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Decisions to use antibiotics for upper respiratory tract infections across China: a large-scale cross-sectional survey among university students

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ABSTRACT

Objectives To investigate the decision-making process of Chinese university students with respect to antibiotic use for upper respiratory tract infections (URTIs).

Design A cross-sectional questionnaire study.

Setting The participants recruited from six universities across all Chinese regions from September to November 2015.

Participants A total of 2834 university students sampled across six Chinese regions who self-reported experiencing symptoms of URTI within the past month completed the survey.

Outcome measures The prevalence of decisions for treatment and antibiotic use for URTIs as well as knowledge about antibiotic use were measured by a self-administrated questionnaire. Using regular and multinomial logistic regression a nd adapted health belief model, we identified and measured a number of variables as potential risk factors for antibiotic misuse behaviours in order to explain and predict people's treatment decisions and antibiotic use including knowledge, perceptions, access to antibiotics and cues to action.

Results Of the 2834 university students who self-diagnosed a URTI, 947 (33.4%) self-reported having taken antibiotics; among them, 462 (48.8%) used non-prescription antibiotics, which came principally from left-over prescriptions (29.0%) and over-the-counter purchases at retail pharmacies (67.3%). One in four who sought care pressured their doctors for antibiotics; all received them. Those who perceived greater severity of the disease, had access to antibiotics, perceived benefits of using antibiotics (for the common cold: adjusted OR (aOR)=2.55, 95% CI 1.93 to 3.38 or as anti-inflammatory drugs: aOR=1.35, 95% CI 1.12 to 1.63), and were cued to action (eg, seeing presence of fever: aOR=2.05, 95% CI 1.62 to 2.60 or self-diagnosing their current infection as severe: aOR=1.86, 95% CI 1.41 to 2.45), keeping antibiotics at home (aOR=2.27, 95% CI 1.83 to 2.81) and access to over-the-counter antibiotics (aOR=2.00, 95% CI 1.63 to 2.45), were more likely to misuse antibiotics.

Conclusions Misconceptions of antibiotic efficacy and easy access to antibiotics—with or without a prescription—were associated with antibiotic misuse among Chinese university students, which calls for context-appropriate multifaceted interventions in order to effectively reduce antibiotic misuse.

Strengths and limitations of this study

- ► Guided by the adapted Health Belief Model, this study identified risk factors influencing antibiotic use for upper respiratory tract infections (URTIs) in the Chinese context (eg, perceived efficacy of antibiotic use for URTIs and easy access to antibiotics), which can inform the design and development of community-based behavioural change interventions aiming to reduce antibiotic misuse.
- ► Heterogeneity exists in antibiotics-related knowledge and in its relationship with use.
- ► This study used a large sample size, with a response rate of 96%, drawn from all six regions across China where respondents were evenly distributed across all demographic groups.
- ► Considering people may have multiple infections during the year and because our sampled population is generally younger, healthier and better educated than the general population, we anticipate antibiotic misuse among the Chinese general population to be more prevalent and severe than what has been presented here.
- ► The differences among the six provinces of different development levels from which the clustered samples of this study were drawn may be greater than those among individuals drawn from a random sample across the country—we have accounted for such variation at the province/university level in the analyses.

INTRODUCTION

Acute upper respiratory tract infections (URTIs), widely known as 'the common cold' and caused by several families of viruses, are the most common infectious diseases.[1] The use of antibiotics is unnecessary for treating URTIs, as most URTIs are viral whereas antibiotics neither expedite recovery from infections nor prevent complications.[2–4] Nevertheless, URTIs remain the most common reason for primary care seeking of antibiotics and antibiotic prescriptions in

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many countries, including China, which has one of the highest reported per capita rates of antibiotics use globally at 138 g/person.[5] Most Chinese antibiotic consumption occurs in outpatient settings, often unnecessarily for URTIs, which is a critical driver of inappropriate and excessive antibiotic use in China.[6 7] Despite the magnitude of antibiotic misuse in China, there is little evidence towards understanding how people make URTI treatment decisions, and little effort has been made to apply health behaviour theories towards understanding such decision-making.

An individual's medical decisions, such as antibiotic use for URTIs, are influenced by their attitudes and perceptions of the illness and treatment options while these attitudes and perceptions themselves are heavily influenced by socioecological context.[8–10] Adults may experience a URTI two to five times annually,[1] making it so well recognised that, before consulting a physician, individuals commonly engage in self-diagnosis and decide a course of action—a majority of these self-recognised episodes were managed without seeking formal care.[11] To date, a majority of studies on antibiotic use behaviours examine the issues from a traditional, knowledge-attitudes-practice perspective, assuming people would make more 'risk-conscious' choices if informed of risks that could easily have been avoided (ie, improved knowledge and awareness leads to changes in practice). However, decision scientists argue that when people engage in healthcare decision-making, they focus on attaining a goal—curing of an illness.[12] This thinking focuses on a positive rather than a negative outcome, where people accept the risks of drug resistance (for the immediate perceived benefits of antibiotic use) rather than intentionally taking risks.[12]

The 2019 *British Medical Journal* policy review of China's 10-year effort in health reform[13] clearly pointed to a current research and intervention gap that demonstrates there has been no improvement in primary care settings, where most of the population resides and the majority of antibiotic use takes place. Further, recent meta-analysis showed that despite being younger and better educated than the general public, university students' misuse of antibiotics has been a global health problem, especially in low-income and middle-income countries (LMIC).[14] In China, university students represent the future opinion leaders and the next generation of parents, and therefore, could serve as an entry point for assessment and intervention to the future trajectory of antibiotic misuse in China. However, previous studies on Chinese university students were limited in scale to one school[9 15] and/or one region[9 15 16] and were not grounded in behavioural theories. In this study, we undertook a risk factor analysis for the public's antibiotic misuse behaviours for informing effective intervention development. Risk factors were identified using the Health Belief Model with an aim to explain and predict health behaviours with respect to antibiotic use for URTIs. Specifically, with self-diagnosed URTI cases, we aimed to assess Chinese university students' (1) Antibiotic use. (2) Treatment decisions regarding care seeking and antibiotic use. (3) Prescription outcomes after seeking formal care, with a focus on antibiotic demands.

METHODS

Population sample

We used a cluster random sampling method to recruit university students across six Chinese regions for a cross-sectional survey from September to November 2015. The single best comprehensive university[17] in each of six sampled provinces in each region was identified as they represent educational elite, future opinion leaders and the next generation of parents of the country. Students attending these universities were eligible for enrolment. With assistance from school officials, class schedules were obtained the day prior to the survey. Classes were randomly selected from the timetable; every class had an equal chance of selection. All university students attending these classes were included. Over 95% of students in the selected classes completed the questionnaire; some students did not participate due to lacking a phone or laptop at the time of survey. Pilot tests indicated the prevalence of URTIs among Chinese university students in the past month to be 25%–30%. To ensure an adequate sample size for the planned subgroup analyses, we aimed to achieve a sample size per university of ca.1800 students. A total of 11 192 students completed the survey. Among them, 25.32% (n=2834) self-reported experiencing symptoms of URTI[1]—including cold (cough, runny/stuffy nose), fever, sore throat, headache and influenza, either alone or in combination—within the past month. These respondents were evenly distributed across all demographic groups and included in this study. Further details on the survey's design and sampling methods have been previously described and published.[10 18]

Data collection

This study used a systematically developed questionnaire. Questions were tailored to the Chinese sociocultural context, as informed by literature review,[8 9 15 16] behavioural theories, and qualitative interviews with stakeholders and experts for face validity and content validity. A consent form was presented at the first section of the questionnaire and was signed by all participants, who were informed that participation was confidential, voluntary, could be terminated at any time, and that the questionnaire would take ~5 min to complete. The survey was developed using Wen Juan Xing—a popular web-based platform for professional electronic questionnaires and data collection—and delivered via WeChat, China's most used communication application. The survey was finalised after a pilot test with 254 respondents to evaluate potential sources of response error and improve the instrument. The reliability and validity fit the requirements.

