Disagree □ Not sure
2.6	How other people use antibiotics doesn't affect my chance of getting antibiotic resistant infections.	□ Agree □ Disagree □ Not sure
2.7	How I use antibiotic doesn't affect other people's chance of getting antibiotic resistant infections	□ Agree □ Disagree □ Not sure

*Which of the following do you think can reduce the spread of antibiotic resistance? For each option, please answer **yes, no or not sure***		
2.8	Using fewer antibiotics	□ Yes □ No □ Not sure
2.9	Vaccination	□ Yes □ No □ Not sure
2.10	Handwashing	□ Yes □ No □ Not sure
2.11	Better hygiene and infection control measures in hospitals	□ Yes □ No □ Not sure

Section 3 – Experiences in using health care services

I will now ask you some questions about the last time you had symptoms of cold and flu, like sore throat, coughing, runny nose and fever.		
3.1	When was the last time you had symptoms of cold and flu?	_____ months ago
3.2	How long did your symptoms last?	□ 1-3 days □ 4-6 days □ ≥ 1 week □ Not sure
3.3	On a scale of 1 to 10, where 1 is not at all severe and 10 is extremely severe, how severe were your symptoms at that time?	___ (fill a number from 1 to 10)
3.4	Did you see a doctor for these symptoms?	□ Yes (go to 3.6) □ No (go to 3.5)
3.5	If no, what did you do to relieve the symptoms?	□ Took extra rest □ Took left-over antibiotics □ Other: ___ □ Took traditional medicine □ Took over-the-counter medicine
3.6	If yes, did you feel your doctor took the time to explain your illness to you?	□ Yes □ No
3.7	On a scale of 1 to 10, where 1 is not at all satisfied and 10 is extremely satisfied, how satisfied were you with how your doctor answered your questions about your illness?	___ (fill a number from 1 to 10)

3.8	When you went to see the doctor, what did you expect?	□ Advice for self-care □ Information about the illnesses such as duration □ Rule out more serious illnesses □ For referral to hospital or specialists □ Medical leave for work □ Antibiotics □ Other (please specify: _____)
3.9	Did you ask your doctor for antibiotics?	□ Yes □ No
3.10	Did your doctor prescribe you antibiotics?	□ Yes (go to 3.11) □ No (go to 3.14) □ Not sure (go to Section 4)
3.11	Did your doctor explain to you why you needed antibiotics?	□ Yes □ No
3.12	Did your doctor talk to you about antibiotic resistance?	□ Yes □ No
3.13	Did your doctor talk to you about possible side-effects of antibiotics?	□ Yes □ No
3.14	Did your doctor explain to you why you did not need antibiotics?	□ Yes □ No

Section 4 – Vaccination behaviors for different age groups

For all participants (all ages): I will now ask you some questions about your use of different vaccines to protect against infections		
4.1	Have you ever received an influenza vaccine? *(prompt: Also known as flu shot, flu vaccine, flu jab)*	□ Yes □ No □ Not sure
4.2	Have you received an influenza vaccine in the past year?	□ Yes (go to 4.3) □ No (go to next section) □ Not sure
4.3	When was the last time you received it?	□ In the past month □ 1-3 months ago □ 4-6 months ago □ 6-12 months ago
4.4	What was the reason that you received the influenza vaccine?	□ Recommended by my doctor because I am/was traveling □ Recommended by my doctor because I am/was pregnant □ My job requires it □ It was offered at no cost by my employer

		□ I usually get annual flu vaccinations3□ Other (please specify: _____)

For participants aged 65 and above		
5.1	Have you ever received the pneumococcal vaccine? *(Prompt: This is a vaccination against pneumonia)*	□ Yes (go to 5.2) □ No (go to 5.4) □ Not sure
5.2	How many doses of the vaccine did you receive? *(Prompt: Pneumococcal vaccines in the NAIs include 13-valent pneumococcal conjugate vaccine (PCV13) and 23-valent pneumococcal polysaccharide vaccine (PPSV23)—one dose each is receommended for persons aged 65 and above)*	□ 1 □ 2 □ Not sure
5.3	When did you receive the last dose ?	_____ □ Not sure
5.4	Have you ever received the varicella vaccine? *(Prompt: The varicella vaccine protects against chickenpox and shingles)*	□ Yes (go to 5.5) □ No (go to next section) □ Not sure
5.5	How many doses of the vaccine did you receive?	□ 1 □ 2 □ Not sure
5.6	When did you receive the last dose?	_____ □ Not sure

For female participants (18-26 years old) and parents with daughters from the ages of 9-18 years old		
6.1	Have you/has your daughter ever received the HPV vaccine? *(Prompt: HPV stands forHuman Papillomavirus; two vaccines, Gardasil and Cervavix, are currently approved for use in Singapore; the HPV vaccine protects against cervical cancer and is claimable under Medisave)*	□ Yes (go to 6.2) □ No (go to next section) □ Not sure
6.2	How old were you/was your daughter when you/she received the HPV vaccine?	Age: _____

		□ Not sure
6.3	How many doses of the vaccine did you/your daughter receive? *(Prompt: This is recommended for females 9-26 years, this vaccine can be given in either 2 or 3 doses)*	□ 1 □ 2 □ 3 □ Not sure
6.4	When did you/your daughter receive the last dose of the HPV vaccine?	_____ □ Not sure

For parents with young children under the age of 5		
7.1	Do you have any children under the age of 5? *(Prompt: Your child has not had his/her 5th birthday yet)*	□ Yes □ No
7.2	How many children do you have under the age of 5?	_____
If you have more than one child under the age of 5, please first answer questions about the child whose birthday is next:		
7.3	What is your child's birth month and year?	Month: ____ Year: ____
7.4	Has your child received an influenza vaccination in the past year? *(Prompt:: This is also known as flu vaccine, flu shot, flu jab)*	□ Yes □ No □ Not sure
7.5	Has your child ever received the pneumococcal vaccine? *(Prompt: Also known as PCV13 or Prevnar. This vaccine is given in 3 doses usually at 3, 5 and 12 months of age. PCV13 is claimable under Medisave")*	□ Yes (go to 7.6) □ No (go to 7.9) □ Not sure
7.6	How many doses of the pneumococcal vaccine did your child receive?	□ 1 □ 2 □ 3 □ Not sure
7.7	When did your child receive the last dose of pneumococcal vaccine?	_____ □ Not sure
7.8	Has your child ever received the rotavirus vaccine? *(prompt: This vaccine protects against childhood diarrhoea and is given as drops in the mouth. Usually 2 or 3 doses are given before 8 months of age".*	□ Yes □ No □ Not sure

	there are two types licenced in Singapore, Rotarix (RV5, 2 doses) and RotaTeq (RV1, 3 doses) usually given before 8 months of age. This vaccine is not currently claimable under Medisave)	
7.9	How old was your child when he/she received the rotavirus vaccine?	Age: _____ months □ Not sure
7.10	Which type of rotavirus vaccination did your child receive?	□ RotaTeq™ (given in 3 doses) □ Rotarix™ (given in 2 doses) □ Not sure
7.11	How many doses of the vaccine did your child receive?	□ 1 □ 2 □ 3 □ Not sure

