Latent Patterns of Upper Respiratory Tract Infection Symptoms in the Public and Their Impact on Antibiotic Use Behavior: A Postprint Study

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Abstract

Background: Antimicrobial resistance resulting from antibiotic misuse has emerged as a critical global public health challenge. Reducing irrational antibiotic use for upper respiratory tract infections (URTIs) among the public represents a key strategy in China's efforts to combat antibiotic misuse. Identifying the characteristic features of URTI symptoms and their influence on irrational antibiotic use behaviors can facilitate the design of more targeted intervention policies by clinicians.

Objective: To quantitatively analyze latent patterns of URTI symptoms among the public and investigate their impact on antibiotic use behaviors.

Methods: This study utilized a cluster random sampling survey, selecting members of the public from three counties (districts) in Chongqing as participants from July 20 to August 2, 2022. The survey assessed URTI symptoms, antibiotic use behaviors for URTIs among the public, public knowledge regarding antibiotic use, and demographic characteristics. Latent class analysis was employed to identify latent patterns of URTI symptoms, while multivariate Logistic regression analysis was used to explore the effects of different latent symptom patterns on antibiotic use behaviors.

Results: A total of 815 members of the public participated in this study. Among them, 30.06% (245/815) of respondents reported purchasing antibiotics from pharmacies without a prescription, and 14.72% (120/815) reported using antibiotics for self-medication to treat URTIs. The public's knowledge level regarding rational antibiotic use was relatively low [(2.3$±$1.7) points]. Regarding URTI disease patterns, latent class analysis identified four symptom patterns: a diverse symptoms group (39 cases, 11.41%), a systemic symptoms group (124 cases, 15.21%), a nasopharyngeal symptoms group (282 cases, 34.60%), and

a mild symptoms group (316 cases, 38.77%). Multivariate Logistic regression analysis revealed that, compared with the mild symptoms group, the nasopharyngeal symptoms group exhibited a higher probability of purchasing antibiotics without a prescription (OR=1.538, P<0.05), and this association remained significant after adjusting for knowledge and demographic variables. In addition to individual latent symptom patterns, age and type of medical insurance also significantly influenced public behavior of purchasing antibiotics without a prescription (P<0.05). Antibiotic use knowledge level significantly affected antibiotic self-medication behavior (OR=0.869, P<0.05) and also influenced public behavior of purchasing antibiotics without a prescription (OR=1.155, P<0.05).

Conclusion: Four latent patterns of URTI symptoms exist among the public, and disease symptom patterns significantly affect the rational use of antibiotics by the public. Particular attention should be directed toward irrational antibiotic use behaviors in patients presenting with nasopharyngeal symptoms.

Full Text

The Potential Patterns of Symptoms of Upper Respiratory Tract Infections in the Public and Their Effects on Antibiotic Use Behavior

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Abstract

Background: Antibiotic resistance caused by antibiotic abuse has become a major global public health issue. Reducing the irrational use of antibiotics for upper respiratory tract infections (URTIs) among the public represents an important strategy for addressing antibiotic abuse in China. Identifying the characteristics of URTI symptom patterns and their influence on irrational antibiotic use can help clinicians design more targeted intervention policies.

Objective: To quantitatively analyze the potential patterns of URTI symptoms in the public and explore their effects on antibiotic use behavior.

Methods: This study employed a cluster random sampling survey, selecting the public from three counties (districts) in Chongqing Municipality between July 20 and August 2, 2022. We surveyed URTI symptoms, antibiotic use

behaviors, antibiotic use knowledge, and demographic characteristics. Latent class analysis was used to identify potential patterns of URTI symptoms, and multivariate logistic regression was applied to explore the influence of different symptom patterns on antibiotic use behavior.

Results: A total of 815 participants were included. Among them, 30.06% (245/815) purchased antibiotics from pharmacies without a prescription, and 14.72% (120/815) used antibiotics for self-medication to treat URTIs. Public knowledge regarding rational antibiotic use was relatively low, with an average score of (2.3$±$1.7) points. Regarding URTI symptom patterns, latent class analysis identified four distinct patterns: diverse symptoms group (39 cases, 11.41%), systemic symptoms group (124 cases, 15.21%), nasopharyngeal symptoms group (282 cases, 34.60%), and mild symptoms group (316 cases, 38.77%). Multivariate logistic regression analysis showed that, compared with the mild symptoms group, the nasopharyngeal symptoms group had a significantly higher probability of purchasing antibiotics without a prescription (OR=1.538, P<0.05), and this association remained significant after adjusting for knowledge and demographic variables. In addition to individual disease symptom patterns, age and medical insurance type also significantly affected non-prescription antibiotic purchasing behavior (P<0.05). Antibiotic use knowledge level significantly influenced both antibiotic self-medication behavior (OR=0.869, P<0.05) and non-prescription antibiotic purchasing behavior (OR=1.155, P<0.05).

Conclusion: Four potential patterns of URTI symptoms exist among the public, and these patterns significantly influence rational antibiotic use. Particular attention should be paid to irrational antibiotic use among patients presenting with nasopharyngeal symptoms.

Keywords: Respiratory tract infections; Anti-bacterial agents; Rational use of antibiotics; Signs and symptoms; Latent class analysis; Logistic models

Introduction

Antimicrobial resistance poses a severe threat to population health and socioeconomic development, with consequences comparable to the COVID-19 pandemic but of longer duration and greater severity [1]. Antibiotic resistance has become a critical global health and development issue requiring urgent attention. Without effective interventions, antimicrobial resistance is projected to cause over 10 million deaths annually by 2050, surpassing cancer as the leading cause of death worldwide [2]. The Chinese government has prioritized antibiotic resistance as a national strategic issue, issuing the “National Action Plan to Contain Bacterial Resistance (2016–2020)” [3] and the “National Action Plan to Contain Microbial Resistance (2022–2025)” [4] in collaboration with more than ten ministries. For the first time, improving public antibiotic use behavior

has been included as one of nine core targets in the latest national action plan (2022–2025).