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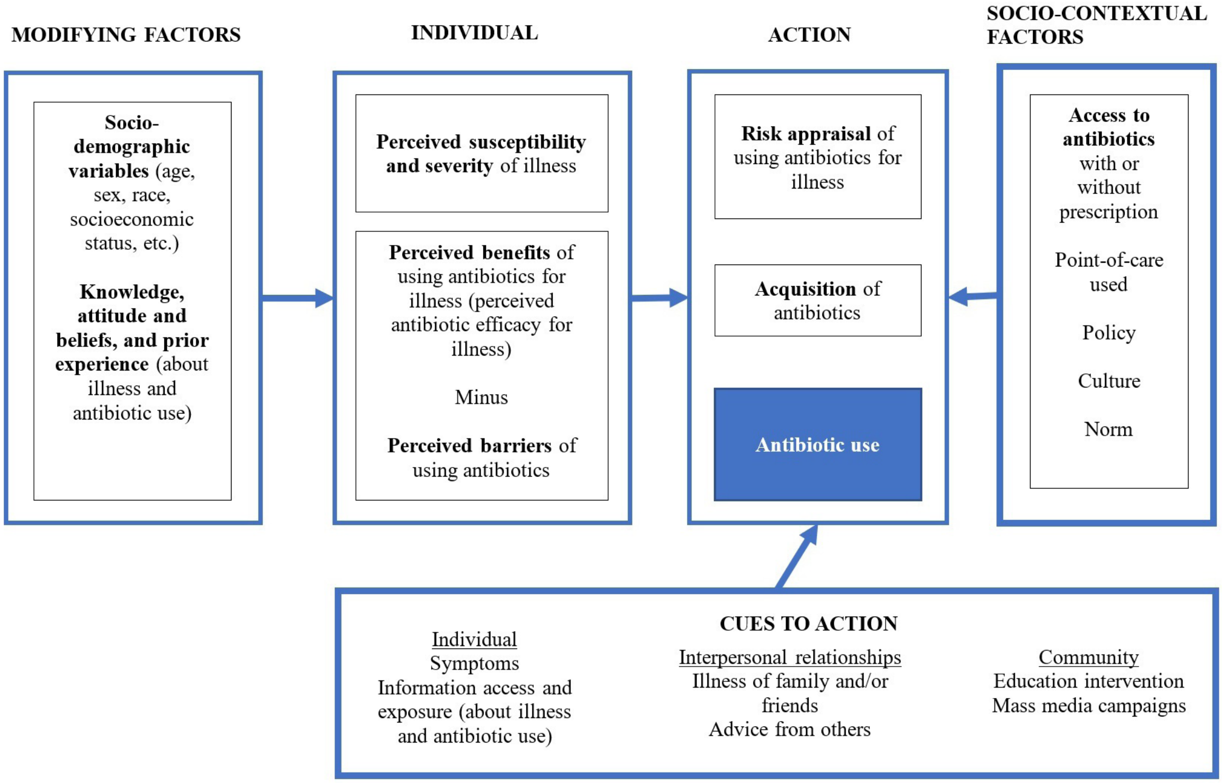

Figure 1 Modified health belief model for public antibiotic use.

Behavioural frameworks

We adapted the Health Belief Model[19 20] and the conceptual framework for analysis, as presented in figure 1. The study aims to understand the impact of individuals' perception of illness and treatment on one's decisions for antibiotic use while accounting for the complex interplay between factors at different levels of socioecological environment[21] (ie, individual, interpersonal and societal). *Knowledge* relates to antimicrobial resistance (AMR) awareness, ability to identify antibiotics and misconceptions. Perceptions involve expectations about the seriousness of the consequences of acquiring URTIs (ie, *perceived severity*) or the benefits of antibiotic treatment for URTI symptoms (*perceived* antibiotic efficacy). *Cues to action* are external determinants of health behaviours (eg, *presence of symptoms*).

Outcome variables

To assess the prevalence of antibiotic use for self-diagnosed URTIs, participants were first assessed based on whether or not they had used antibiotics (with or without a prescription) for the symptoms they experienced. They were then categorised into three subgroups with respect to their treatment decisions for using antibiotics: *no treatment or self-treated without antibiotics (reference group), self-treated with antibiotics, and sought formal care.* Diagnostic outcomes of care seeking were categorised into three subgroups with respect to doctors' prescribing decisions for antibiotics: *no antibiotic prescription (reference group), unnecessary antibiotic prescriptions for URTI symptoms* and *inappropriate antibiotic prescriptions due to patients' demands.*

Exposure variables

Consulting the modified Health Belief Model for antibiotic use (figure 1), we included the following potential risk factors in our analyses:

1. *Knowledge about antibiotics and resistance* was measured by a series of factual statements related to *AMR awareness (five items), ability to identify antibiotics (seven items)* and *misconception about the antibiotics as 'anti-inflammatory drugs' (one item)*.
2. *Perceived severity of URTIs* was measured by knowing that URTIs are self-limiting and will dissipate naturally.
3. *Perceived antibiotic efficacy* was measured by five factual statements about antibiotics' efficacy to treat URTIs.
4. *Cues to action:* (a) *self-diagnosed severity of currentinfection, measured by numbers of cold symptoms experienced.* (b) *Presence of fever.*
5. *Access to antibiotics* was measured by two yes/no questions: (a) *Keeping antibiotics at home in the past year.* (b) *Over-the-counter purchase of non-prescription antibiotics in the past year.*

Additionally, considering the Chinese socioecological environment regarding healthcare decisions, data on (6) *Point of care* used for care seeking was collected, ranging from hospitals above county level, county level hospitals, township hospitals and private clinics.

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Covariates

Sociodemographic characteristics were included as potential confounders for the association between each exposure and treatment decisions, including age, sex, household income, urbanicity, university major in medicine, having at least one parent with medical background and region/province.

Statistical analysis

First, we described and summarised participants' sociodemographic characteristics and risk factors by treatment decision/behavioural outcomes. Second, we developed a flow diagram to show pathways of different medical decision outcomes with respect to antibiotic use for URTIs. Third, we described responses to different domains of knowledge about antibiotic use and resistance. Fourth, to examine the association between each risk factor and outcome, we applied logistic regressions to estimate the OR (95% CI) for 'treatment with antibiotic for URTIs' (vs 'no antibiotic use'). Last, we explored the associations with subgroups of antibiotic use for URTIs by self-medication and via formal care, and applied multinomial logistic regressions to estimate the relative risk ratio, RRR (95% CI) for (1) 'self-treatment with antibiotics' and 'sought healthcare' (vs 'no treatment or self-medication without antibiotics'). For students who sought healthcare, we estimated RRR (95% CI) for (2) 'receiving (unnecessary) prescriptions without request' and 'receiving (inappropriate) prescriptions due to patients request' (vs 'without an antibiotic prescription'). For each outcome and exposure, we first fitted an unadjusted model, and then a full model adjusted for potential confounders. These confounders—identified via published studies[8 9 15 16] on public's antibiotic use—include: *age, sex, household income, urbanicity, being a medical student or having at least one parent with a medical background, and hometown region of residence (university/province)*.

Indirect patient and public involvement

We did not directly include patient and public involvement in this study, but the database used was developed with stakeholders, including the general public who had previously experienced URTIs.

Guidelines

The guidelines for observational studies in epidemiology (Strengthening the Reporting of Observational studies in Epidemiology (STROBE) checklist) were followed during the preparation of the manuscript.

RESULTS

Distributions of decisions for treatment and antibiotic use for URTIs

As presented in figure 2, when the 2834 university students with self-diagnosed URTIs were asked about their choice of treatment, 20.4% decided against treatment (n=579), 54.5% decided to self-treat (with or without antibiotics, n=1545), and a quarter sought formal care (n=710, 25.1%). A total of 947 students self-reported having taken antibiotics for URTI symptoms: 462 (48.8%) used non-prescription antibiotics and the rest obtained a prescription. Non-prescription antibiotics came principally from left-over prescriptions (29.0%) and over-the-counter purchases from pharmacies (67.3%). One out of every four respondents who sought formal care admitted to pressuring their doctors for antibiotics (n=123, 17.3%), with a 100% success rate.