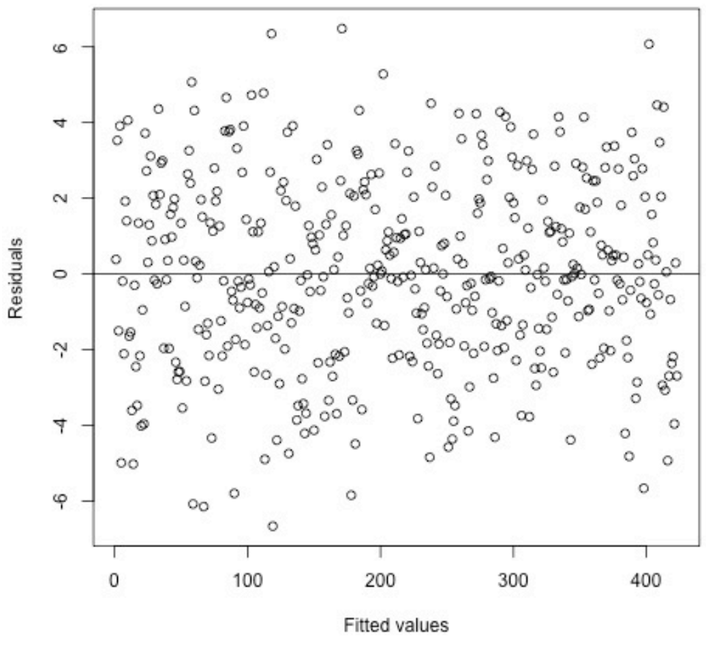
APPENDIX B

Knowledge score Range: 0 – 14 Median: 8		
Knowledge of antibiotic resistance	Have you ever heard of the abbreviation 'AMR'?	Yes = 1 point
	Have you ever heard of the term 'antibiotic resistance'?	
	Antibiotic resistance occurs when antibiotics become less powerful so they don't work as well	Disagree = 1 point
	Antibiotic resistance occurs when your body becomes resistant to the antibiotics and they no longer work as well	
	Antibiotic resistance only affects people with serious infections in hospitals	
	If I use antibiotics appropriately I don't have to worry about getting antibiotic resistant infections	
	How other people use antibiotics doesn't affect my chance of getting antibiotic resistant infections	
	How I use antibiotics doesn't affect other people's chances of getting antibiotic resistant infections	
	Antibiotic resistance occurs when bacteria become resistant to the antibiotics so they are more difficult to kill	Agree = 1 point
	Antibiotic resistance affects common infections such as sore throats and urinary tract infections	
	Using fewer antibiotics will reduce the spread of antibiotic resistance	
	Vaccinations will reduce the spread of antibiotic resistance	
	Handwashing will reduce the spread of antibiotic resistance	
	Better hygiene and infection control measures in hospitals will reduce the spread of antibiotic resistance	

APPENDIX B

Attitudes score Range: 0 – 11 Median: 7		
Attitudes towards antibiotic use (6 points)	Antibiotics can help me recover from bacterial infections	Agree = 1 point
	It is important to always finish the course of antibiotics prescribed to me	
	Antibiotics can help me recover from viral infections	Disagree = 1 point
	Antibiotics can help me recover from the common cold and flu	
	Antibiotics can help me recover from serious symptoms of cold and flu	
	Antibiotics can speed up my recovery from the common cold and flu	
	It is okay to keep leftover antibiotics and use them again when I fall sick in the future	
	It is okay to use my leftover antibiotics when I have the same symptoms as before	
	It is okay not to finish the course of antibiotics prescribed to me when I feel better	
	It is okay not to finish the course of antibiotics prescribed to me when I have an alternative remedy	
	It is okay to miss a dose during the course of antibiotics prescribed to me	

Appendix C


Knowledge scores (Univariable analysis)
Residuals
Fitted values
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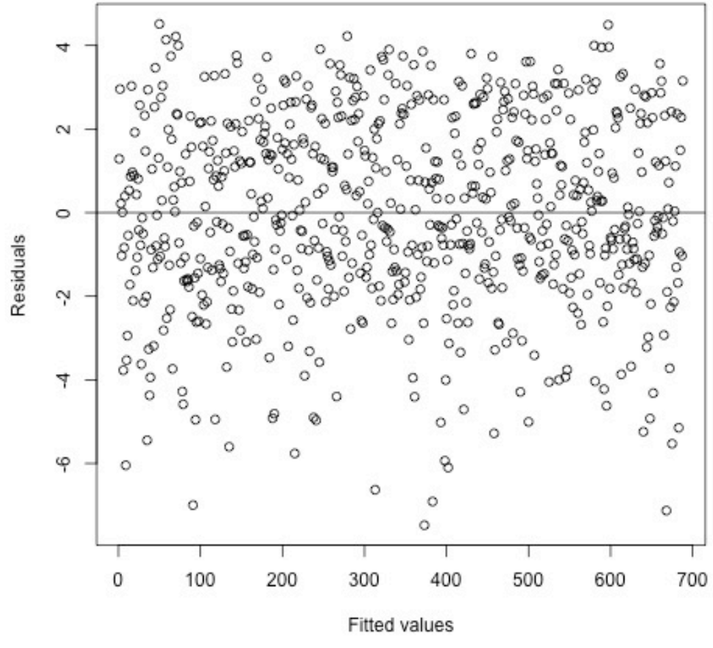
100
200
300
400
6
4
2
0
-2
-4
-6


Attitude scores (Univariable analysis)
Residuals
Fitted values
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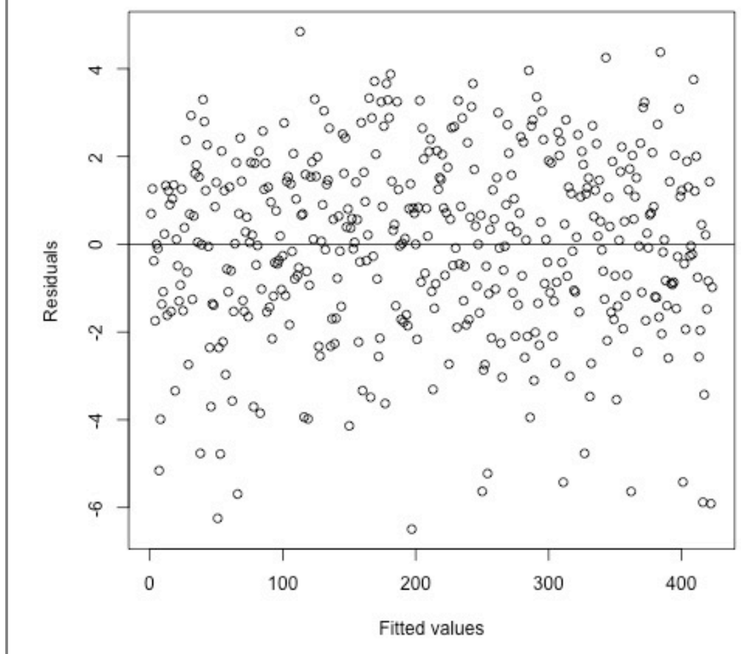
300
400
500
600
700
4
2
0
-2
-4
-6


Attitude scores (Multivariable analysis)
Residuals
Fitted values
0
100
200
300
400
4
2
0
-2
-4
-6

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	4
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4-5
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4-5
Bias	9	Describe any efforts to address potential sources of bias	5
Study size	10	Explain how the study size was arrived at	4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	5
		(*b*) Describe any methods used to examine subgroups and interactions	5
		(*c*) Explain how missing data were addressed	Na
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	Na
		(*e*) Describe any sensitivity analyses	5
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	5-6
		(b) Give reasons for non-participation at each stage	Na
		(c) Consider use of a flow diagram	Na
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	6
		(b) Indicate number of participants with missing data for each variable of interest	6-7
Outcome data	15*	Report numbers of outcome events or summary measures	6-7
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	7

		(*b*) Report category boundaries when continuous variables were categorized	7
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Na
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	7-8
Discussion			
Key results	18	Summarise key results with reference to study objectives	7
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	8
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	8
Generalisability	21	Discuss the generalisability (external validity) of the study results	8
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	9

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

A cross-sectional population survey of public knowledge, attitudes and practices related to antibiotic use and resistance in Singapore

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Secondary Subject Heading:	Infectious diseases
Keywords:	Public health < INFECTIOUS DISEASES, EPIDEMIOLOGY, EDUCATION & TRAINING (see Medical Education & Training)

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A cross-sectional population survey of public knowledge, attitudes and practices related to antibiotic use and resistance in Singapore

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Word count: 2,926

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Abstract

Objectives: The WHO's Global Action Plan on Antimicrobial Resistance includes increasing overall public awareness of appropriate antibiotic use and resistance as a key priority area. We aimed to measure public knowledge, attitudes and practices of antibiotics and antibiotic resistance in Singapore, as well as their healthcare seeking behaviours relating to respiratory illnesses, providing baseline data against which to measure the progress of future interventions.

Design: A cross-sectional study

Setting: The general population in Singapore

Participants: Between May and June 2019, we conducted a survey via an online panel in Singapore with 706 respondents.

Results: Our findings indicated common misconceptions surrounding antibiotic effectiveness and mechanisms of antibiotic resistance – most participants thought that resistance occurs when our bodies become resistant to antibiotics (62.5%) or when antibiotics become less powerful (48.5%). In multivariable analyses, better knowledge scores were associated with more favourable antibiotic attitudes ($\beta = 0.29$; 95% CI: 0.20 – 0.37). In addition, more favourable attitude scores were associated with lower odds of both expecting (OR: 0.84, 95% CI: 0.72 – 0.99) and being prescribed antibiotics by a primary care doctor (OR: 0.76, 95% CI: 0.63- 0.90).

Conclusions: This study presents important information about population perceptions towards antibiotics and antibiotic resistance in Singapore. Results from this study emphasise the importance of effective public communication strategies to promote responsible antibiotic use locally and should be used to inform future implementation of programmes and activities as laid out in Singapore's National Strategic Action Plan on AMR.

Word count: 240

Keywords: antimicrobial resistance, antibiotic use, population survey,

Strengths and limitations of this study

- This is the first population-level study on public knowledge, attitudes and practices of antibiotics and antibiotic resistance in Singapore. Findings from this study provide baseline information against which to measure the progress of future antibiotic interventions.
- A key strength of our online survey is increased access to groups and individuals in the community who may not have been reached through other channels.
- A potential limitation of our study is that respondents in online surveys may not be fully representative of the general population. In our study, we had an over-representation of respondents with at least a university education and those living in private accommodation. This may affect the generalisability of our results.
- In an online survey where the research team is unable to clarify or answer questions in-person, respondents may have misinterpreted questions especially relating to the mechanisms of antibiotic resistance.

Introduction

One of five key priority areas highlighted in the World Health Organization's Global Action Plan on Antimicrobial Resistance (AMR) is the improvement of overall public awareness of antibiotics and antimicrobial resistance to promote effective behavioural change population-level antibiotic use.[1] Research on the drivers of antibiotic use in several countries highlights widespread misconceptions among the public regarding appropriate use of antibiotics and the development of antibiotic resistance, showing that less antibiotic knowledge is often associated with unfavourable antibiotic use behaviours, such as self-medication with antibiotics or sharing leftover antibiotics with others.[2] These findings are supported by qualitative studies indicating that the general public is unfamiliar with technical terms such as "antimicrobial resistance", that they feel they "know" when they need antibiotics, and that antibiotic prescription is often viewed as a form of validation for their illness. [3–5]

Singapore is a high-income, city state in Asia with a comprehensive system of hybrid public and private primary, secondary and tertiary health care. Currently, all antimicrobials for human use in the country are prescription-only medicines and regulated by the Health Sciences Authority (HSA), the national authority that enforces health product regulation and registration[6]. However, antibiotic resistance is an increasing concern not only in acute care hospitals[7,8] but also in the community[9], an indicator of inappropriate antibiotic consumption. Although antibiotics can be obtained only via prescription by licensed healthcare professionals[6] in Singapore, patients seeking primary health care for upper respiratory tract infections are commonly misinformed about the role of antibiotics in the treatment of viral infections and often seek primary care expecting antibiotics from a medical professional[10].

The development of the WHO's Global Action Plan on AMR and subsequent national action plans[11] serves to complement existing strategies and to prioritise future AMR interventions in both healthcare institutions and the community in preserving antimicrobial effectiveness. To measure the progress of future interventions, as well as to yield evidence-based insights[12] into effective public communication strategies to promote responsible antibiotic use, we conducted an online population survey in Singapore to measure public perceptions of antibiotics and antibiotic resistance.

Methods

Study design + data collection

Survey respondents were participants in an online survey panel recruited and maintained by the Singapore Population Health Improvement Centre (SPHERiC) within the National University Health System. Members of the public are eligible to be part of the online survey panel if they are community-dwelling Singapore Citizens or Permanent Residents, aged 21 and above, English-literate, frequent users of web-based services and if they have a personal email account. Panel participants were recruited using two main strategies. The first strategy was a door-to-door approach conducted to recruit eligible community-dwelling Singaporeans and/or permanent residents. The second strategy involved mailing invitations to de-identified household addresses available from the Singapore Department of Statistics.

From 23 May to 1 June 2019, 1,001 SPHERiC panel members were invited to participate in the survey via an online link in an email or SMS notification. The survey was available to panel members for 10 days and could be completed on any type of personal digital device (e.g. laptops, mobile phones). A reminder notification was sent to panel members who did not respond to the first notification within five days. The self-completed survey was administered in English using RedCap software[13] and took approximately 10-15 minutes to complete. Participants received a reimbursement of SGD5

(~USD3.70) for completing the survey. Survey data were provided by SPHERiC to the research team in an anonymised form for analysis.

Survey questionnaire

The questionnaire consisted of six sections, eliciting information from respondents about their sociodemographic characteristics (8 questions), knowledge about the effectiveness of antibiotics (5 questions), knowledge about the mechanisms of antibiotic resistance and the spread of antibiotic-resistant infections (12 questions), attitudes toward appropriate antibiotic use (9 questions), antibiotic practices in relation to the last time they had an acute respiratory illness (11 questions), as well as their healthcare seeking behaviours (17 questions) (**Appendix A**).

The questionnaire was developed by reviewing available questionnaires from previously published surveys[14,15]. Additionally, to enhance cross-country comparability, questions about antibiotic resistance were taken from the WHO country survey[16]. To ensure that questions in the survey were well understood and adapted to the local context, the questionnaire was field tested with 29 individuals over a period of six days.

Ethics approval

This study was approved by the institutional review board of the National University of Singapore (reference number: B-16-269).

Data analysis

We assessed representativeness of the survey sample by comparing respondents' sociodemographic characteristics with the Singapore Census of Population[17]. We then assessed respondents' general awareness toward antibiotics by tabulating variables related to antibiotic effectiveness, resistance and appropriate use. We also tabulated respondents' practices in relation to antibiotic use for common respiratory illnesses.

We assigned each respondent a knowledge and attitude score based on the number of correct or favorable responses in the respective sections (**Appendix B**). All knowledge and attitude questions had three response options: "Agree", "Disagree" or "Not sure". Correct knowledge and favourable attitude responses were assigned 1 point while incorrect or unfavourable responses scored 0 points.

Respondents' antibiotic practice responses during their last consultation with a primary care provider for acute respiratory illness were dichotomised into: 1) whether respondents expected antibiotics from their doctor (yes = 1; no = 0), 2) whether they asked their doctor for antibiotics (yes = 1; no = 0), and 3) whether they were prescribed antibiotics by their doctor (yes = 1; no = 0).

We first investigated the respective relationships between respondents' sociodemographic characteristics and their antibiotic knowledge and attitude scores using a multivariable linear (Gaussian) regression. Sociodemographic explanatory variables included age group, gender, housing type, household income, education, ethnicity and marital status.

In subsequent regression analyses, we investigated the association between antibiotic practices and antibiotic knowledge and attitudes scores using a multivariable linear (Gaussian) regression, controlling for sociodemographic variables. We then conducted separate multivariable logistic regressions to investigate whether respondents' attitudes scores were associated with each of the three antibiotic practices as outcome variables: 1) whether respondents expected antibiotics, 2) whether they asked for antibiotics and 3) whether they were prescribed antibiotics. We summarised

associations using adjusted odds ratios and corresponding 95% confidence intervals (CI). Regression residual distributions can be found in **Appendix C.**

All data were analysed using R version 3.6.1.[18] No patients were involved

Patient and public involvement

No patients were involved in the study. To inform the survey content, we pilot tested the survey with members of the public external to our research. Key findings will be disseminated to study respondents in an online newsletter.

Results

Of 1,001 eligible panel members, 706 (70.5%) completed the survey. Respondents had a median age of 44 years (range: 22 – 86 years). Four hundred (56.7%) respondents were female and 306 (43.3%) were male. Most respondents were married (60.8%) and had higher than secondary education (78.0%). The survey sample had a similar gender and ethnic group composition compared to the Singapore Census of Population[17] but had slightly lower proportions of individuals who lived in private housing (i.e. condominium, landed property) and a higher proportion of individuals with a university education (**Table 1**).