Knowledge and perceptions about antibiotic use and resistance

Respondents were assessed on their knowledge about antibiotic use and resistance and perceptions on antibiotic efficacy and URTIs as a health threat. In table 1, the overall Cronbach's alpha, including all items, was 0.81, with subscales of 0.71 (for AMR awareness) and 0.81 (for ability to identify antibiotics). Three quarters of participants (74.2%–88.5%) reported being aware of the dangers posed by overuse of antibiotics. A majority of participants (63.0%) had trouble distinguishing cold medicine (eg, Tylenol, Contac NT or Gankang) from antibiotics; 36.5% were unaware antibiotics were not anti-inflammatory drugs; more than 60% had an incorrect perception of antibiotic efficacy for URTIs, either being unsure or wrongly stating that antibiotics might expedite recovery or alleviate symptoms.

Factors associated with antibiotic use for URTIs

Compared with those who did not use antibiotics for treatment of URTIs (see table 2), *ability to identify antibiotics* (adjusted OR (aOR)=1.51, 95% CI 1.17 to 1.94), *perceived antibiotics to be effective for the common cold* (aOR=2.55, 95% CI 1.93 to 3.38) or as *anti-inflammatory drugs* (aOR=1.35, 95% CI 1.12 to 1.63), *not knowing that the common cold is self-limiting* (aOR=1.35, 95% CI 1.12 to 1.62), *presence of fever* (aOR=2.05, 95% CI 1.62 to 2.60), *multiple symptoms experienced* (aOR=1.86, 95% CI 1.41 to 2.45)), *keeping antibiotics at home* (aOR=2.27, 95% CI 1.83 to 2.81) and *access to over-the-counter antibiotics* (aOR=2.00, 95% CI 1.63 to 2.45) were associated with a higher likelihood of antibiotic use for URTIs.

Factors associated with the treatment decisions for URTIs and antibiotic use

Relative to those who did nothing or self-treated without antibiotics for URTIs (reference group in table 3), participants who self-medicated with antibiotics were more likely to have *perceived antibiotic efficacy for URTIs* (adjusted relative risk ratio (aRRR)=3.03, 95% CI 2.10 to 4.38), *mistake antibiotics as anti-inflammatory drugs* (aRRR=1.40, 95% CI 1.10 to 1.77), *not know that the common cold is self-limiting* (aRRR=1.34, 95% CI 1.05 to 1.71), *experience multiple cold symptoms* (aRRR=1.96, 95% CI 1.36 to 2.84), *keep antibiotics at home* (aRRR=4.68, 95% CI 3.24 to 6.74) and *purchase over-the-counter antibiotics* (aRRR=3.21, 95% CI 2.34 to 4.41). Those who sought formal care were more likely to

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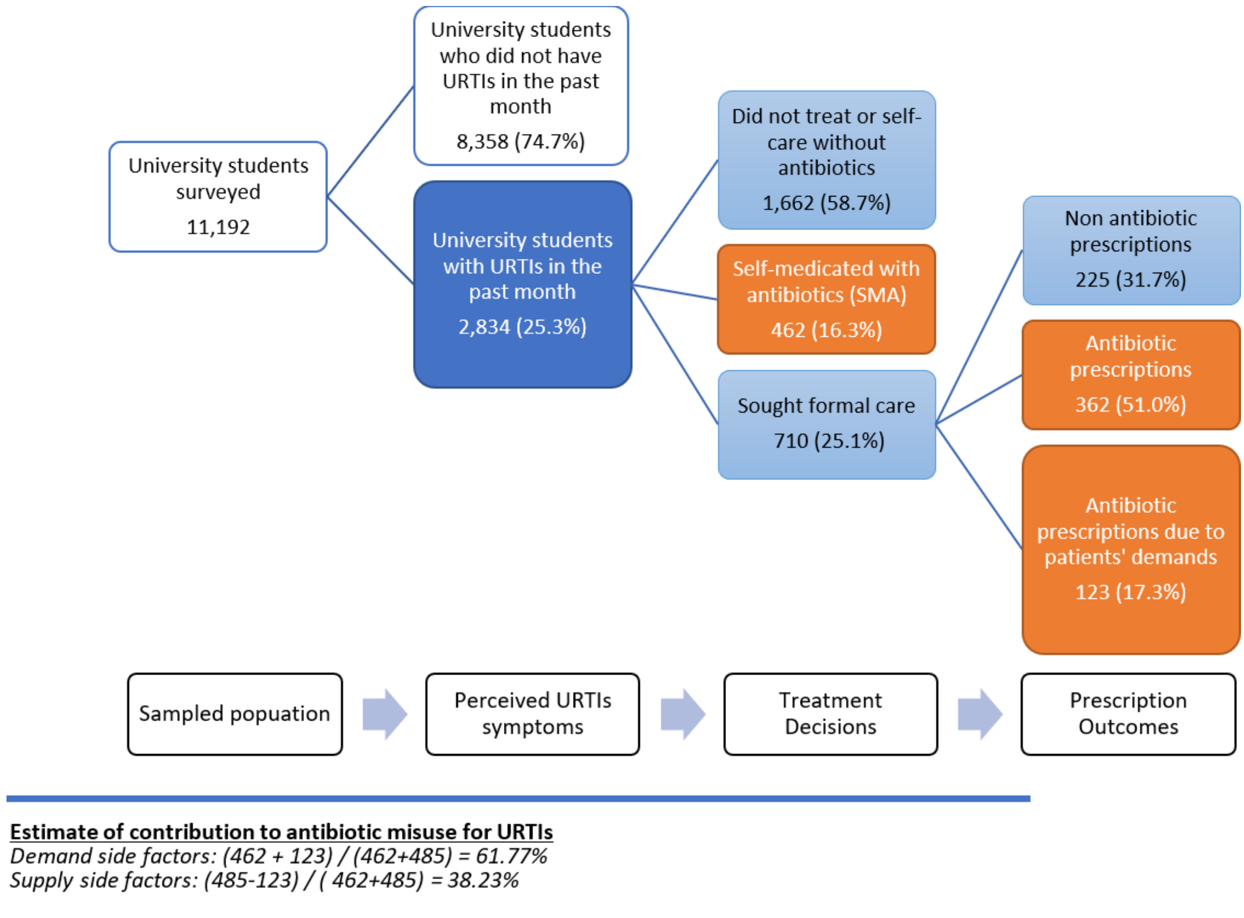

Figure 2 Medical decisions about antibiotic use for upper respiratory tract infections (URTIs) among Chinese university students.

have a *high level of AMR awareness* (aRRR=0.61, 95% CI 0.42 to 0.89), have *not known that URTIs are self-limiting* (aRRR=1.66, 95% CI 1.36 to 2.02), *experienced multiple cold symptoms* (aRRR=1.64, 95% CI 1.21 to 2.21) and had *presence of fever* (aRRR=2.98, 95% CI 2.32 to 3.83). Participants who had *perceived antibiotics to be effective for the common cold* (aRRR=1.89, 95% CI 1.38 to 2.57), *kept antibiotics at home* (aRRR=1.24, 95% CI 1.00 to 1.54) and *purchased over-the-counter antibiotics* (aRRR=1.22, 95% CI 0.99 to 1.51) were also more likely to seek formal care.

Factors associated with antibiotic prescriptions for the treatment of URTIs

Participants who sought care and had high levels of *AMR awareness* had lower risks of demanding antibiotics. Relative to those who sought formal care but did not get an antibiotics prescription (reference group in table 4), participants who had *high ability to identify antibiotics* (aRRR=6.35, 95% CI 2.85 to 14.13), *perceived antibiotics to be effective for the common cold* (aRRR=3.67, 95% CI 1.61 to 8.39) or *as anti-inflammatory drugs* (aRRR=1.92, 95% CI 1.11 to 3.33), *presence of fever* (aRRR=3.24, 95% CI 1.70 to 6.18), *kept antibiotics at home* (aRRR=2.46, 95% CI 1.33 to 4.56) and made *over-the-counter purchase* (aRRR=3.69, 95% CI 1.97 to 6.91) had a higher likelihood of demanding antibiotic prescriptions. Evidence of structural differences was observed in antibiotic prescribing outcomes in *point of care*; 54.3% of patients who sought care at tertiary hospitals and 52.7% at township hospitals were prescribed antibiotics for URTIs, whereas 43.2% of county hospitals and 43.1% of local clinics gave antibiotic prescriptions for URTIs. All patients who demanded antibiotic prescriptions from a doctor received them.

DISCUSSION

We found that 33.4% of young Chinese educated in top universities (n=947) with URTIs used antibiotics; among them, 462 (48.8%) used non-prescription antibiotics and additionally, a quarter of prescriptions originated from patients' demands (n=123, 25.4%). We therefore estimated that the demand side is responsible for 61.8% of antibiotic use for URTIs ((462+123)/947). Surprisingly, high *ability to identify antibiotics* was linked to higher likelihoods of antibiotic use, especially antibiotic prescriptions. Mistaking antibiotics as anti-inflammatory drugs, perceiving antibiotics as efficacious for treating URTIs and access to non-prescription antibiotics were strongly associated with antibiotic misuse, including self-medication with antibiotics and demands for antibiotic prescriptions. We found non-prescription antibiotics are

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Table 1 Knowledge and perceptions about antibiotic use and resistance score distribution (n=2834)

	Yes	No	I don't know	Alpha
	n (%)	n (%)	n (%)	0.81
AMR awareness				0.71
1. Antibiotic overuse is a serious problem in China.	**2168** (**76.5**)	51 (1.8)	615 (21.7)	
2. The more frequently people use antibiotics; the more difficult it will be to treat bacterial infections.	**2270** (**80.1**)	262 (9.2)	302 (10.7)	
3. Antibiotic overuse may increase antibiotic resistance.	**2509** (**88.5**)	184 (6.5)	141 (5.0)	
4. Antibiotic resistance will become a serious problem in China.	**2102** (**74.2**)	61 (2.2)	671 (23.7)	
5. We will have few antibiotics to use in the future if we don't use antibiotics properly.	**2367** (**83.5**)	222 (7.8)	245 (8.7)	
Ability to identify antibiotics				0.81
1. Penicillin (amoxicillin)	**2263** (**79.9**)	275 (9.7)	296 (10.4)	
2. Cephalosporin (cefaclor, ceftriaxone sodium)	**1969** (**69.5**)	342 (12.1)	523 (18.5)	
3. Non-steroidal anti-inflammatory drugs (ibuprofen, aspirin)	1129 (39.8)	**894** (**31.6**)	811 (28.6)	
4. Quinolones (norfloxacin, ofloxacin)	**1306** (**46.1**)	600 (21.2)	928 (32.8)	
5. Acetaminophen (Tylenol, Contac NT, Gankang)	799 (28.2)	**1049** (**37.0**)	986 (34.8)	
6. Macrolides (azithromycin, roxithromycin)	**1669** (**58.9**)	331 (11.7)	834 (29.4)	
7. Steroids (dexamethasone, prednisone)	761 (26.9)	**820** (**28.9**)	1253 (44.2)	
Misconception about antibiotics				
1. Antibiotics are anti-inflammatory drugs.	575 (20.3)	**1799** (**63.5**)	460 (16.2)	
Perceived antibiotic efficacy on URTIs				
1. Antibiotics can speed up recovery from influenza.	1250 (44.1)	**1081** (**38.1**)	503 (17.8)	
2. Antibiotics can relieve the symptoms of cold.	1384 (48.8)	**943** (**33.3**)	507 (17.9)	
3. Antibiotics are necessary for treating sore throat.	978 (34.5)	**1620** (**57.2**)	236 (8.3)	
4. Antibiotics are necessary for treating common cold (cough, runny nose).	687 (24.2)	**1912** (**67.5**)	235 (8.3)	
Perceived threat about URTIs				
1. Common cold is self-limiting and does not require medication as the symptoms will dissipate naturally.	**1927** (**68.0**)	725 (25.6)	182 (6.4)	

URTI, upper respiratory tract infection.

easily accessible in China: 68.2% of participants kept antibiotics at home at the time of the survey and 64.2% made over-the-counter purchases at least once within the past year. At health facilities, roughly 70% of clinicians prescribed antibiotics—most deemed as inappropriate and unnecessary—for URTI symptoms, and there was practically no barrier to accessing antibiotic prescriptions from a doctor.

Strengths and limitations

This study used a large sample size, with a response rate of 96%, drawn from all six regions across China where respondents were evenly distributed across all demographic groups. As of today, the survey provided the most recent, nationwide data of its kind. This study is guided by the adapted Health Belief Model for analysis in explaining and predicting patients' treatment decisions and antibiotic use for URTIs. We found perceived infection severity, efficacy of antibiotic use for URTIs, barriers/access to antibiotics and cues to action are determinants of higher likelihoods of antibiotic use for URTIs, with or without prescriptions. In the Chinese context, our data further identified the demands of the health system—rather than supply—as the driving force for outpatient antibiotic use for URTIs, with a 1.6:1 ratio (62% vs 38%), and that access to antibiotics, with or without a prescription, was extremely easy. This model can guide the design and development of behavioural change interventions which aim to reduce antibiotic misuse in the community, with a focus on the complex interplay between individual/interpersonal/societal factors and individuals' decisions on treatment and antibiotic use for URTIs. Compared with previous studies on similar populations in China[9 15 16] and other low- and middle-income countries (LMIC),[14] this study made a novel contribution to the field of AMR by rooting in a behavioural theory and conducting a holistic assessment on individual self-diagnostic and treatment decision-making processes with respect to antibiotics for URTIs, including the interaction between doctors and patients.

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Table 2 Logistic regression to assess factors associated with antibiotic use for upper respiratory tract infections (URTIs) among Chinese university students (n=2834)

	All students with URTIs (n=2834)	Antibiotic use for URTIs (n=947, 33.42%)§			P value*§
	N (%)	N(%)	OR (95% CI)	Adjusted OR (95% CI)‡	
Knowledge about antibiotics					
AMR awareness					0.97
Low	181 (6.39)	73 (7.71)	Reference	Reference	
Medium	571 (20.15)	210 (22.18)	0.86 (0.61 to 1.21)	1.02 (0.70 to 1.50)	
High	2082 (73.47)	664 (70.12)	**0.69 (0.51 to 0.95)**	0.99 (0.70 to 1.42)	
Ability to identify antibiotics					**0.002**
Low	806 (28.44)	226 (23.86)	Reference	Reference	
Medium	1267 (44.71)	470 (49.63)	**1.51 (1.25 to 1.83)**	**1.37 (1.11 to 1.70)**	
High	761 (26.85)	251 (26.50)	**1.26 (1.02 to 1.57)**	**1.51 (1.17 to 1.94)**	
Perceived severity of the infection					
Common cold is self-limiting					**0.002**
Yes	1927 (68.00)	581 (61.35)	Reference	Reference	
No/I don't know	907 (32.00)	366 (38.65)	**1.57 (1.33 to 1.85)**	**1.35 (1.12 to 1.62)**	
Perceived antibiotic efficacy					
Perceived antibiotic efficacy for URTIs					**<0.0001**
No/low	938 (33.10)	200 (21.12)	Reference	Reference	
Medium	1476 (52.08)	542 (57.23)	**2.14 (1.77 to 2.59)**	**1.71 (1.39 to 2.10)**	
High	420 (14.82)	205 (21.65)	**3.52 (2.75 to 4.50)**	**2.55 (1.93 to 3.38)**	
Antibiotics are anti-inflammatory drugs					**0.001**
No	1799 (63.48)	524 (55.33)	Reference	Reference	
Yes/I don't know	1035 (36.52)	423 (44.67)	**1.68 (1.43 to 1.97)**	**1.35 (1.12 to 1.63)**	
Cues to action					
Severity of current infection (number of symptoms experienced)					**<0.0001**
Low (1 symptom)	1488 (52.51)	395 (41.71)	Reference	Reference	
Medium (two symptoms)	893 (31.51)	317 (33.47)	**1.52 (1.27 to 1.82)**	**1.37 (1.13 to 1.67)**	
High (three symptoms or more)	453 (15.98)	235 (24.82)	**2.98 (2.40 to 3.71)**	**1.86 (1.41 to 2.45)**	
Fever					**<0.0001**
No	2235 (78.86)	638 (67.37)	Reference	Reference	
Yes	599 (21.14)	309 (32.63)	**2.67 (2.22 to 3.21)**	**2.05 (1.62 to 2.60)**	
Barriers/access to antibiotics					
Keeping antibiotics at home					**<0.0001**
No	900 (31.76)	179 (18.90)	Reference	Reference	
Yes	1934 (68.24)	768 (81.10)	**2.65 (2.20 to 3.20)**	**2.27 (1.83 to 2.81)**	
Over-the-counter purchase of non-prescription antibiotics in the past year					**<0.0001**
No	1015 (35.82)	202 (21.33)	Reference	Reference	
Yes	1819 (64.18)	745 (78.67)	**2.79 (2.33 to 3.34)**	**2.00 (1.63 to 2.45)**	
Sociodemographic characteristics					
Age	21.13† (2.67)		1.02 (0.99 to 1.05)	1.00 (0.96 to 1.03)	0.79
Sex					0.44
Male	1476 (52.08)	496 (52.38)	Reference	Reference	
Female	1358 (47.92)	451 (47.62)	0.98 (0.84 to 1.15)	1.07 (0.90 to 1.28)	