Descriptive analysis

Tabulations and frequencies of the descriptive analysis are shown in **Table 2**.

Awareness of antibiotic effectiveness

Almost all the respondents (97.5%) had heard of the term "antibiotics" before. When asked if antibiotics were effective against bacterial infections and viral infections, only about a third of the respondents (35.6%) answered both questions correctly. A large proportion of respondents believed that antibiotics could help to speed up recovery from the common respiratory illness (35.4%), or alleviate serious symptoms associated with these illnesses (45.2%).

Awareness of antibiotic resistance

Among respondents, 60.5% reported having heard of the term "antibiotic resistance", but only 11% had heard of the abbreviation "AMR". About half of the respondents were aware that resistance occurs when bacteria become resistant to the antibiotics. However, many respondents also thought that resistance occurs when our bodies become resistant to antibiotics (62.5%) or when antibiotics become less powerful (48.5%).

There was also lower awareness among respondents about how antibiotic-resistant infections could spread or affect common conditions. More than half (56.1%) either disagreed or were not sure that antibiotic resistance can affect the treatment of common infections such as sore throat and urinary tract infection. More than a third of respondents (39.7%) believed that their own use of antibiotics does not have any impact on other people's chances of acquiring antibiotic-resistant infections, and that they do not have to worry about getting antibiotic-resistant infections as long as they use antibiotics appropriately themselves (44.5%). Overall, respondents agreed that interventions to reduce AMR include implementing better infection control measures in hospitals (76.2%) and using fewer antibiotics (71.9%), although a lower percentage recognized hand hygiene (61.7%) and vaccination (59.5%) as important interventions.

Awareness on how to use antibiotics responsibly

There was generally high awareness about appropriate practices in sharing antibiotics – respondents generally agreed that it is inappropriate to share antibiotics with family and friends when they are sick with either same (84.3%) or different (92.4%) symptoms. Respondents were also reluctant to share antibiotics with their household pets – only 1% thought it was appropriate to do so.

Less than 10% of the respondents said that they felt comfortable keeping leftover antibiotics for future use. While over 90% of the respondents agreed that it is important to always finish the course of antibiotics prescribed, a small proportion of respondents believed that they do not have to finish a prescribed course of antibiotics when they feel better (7.9%) or when they have an alternative remedy (8.2%).

Cold/flu practices

We asked all 706 respondents what they did the last time they had symptoms of the common cold or flu (**Figure 1**). More than half (50.6%) chose to see a doctor. The rest chose to take extra rest (59.0%), over-the-counter medication (39.9%), traditional Chinese medicine (12.4%) or did nothing about the symptoms (12.6%). Only 2.8% of respondents used leftover antibiotics (1.4%).

Of the 350 respondents who chose to see a doctor for their cold and flu symptoms, 12.6% expected an antibiotic prescription and 11.4% explicitly asked their doctor for antibiotics. Despite this, nearly half (49.7%) of the respondents who visited the doctor for cold or flu symptoms reported that their doctor prescribed them antibiotics, regardless of whether they asked for them explicitly or not.

For respondents who were prescribed antibiotics, 71.1% said that the doctor explained to them why they needed antibiotics, but only a minority stated that their doctor talked to them about possible side-effects of antibiotics (28.3%), or about antibiotic resistance (18.1%). For respondents who were not prescribed antibiotics, 44.6% of them said that the doctor explained why they did not need them.

Multivariable analysis

Respondents' knowledge & attitude scores

Respondents' median knowledge score was 8 (range: 0 – 14) and median attitude score was 7 (range 0 – 11).

Compared to female respondents, males scored better in terms of antibiotic knowledge (β: 0.68; 95% CI – 0.15 – 1.22) but scored worse for attitudes (β: -0.40; 95% CI: -0.77 – -0.03). Malays had lower knowledge (β: -0.69; 95% CI: -1.81 – -0.43) and attitude scores (β: -1.04; 95% CI: -1.76 – -0.33) relative to their Chinese counterparts. Respondents with secondary education also scored lower for both knowledge (β: -1.64; 95% CI: -2.53 – -0.75) and attitudes (β: -1.16; 95% CI: - 1.71 – -0.60) compared to respondents with a university education. Respondents in 3 room HDB (public housing) flat scored lower for both knowledge (β: -1.01; 95% CI: -1.90 – -0.13) and attitudes (β: -0.83; 95% CI: -1.42 – -0.24) compared to respondents in 5-room HDB and executive flats (**Table 3**).

Attitude scores increased by 0.29 (95% CI: 0.20 – 0.37) for every unit increase in antibiotic knowledge score (**Table 4**).

Respondents' knowledge & attitude scores with practice variables

We found that more favourable antibiotic attitude scores were associated with lower odds of expecting antibiotics (OR: 0.84, 95% CI: 0.72 – 0.99) per unit increase in score. Antibiotic knowledge and attitude scores were not associated with whether participants asked their doctors for antibiotics. However, higher scores on knowledge of antibiotic resistance (OR: 0.90, 95% CI: 0.79 – 1.05) and attitude (OR: 0.76, 95% CI: 0.63 – 0.90) were associated with lower odds of being prescribed antibiotics by the doctor (**Table 4**).

Discussion

Our cross-sectional study of 706 participants in Singapore showed that there is a high level of awareness towards appropriate antibiotic use among the Singapore general population, but greater knowledge and awareness can be beneficial for curbing expectation and receipt of antibiotics during primary care consultations.

While most of the respondents said that they had heard of the term antibiotics before, only about a third of the respondents could correctly identify that antibiotics are effective towards bacterial and not viral infections. Comparable to previously published surveys in other countries [15,19,20], almost half of the respondents believed that antibiotics could be used for speeding up recovery or alleviating symptoms from conditions like the common cold and the flu, indicating knowledge gaps in the appropriate use of antibiotics.

In terms of awareness of antibiotic resistance, only about a tenth of the respondents were able to correctly identify the mechanisms of resistance, suggesting a need for increased public education in this area. These misconceptions are also mirrored in other population-level antibiotic surveys[21–23] as well as the WHO multi-country antibiotic resistance public awareness survey in 12 countries.[16] Similar to our findings, a majority of respondents in all countries surveyed thought that antibiotic resistance occurs when our bodies become resistant to antibiotics, while approximately half of the respondents thought that antibiotic resistance is only a problem for people who take antibiotics regularly.

Approximately half of the respondents went to a medical doctor when they experienced symptoms of the cold or flu, and a tenth of these respondents expressed that they explicitly asked for antibiotics. These results are congruent with a previously published study on Singaporean adult patients seeking medical care for upper respiratory tract infection symptoms, where a third of patients said that they would ask the doctor for antibiotics or see another doctor if antibiotics were not prescribed[10]. While the studies looked at different target populations, this could indicate favourable population-level changes in antibiotic seeking behaviours over time.

While only a small proportion of respondents who sought care for their symptoms of the cold or flu said that they expected antibiotics, close to half of them left the clinic with antibiotics whether they asked for them or not. While respondents with higher attitude scores were less likely to expect antibiotics and to leave the clinic with an antibiotic prescription, this discrepancy between patient expectation and prescription is an indication of sub-optimal antibiotic prescribing. As respondents' antibiotic prescribing information was self-reported, we were unable to verify whether they actually received antibiotics, or if those who knew more about antibiotics were less likely to take any form of prescription. We also do not know from our study if there are significant differences in patient antibiotic seeking behaviours or clinician prescribing practices between public and private healthcare sectors. However, previous research in other countries indicates the effectiveness of potential strategies such as delayed prescription[24,25] and shared decision-making[26,27] to reduce inappropriate antibiotic use especially for acute respiratory infections. Additional strategies from other settings

have also found that decreasing the frequency of medical consultations pertaining to respiratory illnesses were effective in reducing ambulatory antibiotic prescriptions[28,29].

These findings highlight the importance of disseminating clear information about antibiotics and antibiotic resistance to reduce public expectations surrounding antibiotic prescriptions. It also emphasizes the need to provide resources such as clinical practice guidelines on antibiotic use in acute upper respiratory infections[30], accessible diagnostic tools in upskilling primary care healthcare professionals as well as more comprehensive policies to manage profit-making in antibiotic dispensation[31,32]. Further, while public campaign messages have focused on antibiotic effectiveness towards specific medical conditions[12,28,33,34], our findings suggest that more should be done with regard to how people can use antibiotics more effectively and how health professionals can communicate that information. Future research should further explore where people usually get information about antibiotics and how this influences their antibiotic seeking behaviours. Additionally, follow-up population surveys using consistent methods and question structures can provide valuable insights into progress of future AMR interventions.