Continued

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Table 2 Continued

	All students with URTIs (n=2834)	Antibiotic use for URTIs (n=947, 33.42%)§			P value*§
	N (%)	N(%)	OR (95% CI)	Adjusted OR (95% CI)‡	
Urbanicity of home town					0.07
Rural	1644 (58.01)	505 (53.33)	Reference	Reference	
Urban	1190 (41.99)	442 (46.67)	**1.33 (1.14 to 1.56)**	1.20 (0.98 to 1.47)	
Average household income (¥, monthly)					0.05
>10 000 (>$1538)	496 (17.50)	147 (15.52)	Reference	Reference	
3001–10 000 ($462–$1538)	1503 (53.03)	470 (49.63)	1.08 (0.87 to 1.35)	0.92 (0.72 to 1.17)	
≤3000 ($461)	835 (29.46)	330 (34.85)	**1.55 (1.22 to 1.97)**	1.21 (0.90 to 1.62)	
Major in medicine					**0.02**
No	2396 (84.54)	835 (88.17)	Reference	Reference	
Yes	438 (15.46)	112 (11.83)	**0.64 (0.51 to 0.81)**	**0.73 (0.56 to 0.95)**	
Having at least one parent with medical background					0.47
No	2524 (89.06)	836 (88.28)	Reference	Reference	
Yes	310 (10.94)	111 (11.72)	1.13 (0.88 to 1.44)	1.11 (0.84 to 1.46)	
Region (University, Province)					**0.001**
North (Nankai University, Tianjin)	417 (14.71)	121 (12.78)	Reference	Reference	
East (Zhejiang University, Zhejiang)	459 (16.20)	104 (10.98)	**0.72 (0.53 to 0.97)**	0.81 (0.58 to 1.14)	
Southwest (Guizhou University, Guizhou)	493 (17.40)	223 (23.55)	**2.02 (1.53 to 2.66)**	**1.56 (1.15 to 2.13)**	
Northwest (Lanzhou University, Gansu)	528 (18.63)	203 (21.44)	**1.53 (1.16 to 2.01)**	1.29 (0.95 to 1.74)	
South (Wuhan University, Hubei)	480 (16.94)	121 (12.78)	0.82 (0.61 to 1.11)	0.93 (0.67 to 1.28)	
Northeast (Jilin University, Jilin)	457 (16.13)	175 (18.48)	1.52 (1.14 to 2.02)	1.09 (0.79 to 1.49)	

*Likelihood ratio tests for antibiotic use for URTIs.
†Mean (SD).
‡Adjusted for age, sex, household income, urbanicity, university major in medicine, having at least one parent with medical background and region/province.
§Bold values denote statistical significance at the p < 0.05 level.
AMR, antimicrobial resistance.

Though the cross-sectional study design limited us from drawing causal relationships between knowledge and practice of antibiotic misuse, it helped to generate causal hypotheses and offered several points for intervention. Experiments, longitudinal studies or behavioural data are needed in the near future to avoid recall bias, an inherent limitation of self-reported survey data. Considering people may have multiple infections during the year and because our target population consisted of university students, who are generally younger, healthier and better educated than the general population, we anticipate antibiotic misuse among the Chinese general population to be more prevalent and severe than what has been presented here. Further, China is a vast and dynamic country; it is likely that some findings about this particular population may have changed over the last 5 years, which put constraints on the generalisability of the findings. Future studies should assess feasibility and appropriateness of the intervention proposed to the target population before full-scale implementation. As an example, a feasibility study conducted in rural Zhejiang in 2019 showed that findings from this study were applicable to its target population.[22] Lastly, because the samples were clustered, the estimated standard errors used in significance tests may be biassed. In our case, samples were drawn from six universities across China, from provinces of different development levels; the differences among these provinces might be greater than those among individuals drawn from a random sample across the country. We have accounted for such variation at the province/university level in the analyses.

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Table 3 Multinomial regression model to assess factors associated with treatment decisions for upper respiratory tract infections (URTIs) with respect to antibiotic use among Chinese university students (n=2834)

	Did not treat or self-treated without antibiotics (n=1662, 58.65%)	Self-medicated with antibiotics (n=462, 16.30%)‡			Sought formal care (n=710, 25.05%)‡			
	n (%)	n (%)	RRR (95% CI)	aRRR (95% CI)†	n (%)	RRR (95% CI)	aRRR (95% CI)†	P value*‡
Knowledge about antibiotics								
AMR awareness								**0.006**
Low	84 (5.05)	23 (4.98)	Reference	Reference	74 (10.42)	Reference	Reference	
Medium	302 (18.17)	94 (20.35)	1.14 (0.68 to 1.90)	1.34 (0.77 to 2.34)	175 (24.65)	**0.66 (0.46 to 0.95)**	0.80 (0.54 to 1.18)	
High	1276 (76.77)	345 (74.68)	0.99 (0.61 to 1.59)	1.38 (0.82 to 2.33)	461 (64.93)	**0.41 (0.29 to 0.57)**	**0.61 (0.42 to 0.89)**	
Ability to identify antibiotics								0.49
Low	488 (29.36)	108 (23.38)	Reference	Reference	210 (29.58)	Reference	Reference	
Medium	718 (43.20)	224 (48.48)	**1.41 (1.09 to 1.82)**	1.08 (0.82 to 1.43)	325 (45.77)	1.05 (0.85 to 1.30)	1.08 (0.86 to 1.36)	
High	456 (27.44)	130 (28.14)	1.29 (0.97 to 1.71)	1.20 (0.87 to 1.67)	175 (24.65)	0.89 (0.70 to 1.13)	1.27 (0.97 to 1.66)	
Perceived severity of the infection								
Common cold is self-limiting								**<0.0001**
Yes	1216 (73.16)	297 (64.29)	Reference	Reference	414 (58.31)	Reference	Reference	
No/I don't know	446 (26.84)	165 (35.71)	**1.51 (1.22 to 1.89)**	**1.34 (1.05 to 1.71)**	296 (41.69)	**1.95 (1.62 to 2.34)**	**1.66 (1.36 to 2.02)**	
Perceived antibiotic efficacy								
Perceived antibiotic efficacy for URTIs								**<0.0001**
No/low	664 (39.95)	90 (19.48)	Reference	Reference	184 (25.92)	Reference	Reference	
Medium	813 (48.92)	267 (57.79)	**2.42 (1.87 to 3.14)**	**1.99 (1.50 to 2.64)**	396 (55.77)	**1.76 (1.44 to 2.15)**	**1.46 (1.17 to 1.82)**	
High	185 (11.13)	105 (22.73)	**4.19 (3.02 to 5.80)**	**3.03 (2.10 to 4.38)**	130 (18.31)	**2.54 (1.92 to 3.35)**	**1.89 (1.38 to 2.57)**	
Antibiotics are anti-inflammatory drugs								**0.02**
No	1123 (67.57)	249 (53.90)	Reference	Reference	427 (60.14)	Reference	Reference	
Yes/I don't know	539 (32.43)	213 (46.10)	**1.78 (1.44 to 2.20)**	**1.40 (1.10 to 1.77)**	283 (39.86)	**1.38 (1.15 to 1.66)**	1.12 (0.91 to 1.38)	
Cues to action								
Severity of current infection (number of symptoms experienced)								**<0.001**
Low (one symptom)	974 (58.60)	217 (46.97)	Reference	Reference	297 (41.83)	Reference	Reference	
Medium (two symptoms)	507 (30.51)	152 (32.90)	**1.35 (1.07 to 1.70)**	**1.30 (1.01 to 1.68)**	234 (32.96)	**1.51 (1.24 to 1.85)**	**1.29 (1.04 to 1.61)**	
High (three symptoms or more)	181 (10.89)	93 (20.13)	**2.31 (1.73 to 3.08)**	**1.96 (1.36 to 2.84)**	179 (25.21)	**3.24 (2.54 to 4.14)**	**1.64 (1.21 to 2.21)**	