A potential limitation of our study is that respondents in online surveys may not be fully representative of the general population. Although our survey sample was compared to the Singapore census population in terms of gender and ethnic group, there was a pronounced over-representation of respondents with at least a university education and those living in private accommodation. This may affect the generalisability of our results as these sociodemographic characteristics might be associated with greater awareness about health-related issues as well as knowledge relating to AMR[35–37], as indicated in prior survey findings in similar contexts. Further, although preserving question structure enabled us to maintain comparability with WHO's multi-country antibiotic resistance public awareness survey, respondents may have misinterpreted questions relating to the mechanisms of antibiotic resistance, especially in an online survey where the research team is unable to clarify or answer questions in-person.

Conclusion

This is the first study on public knowledge, attitudes and practices of antibiotics and antibiotic resistance in Singapore, providing baseline information against which to measure the progress of future interventions. Results from this study serve to emphasise the importance of raising awareness surrounding effective antibiotic use, as well as the mechanisms of antibiotic resistance. They also highlight the benefit of clinical practice guidelines on antibiotic prescribing, educational resources and clinical diagnostic tools for providers. These recommendations should be used to inform future implementation of programmes and activities as laid out in Singapore's National Strategic Action Plan on Antimicrobial Resistance.

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Authors' contributions

All authors attest they meet the ICMJE criteria for authorship. JL, DMC and CCT conceived the research study and developed the questionnaire. JL and CCT analysed the data and drafted the manuscript. ARC and HLY provided critical feedback on the manuscript.

Data availability statement

All data relevant to the study are included in the article or uploaded as supplementary information.

Competing interests

The authors declare that they have no competing interests.

Figure caption

Figure 1. Participants' cold/flu practices

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Table 1 Demographic and socioeconomic characteristics of survey participants compared with Singapore Census of Population (2010)

	Survey respondents n (%)	**Census (2010) (%)**
Gender		
Male	306 (43.3)	49.3
Female	400 (56.7)	50.7
Age		
Median age	44	37.4
Ethnicity		
Chinese	549 (77.8)	74.1
Malay	82 (11.6)	13.4
Indian	51 (7.2)	9.2
Other	24 (3.4)	3.3
Education		
Below secondary	13 (1.8)	32.4
Secondary	138 (19.5)	18.9
Post-secondary	243 (34.5)	11.1
Diploma & Professional qualification		14.8
University	308 (43.6)	11.7
Prefer not to say	4 (0.6)	-
Housing		
1-2 room	19 (2.7)	2.1
3-4 room	393 (55.7)	38.1
5-room & Exec	247 (35.0)	21.5
Private housing	36 (5.1)	36.5
Others	11(1.5)	1.4
Household income		
< $2,000	81 (11.5)	21
$2,000 - $3,999	148 (21.0)	16.5
$4,000 - $5,999	141 (20.0)	15.3
$5,000 - $9,999	178 (25.2)	21.7
$10,000 +	79 (11.2)	25.5
Do not know	35 (5.0)	-
Prefer not to say	44 (6.1)	-

Table 2 Participants' responses on antibiotic knowledge, attitudes and antibiotic resistance

Antibiotic knowledge	**Response**	**n = 706** n (%)
Have you ever heard of a type of medication called 'antibiotics'?	Yes	688 (97.5)
	No	18 (2.5)
		n = 688 n (%)
Antibiotics can help me recover from bacterial infections	Agree	574 (83.4)
	Disagree	43 (6.2)
	Not sure	71 (10.3)
Antibiotics can help me recover from viral infections	Agree	314 (45.6)
	Disagree	266 (38.7)
	Not sure	108 (15.7)
Antibiotics can help me recover from the common cold and flu	Agree	228 (33.1)
	Disagree	364 (52.9)
	Not sure	96 (14.0)
Antibiotics can help me recover from serious symptoms of cold and flu	Agree	319 (46.4)
	Disagree	256 (37.2)
	Not sure	113 (16.4)
Antibiotics can speed up my recovery from the common cold and flu	Agree	250 (36.3)
	Disagree	315 (45.8)
	Not sure	123 (17.9)
Antibiotic attitudes	**Response**	**n = 688** n (%)
It is okay to share my antibiotics with family and friends when they are sick with the same symptoms	Agree	50 (7.3)
	Disagree	595 (86.5)
	Not sure	43 (6.2)
It is okay to share my antibiotics with family and friends when they are sick with different symptoms	Agree	9 (1.3)
	Disagree	652 (94.8)
	Not sure	27 (9.3)
It is okay to share my antibiotics with my pets when they are sick	Agree	7 (1.0)
	Disagree	661 (96.1)
	Not sure	20 (2.9)
It is okay to keep leftover antibiotics and use them again when I fall sick in the future	Agree	39 (5.7)
	Disagree	604 (87.8)
	Not sure	45 (6.5)
It is okay for me to use my leftover antibiotics when I have the same symptoms as before	Agree	59 (8.6)
	Disagree	590 (85.8)
	Not sure	39 (5.7)
It is important to always finish the course of antibiotics prescribed to me	Agree	642 (93.3)
	Disagree	28 (4.1)
	Not sure	18 (2.6)
It is okay not to finish the course of antibiotics prescribed to me when I feel better	Agree	56 (8.4)
	Disagree	592 (86.0)
	Not sure	67 (9.7)
It is okay not to finish the course of antibiotics prescribed to me when I have an alternative remedy	Agree	58 (8.4)
	Disagree	563 (81.8)
	Not sure	67 (9.7)
It is okay to miss a dose during the course of	Agree	139 (20.2)

antibiotics prescribed to me	Disagree	433 (62.9)
	Not sure	116 (16.9)
Antibiotic resistance knowledge	**Response**	**n = 706** n (%)
Have you ever heard of the abbreviation 'AMR'?	Yes	78 (11.0)
	No	628 (89.0)
Have you ever heard of the term 'antibiotic resistance'?	Yes	427 (60.5)
	No	279 (39.5)
		n = 427 n (%)
Antibiotic resistance occurs when antibiotics become less powerful so they don't work as well	Agree	207 (48.5)
	Disagree	177 (41.4)
	Not sure	43 (10.1)
Antibiotic resistance occurs when your body becomes resistant to the antibiotics and they no longer work as well	Agree	266 (62.3)
	Disagree	127 (29.7)
	Not sure	34 (8.0)
Antibiotic resistance occurs when bacteria become resistant to the antibiotics so they are more difficult to kill	Agree	382 (89.5)
	Disagree	18 (4.2)
	Not sure	27 (6.3)
Antibiotic resistance only affects people with serious infections in hospitals	Agree	31 (7.3)
	Disagree	334 (78.2)
	Not sure	62 (14.5)
Antibiotic resistance affects common infections such as sore throats and urinary tract infections	Agree	188 (44.0)
	Disagree	100 (23.4)
	Not sure	139 (32.6)
If I use antibiotics appropriately, I don't have to worry about getting antibiotic resistant infections	Agree	190 (44.5)
	Disagree	141 (33.0)
	Not sure	96 (22.5)
How other people use antibiotics doesn't affect my chance of getting antibiotic resistant infections	Agree	157 (36.8)
	Disagree	183 (42.9)
	Not sure	87 (20.4)
How I use antibiotics doesn't affect other's peoples' chances of getting antibiotic resistant infections	Agree	169 (39.6)
	Disagree	176 (41.2)
	Not sure	82 (19.2)

Table 3 Univariate analysis: Participant characteristics associated with knowledge and attitude scores