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Table 3 Continued

	Did not treat or self-treated without antibiotics (n=1662, 58.65%)	Self-medicated with antibiotics (n=462, 16.30%)‡			Sought formal care (n=710, 25.05%)‡			
	n (%)	n (%)	RRR (95% CI)	aRRR (95% CI)†	n (%)	RRR (95% CI)	aRRR (95% CI)†	P value*‡
Fever								**<0.0001**
No	1432 (86.16)	359 (77.71)	Reference	Reference	444 (62.54)	Reference	Reference	
Yes	230 (13.84)	103 (22.29)	**1.79 (1.38 to 2.32)**	1.23 (0.89 to 1.72)	266 (37.46)	**3.73 (3.04 to 4.58)**	**2.98 (2.32 to 3.83)**	
Barriers/access to antibiotics								
Keeping antibiotics at home								**<0.0001**
No	628 (37.79)	38 (8,23)	Reference	Reference	234 (32.96)	Reference	Reference	
Yes	1034 (62.21)	424 (91.77)	**6.78 (4.79 to 9.58)**	**4.68 (3.24 to 6.74)**	476 (67.04)	**1.24 (1.03 to 1.49)**	**1.24 (1.00 to 1.54)**	
Over-the-counter purchase of non-prescription antibiotics in the past year								**<0.0001**
No	709 (42.66)	55 (11.90)	Reference	Reference	251 (35.35)	Reference	Reference	
Yes	953 (57.34)	407 (88.10)	**5.51 (4.09 to 7.42)**	**3.21 (2.34 to 4.41)**	459 (64.65)	**1.36 (1.13 to 1.63)**	**1.22 (0.99 to 1.51)**	
Sociodemographic characteristics								
Age			1.03 (0.99 to 1.07)	1.01 (0.97 to 1.05)		0.99 (0.96 to 1.02)	0.99 (0.95 to 1.03)	
Sex								0.19
Male	876 (52.71)	243 (52.60)	Reference	Reference	357 (50.28)	Reference	Reference	
Female	786 (47.29)	219 (47.40)	1.00 (0.82 to 1.23)	1.22 (0.97 to 1.52)	353 (49.72)	1.10 (0.92 to 1.31)	1.12 (0.92 to 1.35)	
Urbanicity of home town								0.64
Rural	1000 (60.17)	273 (59.09)	Reference	Reference	371 (52.25)	Reference	Reference	
Urban	662 (39.83)	189 (40.91)	1.05 (0.85 to 1.29)	1.07 (0.83 to 1.39)	339 (47.75)	**1.38 (1.16 to 1.65)**	1.11 (0.89 to 1.38)	
Average household income (¥, monthly)								0.14
>10 000 (>$1538)	307 (18.47)	83 (17.97)	Reference	Reference	106 (14.93)	Reference	Reference	
3001–10 000 ($462–$1538)	907 (54.57)	239 (51.73)	0.97 (0.74 to 1.29)	0.82 (0.60 to 1.12)	357 (50.28)	1.14 (0.89 to 1.47)	1.07 (0.82 to 1.41)	
≤3000 ($461)	448 (26.96)	140 (30.30)	1.16 (0.85 to 1.57)	0.97 (0.67 to 1.41)	247 (34.79)	**1.60 (1.22 to 2.09)**	1.37 (0.99 to 1.89)	
Self-efficacy for healthcare decisions								
Major in medicine								**0.03**
No	1365 (82.13)	397 (85.93)	Reference	Reference	634 (89.30)	Reference	Reference	
Yes	297 (17.87)	65 (14.07)	0.75 (0.56 to 1.01)	0.89 (0.64 to 1.25)	76 (10.70)	**0.55 (0.42 to 0.72)**	**0.68 (0.50 to 0.91)**	
Having at least one parent with medical background								0.34
No	1488 (89.53)	395 (85.50)	Reference	Reference	641 (90.28)	Reference	Reference	
Yes	174 (10.47)	67 (14.50)	**1.45 (1.07 to 1.96)**	1.27 (0.91 to 1.78)	69 (9.72)	0.92 (0.69 to 1.23)	1.00 (0.72 to 1.37)	

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Table 3 Continued

	Did not treat or self-treated without antibiotics (n=1662, 58.65%)	Self-medicated with antibiotics (n=462, 16.30%)‡			Sought formal care (n=710, 25.05%)‡			
	n (%)	n (%)	RRR (95% CI)	aRRR (95% CI)†	n (%)	RRR (95% CI)	aRRR (95% CI)†	P value*‡
Region (University, Province)								**<0.0001**
North (NKU, Tianjin)	276 (16.61)	81 (17.53)	Reference	Reference	60 (8.45)	Reference	Reference	
East (ZJU, Zhejiang)	310 (18.65)	38 (8.23)	**0.42 (0.27 to 0.63)**	**0.50 (0.32 to 0.79)**	111 (15.63)	**1.65 (1.16 to 2.35)**	**1.86 (1.27 to 2.73)**	
Southwest (GZU, Guizhou)	240 (14.44)	84 (18.18)	1.19 (0.84 to 1.69)	0.98 (0.66 to 1.44)	169 (23.80)	**3.24 (2.30 to 4.56)**	**2.49 (1.72 to 3.60)**	
Northwest (LZU, Gansu)	287 (17.27)	103 (22.29)	1.22 (0.88 to 1.71)	1.08 (0.75 to 1.56)	138 (19.44)	**2.21 (1.57 to 3.12)**	**1.92 (1.33 to 2.77)**	
South (WHU, Hubei)	297 (17.87)	50 (10.82)	**0.57 (0.39 to 0.85)**	**0.66 (0.43 to 1.00)**	133 (18.73)	**2.06 (1.46 to 2.91)**	**2.39 (1.66 to 3.45)**	
Northeast (JLU, Jilin)	252 (15.16)	106 (22.94)	**1.43 (1.02 to 2.01)**	1.10 (0.76 to 1.60)	99 (13.94)	**1.81 (1.26 to 2.60)**	1.37 (0.93 to 2.03)	

*Likelihood ratio tests for treatment decisions for URTIs.
†Adjusted for age, sex, household income, urbanicity, university major in medicine, having at least one parent with medical background and region/province.
‡Bold values denote statistical significance at the $p < 0.05$ level.
AMR, antimicrobial resistance; aRRR, adjusted relative risk ratio; RRR, relative risk ratio.

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Table 4 Multinomial regression model to assess factors associated with diagnostic outcomes with respect to antibiotic prescriptions for upper respiratory tract infections among Chinese university students who sought care (n=710)

	All students who sought care (n=710)	No antibiotic prescription (n=225, 31.69%)	Prescribed with antibiotics (n=362, 50.99%)‡§			Asked for antibiotics (n=123, 17.32%)§†			P value*§
	N (%)	N (%)	N (%)	RRR (95% CI)	aRRR (95% CI)	N (%)	RRR (95% CI)	aRRR (95% CI)	
Knowledge about antibiotics									
AMR awareness									**0.004**
Low	74 (10.42)	24 (10.67)	27 (7.46)	Reference	Reference	23 (18.70)	Reference	Reference	
Medium	175 (24.65)	59 (26.22)	84 (23.20)	1.27 (0.67 to 2.41)	1.18 (0.59 to 2.38)	32 (26.02)	0.57 (0.28 to 1.16)	**0.37 (0.16 to 0.87)**	
High	461 (64.93)	142 (63.11)	251 (69.34)	1.57 (0.87 to 2.83)	1.62 (0.82 to 3.19)	68 (55.28)	**0.50 (0.26 to 0.95)**	**0.40 (0.17 to 0.91)**	
Ability to identify antibiotics									**<0.0001**
Low	210 (29.58)	92 (40.89)	100 (27.62)	Reference	Reference	18 (14.63)	Reference	Reference	
Medium	325 (45.77)	79 (35.11)	180 (49.72)	**2.10 (1.42 to 3.09)**	**1.85 (1.20 to 2.84)**	66 (53.66)	**4.27 (2.34 to 7.79)**	**4.03 (2.01 to 8.11)**	
High	175 (24.65)	54 (24.00)	82 (22.65)	1.40 (0.90 to 2.18)	1.48 (0.88 to 2.46)	39 (31.71)	**3.69 (1.92 to 7.08)**	**6.35 (2.85 to 14.13)**	
Perceived severity of the infection									
Common cold is self-limiting									0.25
Yes	414 (58.31)	130 (57.78)	209 (57.73)	Reference	Reference	75 (60.98)	Reference	Reference	
No/I don't know	296 (41.69)	95 (42.22)	153 (42.27)	1.00 (0.72 to 1.40)	0.89 (0.61 to 1.29)	48 (39.02)	0.88 (0.56 to 1.37)	0.64 (0.38 to 1.09)	
Perceived antibiotic efficacy									
Antibiotic efficacy									**0.04**
Low	184 (25.92)	74 (32.89)	91 (25.14)	Reference	Reference	19 (15.45)	Reference	Reference	
Medium	396 (55.77)	121 (53.78)	207 (57.18)	1.39 (0.95 to 2.03)	1.23 (0.80 to 1.87)	68 (55.28)	**2.19 (1.22 to 3.93)**	**2.17 (1.12 to 4.24)**	
High	130 (18.31)	30 (13.33)	64 (17.68)	**1.73 (1.02 to 2.95)**	1.56 (0.86 to 2.84)	36 (29.27)	**4.67 (2.32 to 9.40)**	**3.67 (1.61 to 8.39)**	
Antibiotics are anti-inflammatory drugs									0.07
No	427 (60.14)	152 (67.56)	219 (60.50)	Reference	Reference	56 (45.53)	Reference	Reference	
Yes/I don't know	283 (39.86)	73 (32.44)	143 (39.50)	1.36 (0.96 to 1.93)	1.26 (0.85 to 1.89)	67 (54.47)	**2.49 (1.59 to 3.91)**	**1.92 (1.11 to 3.33)**	
Cues to action									
Severity of current infection (number of symptoms experienced)									0.18
Low (one symptom)	297 (41.83)	119 (52.89)	138 (38.12)	Reference	Reference	40 (32.52)	Reference	Reference	
Medium (two symptoms)	234 (32.96)	69 (30.67)	122 (33.70)	**1.52 (1.04 to 2.24)**	**1.48 (0.97 to 2.25)**	43 (34.96)	**1.85 (1.10 to 3.13)**	1.65 (0.89 to 3.06)	
High (three symptoms or more)	179 (25.21)	37 (16.44)	102 (28.18)	**2.38 (1.52 to 3.72)**	**1.77 (1.00 to 3.13)**	40 (32.52)	**3.22 (1.81 to 5.70)**	1.48 (0.67 to 3.28)	
Fever									**0.001**
No	444 (62.54)	165 (73.33)	224 (61.88)	Reference	Reference	55 (44.72)	Reference	Reference	
Yes	266 (37.46)	60 (26.67)	138 (38.12)	**1.69 (1.18 to 2.44)**	1.40 (0.87 to 2.25)	68 (55.28)	**3.40 (2.14 to 5.40)**	**3.24 (1.70 to 6.18)**	

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Table 4 Continued

	All students who sought care (n=710)	No antibiotic prescription (n=225, 31.69%)	Prescribed with antibiotics (n=362, 50.99%)‡§			Asked for antibiotics (n=123, 17.32%)§†			P value*§
	N (%)	N (%)	N (%)	RRR (95% CI)	aRRR (95% CI)	N (%)	RRR (95% CI)	aRRR (95% CI)	
Barriers/access to antibiotics									
Keeping antibiotics at home									**0.01**
No	234 (32.96)	93 (41.33)	116 (32.04)	Reference	Reference	25 (20.33)	Reference	Reference	
Yes	476 (67.04)	132 (58.67)	246 (67.96)	**1.49 (1.06 to 2.11)**	1.39 (0.93 to 2.07)	98 (79.67)	**2.76 (1.65 to 4.61)**	**2.46 (1.33 to 4.56)**	
Over-the-counter purchase of non-prescription antibiotics									**0.0001**
No	251 (35.35)	104 (46.22)	125 (34.53)	Reference	Reference	22 (17.89)	Reference	Reference	
Yes	459 (64.65)	121 (53.78)	237 (65.47)	**1.63 (1.16 to 2.29)**	**1.68 (1.14 to 2.48)**	101 (82.11)	**3.95 (2.32 to 6.71)**	**3.69 (1.97 to 6.91)**	
Point of care									**<0.01**
Tertiary hospital	116 (16.34)	28 (12.44)	63 (17.40)/54.3	Reference	Reference	25 (20.33)/21.6	Reference	Reference	
Secondary/county hospital	81 (11.41)	23 (10.22)	35 (9.67)/43.2	0.68 (0.34 to 1.35)	0.56 (0.26 to 1.21)	23 (18.70)/28.4	1.12 (0.51 to 2.47)	0.83 (0.32 to 2.14)	
Community health centres/township hospital	448 (63.10)	159 (70.67)	236 (65.19)/52.7	0.66 (0.40 to 1.08)	**0.56 (0.32 to 0.98)**	53 (43.09)/11.8	**0.37 (0.20 to 0.70)**	**0.35 (0.17 to 0.74)**	
Private clinics/ village clinics	65 (9.15)	15 (6.67)	28 (7.73)/43.1	0.83 (0.38 to 1.79)	0.61 (0.26 to 1.43)	22 (17.89)/33.8	1.64 (0.70 to 3.84)	1.03 (0.37 to 2.89)	
Sociodemographic characteristics									
Age	20.95† (2.57)			1.02 (0.95 to 1.09)	0.96 (0.89 to 1.04)		1.04 (0.96 to 1.13)	0.95 (0.85 to 1.04)	0.49
Sex									0.36
Male	357 (50.28)	104 (46.22)	193 (53.31)	Reference	Reference	60 (48.78)	Reference	Reference	
Female	353 (49.72)	121 (53.78)	169 (46.69)	0.75 (0.54 to 1.05)	0.78 (0.54 to 1.13)	63 (51.22)	0.90 (0.58 to 1.40)	0.96 (0.57 to 1.61)	
Urbanicity of home town									0.1
Rural	371 (52.25)	139 (61.78)	173 (47.79)	Reference	Reference	59 (47.97)	Reference	Reference	
Urban	339 (47.75)	86 (38.22)	189 (52.21)	**1.77 (1.26 to 2.48)**	**1.52 (1.00 to 2.31)**	64 (52.03)	**1.75 (1.12 to 2.73)**	1.69 (0.93 to 3.06)	
Average household income (¥, monthly)									0.49
>10 000 (>$1538)	106 (14.93)	42 (18.67)	49 (13.54)	Reference	Reference	15 (12.20)	Reference	Reference	
3001–10 000 ($462–$1538)	357 ((50.28)	126 (56.00)	173 (47.79)	1.18 (0.73 to 1.89)	1.09 (0.65 to 1.82)	58 (47.15)	1.29 (0.66 to 2.51)	1.10 (0.50 to 2.39)	
≤3000 ($461)	247 (34.79)	57 (25.33)	140 (38.67)	**2.11 (1.26 to 3.52)**	1.59 (0.86 to 2.93)	50 (40.65)	**2.46 (1.22 to 4.95)**	1.67 (0.67 to 4.05)	
Major in medicine									0.33
No	634 (89.30)	196 (87.11)	325 (89.78)	**Reference**	Reference	113 (91.87)	**Reference**	Reference	
Yes	76 (10.70)	29 (12.89)	37 (10.22)	**0.77 (0.46 to 1.29)**	0.65 (0.36 to 1.16)	10 (8.13)	**0.60 (0.28 to 1.27)**	0.62 (0.26 to 1.52)	