	Knowledge score		Attitude score	
	Coefficient	**95% CI**	**Coefficient**	**95% CI**
Estimate	10.99	7.80 – 11.35	8.19	6.99 – 9.38
Sex				
Female[#]				
Male	0.68*	0.15 – 1.22	-0.40*	-0.77 – -0.03
Ethnicity				
Chinese[#]				
Malay	-0.69	-1.81 – -0.43	-1.04**	-1.76 – -0.33
Indian	0.23	-0.62 – 1.08	-0.32	-0.89 – 0.25
Other	-0.13	-1.61 – 1.35	0.25	-0.73 – 1.22
Age	-0.03*	-0.06 – -0.01	0.01	-0.00 – 0.03
Education				
University[#]				
Primary (PSLE)	-0.47	-4.48 – 3.53	-1.10	-3.06 – 0.86
Secondary ('O'/'N' Level)	-1.64***	-2.53 – -0.75	-1.16***	-1.71 – -0.60
'A' Level/Polytechnic/Diploma	0.33	-0.26 – 0.94	-0.50*	-0.94 – -0.06
ITE/NTC	0.06	-1.92 – 2.04	-0.13	-1.17 – 0.91
Housing				
5 – room HDB/executive flat[#]				
1 – 2 room HDB[+]	0.23	-2.13 – 2.59	-0.59	-1.79 – 0.62
3 – room HDB	-1.01*	-1.90 – -0.13	-0.83**	-1.42 – -0.24
4 – room HDB	-0.24	-0.81 – 0.34	-0.37	-0.78 – 0.05
Condominium	0.22	-1.13 – 1.56	-0.56	-1.56 – 0.44
Landed house	-1.02	-2.79 – 0.74	0.78	-0.73 – 2.28
Income				
< $2000[#]				
$2000 - $3999	-0.80	-1.91 – 0.31	-0.26	-0.95 – 0.42
$4000 - $5999	-0.49	-1.63 – 0.65	-0.24	-0.95 – 0.48
$6000 - $10000	-0.21	-1.35 – 0.94	-0.12	-0.84 – 0.60
> $10000	0.40	-0.83 – 1.62	-0.17	-1.01 – 0.68
Marital status				
Married[#]				
Divorced	-0.34	-1.97 – 1.29	0.04	-0.88 – 0.96
Never married	0.23	-0.44 – 0.91	-0.32	-0.79 – 0.14
Widowed	-0.71	-3.50 – 2.19	-0.34	-1.95 – 1.29
Separated but not divorced	2.02	-1.80 – 5.83	0.85	-1.85 – 3.56
	Adjusted R-squared = 0.12		Adjusted R-squared = 0.05	

[#]Reference groups

*p ≤ 0.05, **p ≤ 0.01, ***p ≤ 0.001

[+]Public housing in Singapore managed by the Housing and Development Board (HDB)

Table 4 Multivariable regression analysis

	Multivariable linear regression		Multivariable logistic regression					
	Attitudes		**Expected antibiotics**		**Asked for antibiotics**		**Prescribed antibiotics**	
	Coefficient	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Estimate	7.49	5.80 – 9.18	-	-	-	-	-	-
Knowledge score	0.29***	0.20 – 0.37	0.90	0.77 – 1.04	0.96	0.79 – 1.16	0.90	0.79 – 1.05
Attitude score	-	-	0.84*	0.72 – 0.99	0.78	0.71 – 1.07	0.76	0.63 – 0.90
All regression results are adjusted for sociodemographic variables (i.e. gender, income, housing, education, ethnicity, marital status and age)								
*p ≤ 0.05, **p ≤ 0.01, ***p ≤ 0.001								

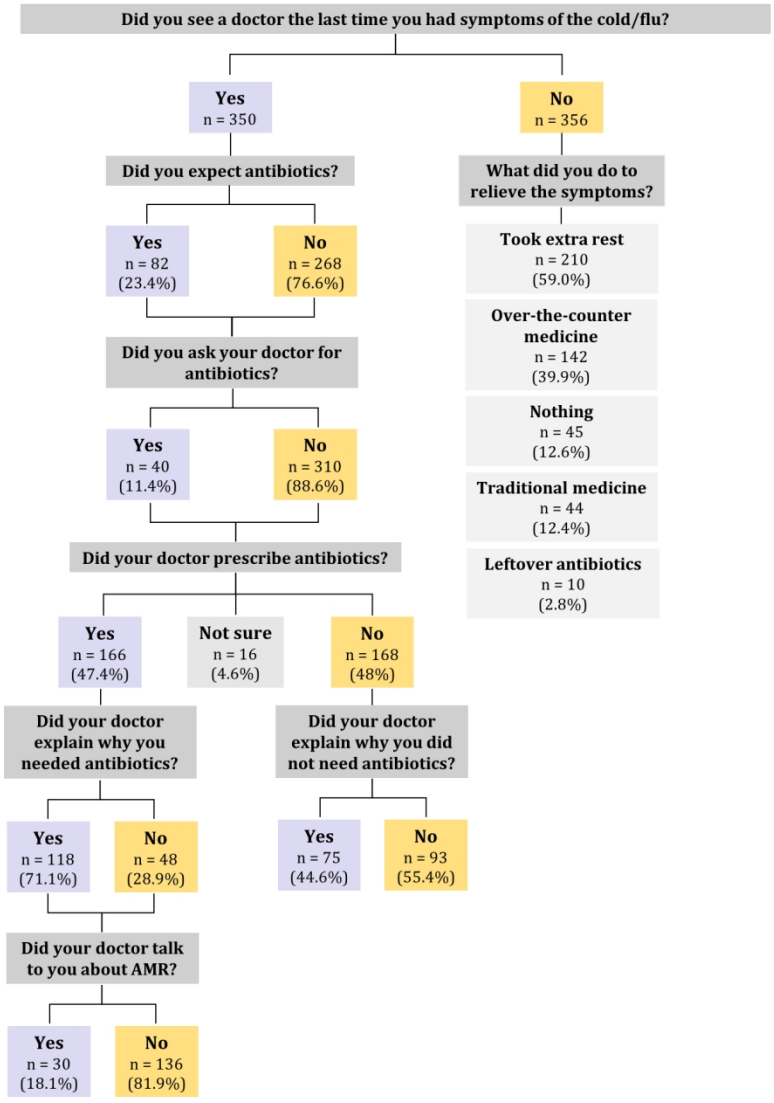


Figure 1 Participants' cold/flu practices

Figure 1: Participants' cold/flu practices

Survey title: A survey of knowledge, attitudes and practices surrounding antibiotics and vaccines in Singapore

Section 1 - Knowledge and attitudes regarding antibiotics

First, I'd like to ask you some questions about antibiotic medications		
1.1	Have you ever heard of a type of medication called 'antibiotics'? *If necessary, prompt: "Antibiotics are a type of medication used to treat certain types of infections. Some examples of antibiotics are Augmentin, Zithromax, amoxycillin, clarithromycin, streptomycin"*	□ Yes (go to 1.2) □ No (go to Section 2)
Now I will tell you a few statements regarding antibiotics. For each statement, please let me know if you ***agree, disagree or not sure***		
1.2	Antibiotics can help you recover from bacterial infections	□ Agree □ Disagree □ Not sure
1.3	Antibiotics can help you recover from viral infections	□ Agree □ Disagree □ Not sure
1.4	Antibiotics can help you recover from the common cold and flu	□ Agree □ Disagree □ Not sure
1.5	Antibiotics can help you recover from serious symptoms of cold and flu	□ Agree □ Disagree □ Not sure
1.6	Antibiotics can speed up your recovery from the common cold and flu	□ Agree □ Disagree □ Not sure
1.7	It is okay to share my antibiotics with family and friends when they are sick with the same symptoms	□ Agree □ Disagree □ Not sure
1.8	It is okay to share my antibitoics with family and friends when they are sick with different symptoms	□ Agree □ Disagree □ Not sure
1.9	It is okay to share my antibiotics with my pets when they are sick	□ Agree □ Disagree □ Not sure
1.10	It is okay to keep leftover antibiotics and use them again when I fall sick in the future	□ Agree □ Disagree □ Not sure

1.11	It is okay for me to use my leftover antibiotics when I have the same symptoms as before	□ Agree □ Disagree □ Not sure
1.12	It is important to always finish the course of antibiotics prescribed to me	□ Agree □ Disagree □ Not sure
1.13	It is okay not to finish the course of antibiotics prescribed to me when I feel better	□ Agree □ Disagree □ Not sure
1.14	It is okay not to finish the course of antibiotics prescribed to me when I have an alternative remedy	□ Agree □ Disagree □ Not sure
1.15	It is okay to miss a dose during the course of antibiotics prescribed to me	□ Agree □ Disagree □ Not sure