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Table 4 Continued

	All students who sought care (n=710)	No antibiotic prescription (n=225, 31.69%)	Prescribed with antibiotics (n=362, 50.99%)‡§			Asked for antibiotics (n=123, 17.32%)§†			P value*§
	N (%)	N (%)	N (%)	RRR (95% CI)	aRRR (95% CI)	N (%)	RRR (95% CI)	aRRR (95% CI)	
Having at least one parent with medical background									0.02
No	641 (90.28)	200 (88.89)	333 (91.99)	**Reference**	Reference	108 (87.80)	**Reference**	Reference	
Yes	69 (9.72)	25 (11.11)	29 (8.01)	**0.70 (0.40 to 1.22)**	0.87 (0.46 to 1.64)	15 (12.20)	**1.11 (0.56 to 2.20)**	1.02 (0.43 to 2.41)	
Region (University, Province)									0.07
North (NKU, Tianjin)	60 (8.45)	20 (8.89)	29 (8.01)	Reference	Reference	11 (8.94)	Reference	Reference	
East (ZJU, Zhejiang)	111 (15.63)	45 (20.00)	56 (15.47)	0.86 (0.43 to 1.71)	0.95 (0.45 to 2.01)	10 (8.13)	0.40 (0.15 to 1.10)	0.41 (0.13 to 1.27)	
Southwest (GZU, Guizhou)	169 (23.80)	30 (13.33)	101 (27.90)	**2.32 (1.15 to 4.68)**	1.87 (0.87 to 4.05)	38 (30.89)	2.30 (0.96 to 5.54)	1.31 (0.46 to 3.68)	
Northwest (LZU, Gansu)	138 (19.44)	38 (16.89)	72 (19.89)	1.31 (0.65 to 2.61)	1.23 (0.57 to 2.62)	28 (22.76)	1.34 (0.55 to 3.24)	0.68 (0.24 to 1.92)	
South (WHU, Hubei)	133 (18.73)	62 (27.56)	60 (16.57)	0.67 (0.34 to 1.31)	0.80 (0.39 to 1.67)	11 (8.94)	**0.32 (0.12 to 0.86)**	0.33 (0.11 to 1.01)	
Northeast (JLU, Jilin)	99 (13.94)	30 (13.33)	44 (12.15)	1.01 (0.49 to 2.11)	0.76 (0.34 to 1.72)	25 (20.33)	1.52 (0.61 to 3.75)	0.44 (0.15 to 1.32)	

*Likelihood ratio tests for prescribing outcomes for URTIs.
†Mean (SD).
‡Adjusted for age, sex, household income, urbanicity, university major in medicine, having at least one parent with medical background and region/province.
§Bold values denote statistical significance at the $p < 0.05$ level.
AMR, antimicrobial resistance; aRRR, adjusted relative risk ratio; RRR, relative risk ratio.

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Interpretation of findings

First, we found that individual awareness of the danger of AMR was high among students, yet such awareness did not translate into prudent antibiotic use. This might imply the existence of an externality associated with antibiotic use for treating infections; despite a high awareness of AMR, the risks AMR imposes on others are unlikely to be felt directly or immediately by either the consumer or the supplier of treatment. Findings from this study identified a significant positive correlation between ability to identify antibiotics and self-medication, prescriptions, and demand for antibiotics. Previous studies demonstrated ‘successful experiences’ in the past for ‘curing’ a similar illness, and knowledge of the previously prescribed antibiotics could lead to improved ability to identify antibiotics and self-medicate with antibiotics (SMA), promoting antibiotic demand by patients, and leading to a cycle of overtreatment.[15 23–27] Our data suggest heterogeneity exists in the ‘domain’ of knowledge about antibiotics and its relationship with antibiotic practices for URTIs. Without sufficient knowledge about correct antibiotic efficacy, appropriate care for URTIs, and using antibiotics only under professional supervision, simply improving the public’s ability to identify antibiotics alone could potentially cause greater misuse. Therefore, the common current practice[28 29] of grouping multiple aspects of antibiotics-related or AMR-related knowledge, attitudes and beliefs, and even practices into one score might not fully capture the complexity of their various associations with antibiotic use behaviours. A blanket awareness campaign or a simple intervention on clear labelling of antibiotics is likely to fail without adapting to the local context—a finding consistent with the recent assessment of the WHO awareness campaign.[30] We found strong evidence showing that demanding antibiotic prescriptions was associated with household stockpiling and over-the-counter purchases of antibiotics. Interventions which target ‘demanders’ and ‘heavy misusers’ of antibiotics in the community and that correct the misperception of antibiotics’ efficacy for URTIs or as anti-inflammatory drugs might reduce misuse.

In our data, all the participants who asked for antibiotics successfully received them. Even with good intentions,[8 31–34] unrealistic patient expectations and pressure from patients or caregivers to prescribe antibiotics have been identified as major reasons why physicians prescribe antibiotics for self-limiting diseases.[34–38] This indicates an urgent need for further training to help clinicians improve clinical skills and doctor-patient communication skills. Clinicians’ overprescribing in China—incentivised by financial profits for health facilities[39]—might have helped shape and reinforce common public misperceptions of antibiotics as effective for URTIs, which, in turn, further perpetuating misuse. This study showed 68.2% of participants stored antibiotics, which mainly came from over-the-counter purchases and previous prescriptions. The effect of keeping antibiotics at home on antibiotic (mis)use in the community is as profound as the impact of unnecessary prescriptions for URTIs through formal care. Since 2011, China has implemented policies (such as banning over-the-counter purchases and capping antibiotic prescriptions at 20% for county hospitals and above and 30% for township hospitals) to control antibiotic misuse, but the success of such initiatives has been limited due to poor enforcement.[40–45] In our data, about 70% of patients with URTI who sought care were prescribed antibiotics; among them, over 50% of the patients received antibiotic prescriptions without prompting and close to 20% successfully obtained antibiotics through explicit requests. These data pointed to an urgent need for effective, context-tailored hospital stewardship programmes that improve adherence to clinical practice guidelines for antibiotic prescribing in China and enhance doctor-patient communication over antibiotic use. Consistent with other studies,[9 33 46 47] over-the-counter sales of non-prescription antibiotics at community pharmacies were found across China. Enforcing regulations regarding the sale of antibiotics, pack-based antibiotic dispensing systems, and public educational interventions to reduce consumer-driven prescriptions and left-over prescriptions could curb the main sources of antibiotics for self-medication use.

CONCLUSION

Determinants of medical decisions for antibiotic use and care seeking are complex. It is critical to consider the heterogeneity of culture, health systems, and social norms in the assessment and intervention of decision-making regarding antibiotic use. This study provided urgently needed evidence for future interventional studies to address the challenges posed by the demand side and to improve the Chinese general population’s antibiotic use.

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Contributors LL led the study design, conducted the literature search, created the tables and figures, conducted data analysis and interpretation, and drafted and revised the manuscript. EF, SH, XW, CL contributed to data interpretation, and commented on the initial and following revisions of the manuscript. XZ conceived the study, led data collection, contributed to data interpretation and commented on all drafts of this manuscript. JH supervised the data analysis and interpretation, and contributed significantly to the first draft and following revisions of the manuscript. All authors approved the final draft of this manuscript.

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Patient and public involvement The perspectives of the public were taken into account in designing the research question, but no patients and/or the public were directly involved in the development, conduct, reporting, or dissemination plans of the study. Refer to the Methods section for further details.

Patient consent for publication Not required.

Ethics approval The study protocol and survey were reviewed and approved by the Institutional Review Board at the School of Public Health Zhejiang University (No. ZGL20160922) and London School of Hygiene & Tropical Medicine (No. 14678).

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement The data sets generated and/or analysed during the current study are not publicly available due to the likelihood of compromising the privacy of participating individuals; the study materials are available from the corresponding author upon reasonable request.

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