Section 2 - Knowledge and attitude regarding antibiotic resistance

Thanks a lot. We will now move on to questions about antibiotic resistance.		
2.1	Have you ever heard of the term 'antibiotic resistance'?	□ Yes (go to 2.2) □ No (go to Section 3)
I will now state a few statements regarding antibiotic resistance. Please tell me if you ***agree, disagree or not sure***		
2.2	Antibiotic resistance occurs when antibiotics become less powerful so they don't work as well	□ Agree □ Disagree □ Not sure
2.3	Antibiotic resistance occurs when your body becomes resistant to the antibiotics and they no longer work as well	□ Agree □ Disagree □ Not sure
2.4	Antibiotic resistance occurs when bacteria become resistant to the antibiotics so they are more difficult to kill	□ Agree □ Disagree □ Not sure
2.5	If I use antibiotics appropriately, I don't have to worry about getting antibiotic resistant infections	□ Agree □ Disagree □ Not sure
2.6	How other people use antibiotics doesn't affect my chance of getting antibiotic resistant infections.	□ Agree □ Disagree □ Not sure
2.7	How I use antibiotic doesn't affect other people's chance of getting antibiotic resistant infections	□ Agree □ Disagree □ Not sure

*Which of the following do you think can reduce the spread of antibiotic resistance? For each option, please answer **yes, no or not sure***		
2.8	Using fewer antibiotics	□ Yes □ No □ Not sure
2.9	Vaccination	□ Yes □ No □ Not sure
2.10	Handwashing	□ Yes □ No □ Not sure
2.11	Better hygiene and infection control measures in hospitals	□ Yes □ No □ Not sure

Section 3 – Experiences in using health care services

I will now ask you some questions about the last time you had symptoms of cold and flu, like sore throat, coughing, runny nose and fever.		
3.1	When was the last time you had symptoms of cold and flu?	_____ months ago
3.2	How long did your symptoms last?	□ 1-3 days □ 4-6 days □ ≥ 1 week □ Not sure
3.3	On a scale of 1 to 10, where 1 is not at all severe and 10 is extremely severe, how severe were your symptoms at that time?	___ (fill a number from 1 to 10)
3.4	Did you see a doctor for these symptoms?	□ Yes (go to 3.6) □ No (go to 3.5)
3.5	If no, what did you do to relieve the symptoms?	□ Took extra rest □ Took left-over antibiotics □ Other: ___ □ Took traditional medicine □ Took over-the-counter medicine
3.6	If yes, did you feel your doctor took the time to explain your illness to you?	□ Yes □ No
3.7	On a scale of 1 to 10, where 1 is not at all satisfied and 10 is extremely satisfied, how satisfied were you with how your doctor answered your questions about your illness?	___ (fill a number from 1 to 10)

3.8	When you went to see the doctor, what did you expect?	□ Advice for self-care □ Information about the illnesses such as duration □ Rule out more serious illnesses □ For referral to hospital or specialists □ Medical leave for work □ Antibiotics □ Other (please specify: _____)
3.9	Did you ask your doctor for antibiotics?	□ Yes □ No
3.10	Did your doctor prescribe you antibiotics?	□ Yes (go to 3.11) □ No (go to 3.14) □ Not sure (go to Section 4)
3.11	Did your doctor explain to you why you needed antibiotics?	□ Yes □ No
3.12	Did your doctor talk to you about antibiotic resistance?	□ Yes □ No
3.13	Did your doctor talk to you about possible side-effects of antibiotics?	□ Yes □ No
3.14	Did your doctor explain to you why you did not need antibiotics?	□ Yes □ No

Section 4 – Vaccination behaviors for different age groups

For all participants (all ages): I will now ask you some questions about your use of different vaccines to protect against infections		
4.1	Have you ever received an influenza vaccine? *(prompt: Also known as flu shot, flu vaccine, flu jab)*	□ Yes □ No □ Not sure
4.2	Have you received an influenza vaccine in the past year?	□ Yes (go to 4.3) □ No (go to next section) □ Not sure
4.3	When was the last time you received it?	□ In the past month □ 1-3 months ago □ 4-6 months ago □ 6-12 months ago
4.4	What was the reason that you received the influenza vaccine?	□ Recommended by my doctor because I am/was traveling □ Recommended by my doctor because I am/was pregnant □ My job requires it □ It was offered at no cost by my employer

		□ I usually get annual flu vaccinations3□ Other (please specify: _____)

For participants aged 65 and above		
5.1	Have you ever received the pneumococcal vaccine? *(Prompt: This is a vaccination against pneumonia)*	□ Yes (go to 5.2) □ No (go to 5.4) □ Not sure
5.2	How many doses of the vaccine did you receive? *(Prompt: Pneumococcal vaccines in the NAIs include 13-valent pneumococcal conjugate vaccine (PCV13) and 23-valent pneumococcal polysaccharide vaccine (PPSV23)—one dose each is receommended for persons aged 65 and above)*	□ 1 □ 2 □ Not sure
5.3	When did you receive the last dose ?	_____ □ Not sure
5.4	Have you ever received the varicella vaccine? *(Prompt: The varicella vaccine protects against chickenpox and shingles)*	□ Yes (go to 5.5) □ No (go to next section) □ Not sure
5.5	How many doses of the vaccine did you receive?	□ 1 □ 2 □ Not sure
5.6	When did you receive the last dose?	_____ □ Not sure

For female participants (18-26 years old) and parents with daughters from the ages of 9-18 years old		
6.1	Have you/has your daughter ever received the HPV vaccine? *(Prompt: HPV stands forHuman Papillomavirus; two vaccines, Gardasil and Cervavix, are currently approved for use in Singapore; the HPV vaccine protects against cervical cancer and is claimable under Medisave)*	□ Yes (go to 6.2) □ No (go to next section) □ Not sure
6.2	How old were you/was your daughter when you/she received the HPV vaccine?	Age: _____

		□ Not sure
6.3	How many doses of the vaccine did you/your daughter receive? *(Prompt: This is recommended for females 9-26 years, this vaccine can be given in either 2 or 3 doses)*	□ 1 □ 2 □ 3 □ Not sure
6.4	When did you/your daughter receive the last dose of the HPV vaccine?	_____ □ Not sure

For parents with young children under the age of 5		
7.1	Do you have any children under the age of 5? *(Prompt: Your child has not had his/her 5th birthday yet)*	□ Yes □ No
7.2	How many children do you have under the age of 5?	_____
If you have more than one child under the age of 5, please first answer questions about the child whose birthday is next:		
7.3	What is your child's birth month and year?	Month: ____ Year: ____
7.4	Has your child received an influenza vaccination in the past year? *(Prompt:: This is also known as flu vaccine, flu shot, flu jab)*	□ Yes □ No □ Not sure
7.5	Has your child ever received the pneumococcal vaccine? *(Prompt: Also known as PCV13 or Prevnar. This vaccine is given in 3 doses usually at 3, 5 and 12 months of age. PCV13 is claimable under Medisave")*	□ Yes (go to 7.6) □ No (go to 7.9) □ Not sure
7.6	How many doses of the pneumococcal vaccine did your child receive?	□ 1 □ 2 □ 3 □ Not sure
7.7	When did your child receive the last dose of pneumococcal vaccine?	_____ □ Not sure
7.8	Has your child ever received the rotavirus vaccine? *(prompt: This vaccine protects against childhood diarrhoea and is given as drops in the mouth. Usually 2 or 3 doses are given before 8 months of age".*	□ Yes □ No □ Not sure

	there are two types licenced in Singapore, Rotarix (RV5, 2 doses) and RotaTeq (RV1, 3 doses) usually given before 8 months of age. This vaccine is not currently claimable under Medisave)	
7.9	How old was your child when he/she received the rotavirus vaccine?	Age: _____ months □ Not sure
7.10	Which type of rotavirus vaccination did your child receive?	□ RotaTeq™ (given in 3 doses) □ Rotarix™ (given in 2 doses) □ Not sure
7.11	How many doses of the vaccine did your child receive?	□ 1 □ 2 □ 3 □ Not sure

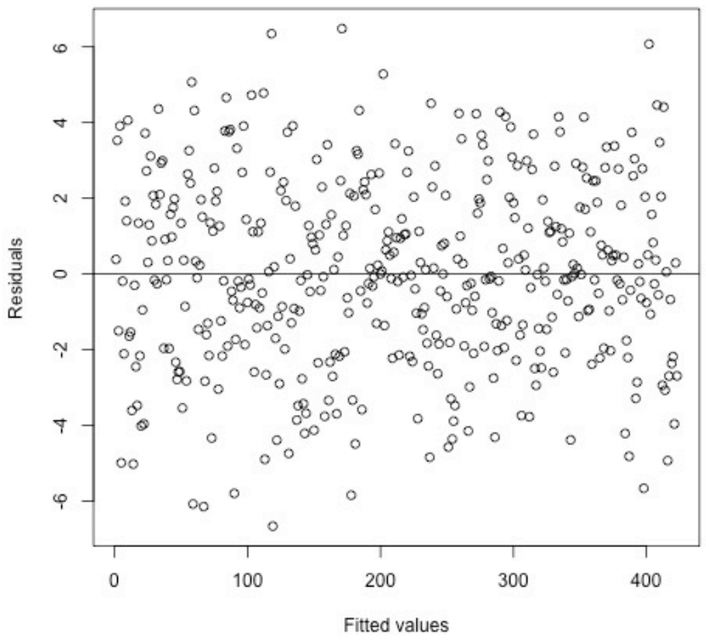
APPENDIX B

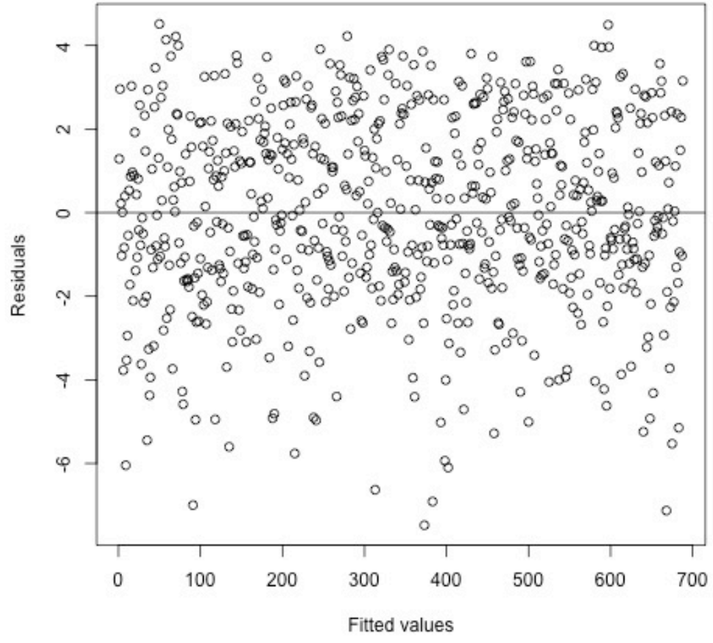
Knowledge score Range: 0 – 14 Median: 8		
Knowledge of antibiotic resistance	Have you ever heard of the abbreviation 'AMR'?	Yes = 1 point
	Have you ever heard of the term 'antibiotic resistance'?	
	Antibiotic resistance occurs when antibiotics become less powerful so they don't work as well	Disagree = 1 point
	Antibiotic resistance occurs when your body becomes resistant to the antibiotics and they no longer work as well	
	Antibiotic resistance only affects people with serious infections in hospitals	
	If I use antibiotics appropriately I don't have to worry about getting antibiotic resistant infections	
	How other people use antibiotics doesn't affect my chance of getting antibiotic resistant infections	
	How I use antibiotics doesn't affect other people's chances of getting antibiotic resistant infections	
	Antibiotic resistance occurs when bacteria become resistant to the antibiotics so they are more difficult to kill	Agree = 1 point
	Antibiotic resistance affects common infections such as sore throats and urinary tract infections	
	Using fewer antibiotics will reduce the spread of antibiotic resistance	
	Vaccinations will reduce the spread of antibiotic resistance	
	Handwashing will reduce the spread of antibiotic resistance	
	Better hygiene and infection control measures in hospitals will reduce the spread of antibiotic resistance	

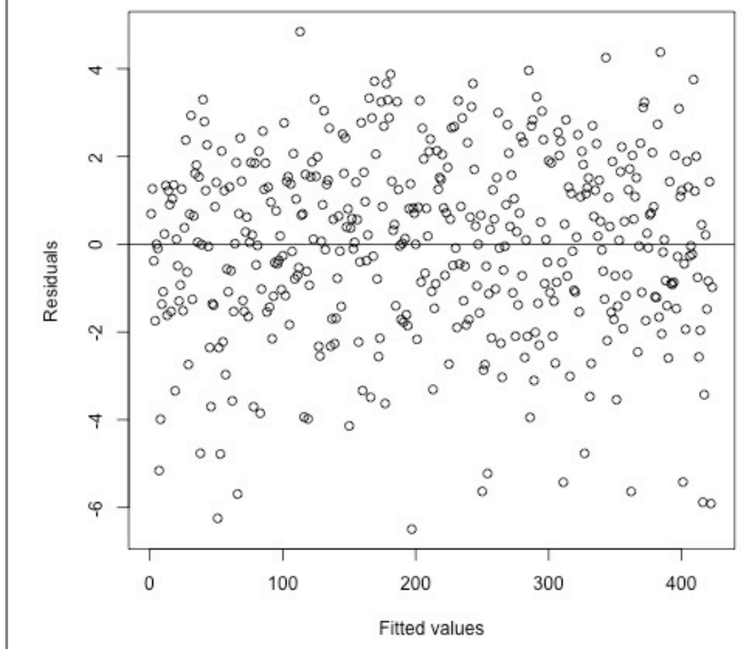
APPENDIX B

Attitudes score Range: 0 – 11 Median: 7		
Attitudes towards antibiotic use (6 points)	Antibiotics can help me recover from bacterial infections	Agree = 1 point
	It is important to always finish the course of antibiotics prescribed to me	
	Antibiotics can help me recover from viral infections	Disagree = 1 point
	Antibiotics can help me recover from the common cold and flu	
	Antibiotics can help me recover from serious symptoms of cold and flu	
	Antibiotics can speed up my recovery from the common cold and flu	
	It is okay to keep leftover antibiotics and use them again when I fall sick in the future	
	It is okay to use my leftover antibiotics when I have the same symptoms as before	
	It is okay not to finish the course of antibiotics prescribed to me when I feel better	
	It is okay not to finish the course of antibiotics prescribed to me when I have an alternative remedy	
	It is okay to miss a dose during the course of antibiotics prescribed to me	

Appendix C


Knowledge scores (Univariable analysis)
Residuals
Fitted values
6
4
2
0
-2
-4
-6
0
100
200
300
400


Attitude scores (Univariable analysis)
Residuals
Fitted values
4
2
0
-2
-4
-6
0
100
200
300
400
500
600
700


Attitude scores (Multivariable analysis)
Residuals
Fitted values
4
2
0
-2
-4
-6
0
100
200
300
400

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	4
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4-5
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4-5
Bias	9	Describe any efforts to address potential sources of bias	5
Study size	10	Explain how the study size was arrived at	4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	5
		(*b*) Describe any methods used to examine subgroups and interactions	5
		(*c*) Explain how missing data were addressed	Na
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	Na
		(*e*) Describe any sensitivity analyses	5
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	5-6
		(b) Give reasons for non-participation at each stage	Na
		(c) Consider use of a flow diagram	Na
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	6
		(b) Indicate number of participants with missing data for each variable of interest	6-7
Outcome data	15*	Report numbers of outcome events or summary measures	6-7
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	7

		(*b*) Report category boundaries when continuous variables were categorized	7
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Na
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	7-8
Discussion			
Key results	18	Summarise key results with reference to study objectives	7
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	8
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	8
Generalisability	21	Discuss the generalisability (external validity) of the study results	8
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	9

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.