However, irrational antibiotic use behaviors, particularly antibiotic self-medication, remain prevalent among the public. Upper respiratory tract infections represent the most common reason for public antibiotic self-medication [5], yet most URTIs are viral in origin [6], and antibiotics have no significant effect on their prevention or treatment [7]. Reducing irrational antibiotic use for URTIs is a crucial component of China's strategy to combat antibiotic abuse [8]. Previous research has shown that public antibiotic self-medication is associated with perceived disease severity and individual knowledge about antibiotics, with individuals more likely to seek antibiotic treatment when they perceive their symptoms as severe [9]. Due to individual heterogeneity, URTIs manifest differently across individuals [10], and varying symptom patterns may influence perceptions of disease severity, thereby affecting antibiotic self-medication behavior.

Latent class analysis can effectively identify underlying symptom combination patterns behind various conditions [11], allowing for the classification of different URTI manifestation types among the public and avoiding a "one-size-fits-all" characterization of the population [12]. This study employs latent class analysis (LCA) to categorize public URTI disease presentation patterns and investigates how different symptom patterns influence antibiotic self-medication behavior, providing evidence to better understand the decision-making mechanisms behind public antibiotic self-medication.

Methods

1.1 Study Subjects

This study used a cluster random sampling survey, selecting the public from three counties (districts) in Chongqing—Yuzhong District, Tongnan County, and Chengkou County—as survey respondents from July 20 to August 2, 2022. Inclusion criteria were: (1) age >18 years; (2) adequate comprehension ability, able to complete the questionnaire independently or with assistance; and (3) willingness to participate and provide informed consent. The sample size for cluster random sampling was calculated using the formula: $n=[Z^2/_2 \times p \times (1-p)]/\delta^2 \times [1+(M-1)\times ICC]$, where α is the significance level, p is the proportion of a certain behavior pattern in the public, δ is the allowable error, M is the number of respondents per cluster, and ICC is the intraclass correlation coefficient. Based on previous research, the proportion of public behavior patterns ranged from 36.5% to 81.8%. With α=0.05, $Z/_2$=1.96, δ=0.05, M=35, and ICC=0.02, the minimum sample size was calculated as 646. Considering a potential non-response rate of 10%–12%, the final target sample size was set at 735, requiring at least 21 clusters with a minimum of 35 respondents per cluster. According to the estimated sample size and actual conditions, 906 questionnaires were distributed, and 815 valid questionnaires were recovered after

excluding those with missing items or inconsistent responses, yielding a valid response rate of 89.96%.

1.2 Survey Tools and Data Processing

1.2.1 Survey Instrument: The questionnaire was developed based on existing survey tools, interview data, and literature review [13-14], comprising four sections: URTI symptoms, antibiotic use behaviors, antibiotic use knowledge, and demographic characteristics. URTI symptoms were measured by asking respondents to report commonly experienced symptoms, including 18 options such as cough, sneezing, watery nasal discharge, low-grade fever, and headache. Antibiotic use behavior was assessed with two items: (1) "How do you usually manage a cold?" with response options including supportive care, home medication for symptomatic relief, home antibiotic treatment, direct medical consultation, home symptomatic treatment followed by medical consultation, home antibiotic treatment followed by medical consultation, and others; and (2) "Where do you obtain antibiotics?" with options including doctor's prescription, self-purchase from pharmacies, family stock, relatives/friends, and others. Antibiotic use knowledge consisted of 8 true/false items covering indications for antibiotic use and causes of antibiotic resistance, with responses scored as correct, incorrect, or "I don't know." Demographic characteristics included gender, age, education level, medical background, medical insurance type, chronic disease status, annual household income, and self-rated health status (measured on a 5-point Likert scale from "very poor" to "healthy"). After initial questionnaire construction, a pilot survey was conducted in Tongji Community, Wuhan (n=17) to assess face and content validity, and items were revised based on feedback. The Cronbach's α coefficient for the knowledge dimension in the formal survey was 0.738.

1.2.2 Data Processing: URTI symptoms were coded based on the presence or absence of each of the 18 common symptoms (0=absent, 1=present). Antibiotic self-medication behavior was coded as 1 for home antibiotic treatment or home antibiotic treatment followed by medical consultation, and 0 for other management approaches. Non-prescription antibiotic purchasing behavior was coded as 1 for self-purchase from pharmacies and 0 for other sources. Knowledge items were scored (0=incorrect/don't know, 1=correct), and the total score was calculated as the antibiotic use knowledge level, with higher scores indicating better knowledge.

1.3 Statistical Methods

Normally distributed continuous data are presented as ($\bar{x}\pm s$) and compared between groups using one-way ANOVA. Categorical data are presented as percentages and compared using ^{2} tests or Fisher-Freeman-Halton tests. Ranked data were compared using Kruskal-Wallis H tests. Latent class analysis was used to identify potential patterns of URTI symptoms, starting with an initial model specifying one latent class and incrementally increasing the number of classes

until optimal model fit was achieved. Model fit was evaluated using multiple criteria: Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), adjusted BIC (aBIC), likelihood ratio test (LMT), entropy index, and minimum class probability. Smaller AIC, BIC, and aBIC values indicate better fit; LMT with $P<0.05$ suggests that a K-class model fits significantly better than a K+1 class model; entropy (range 0–1) assesses posterior classification accuracy, with values closer to 1 indicating higher accuracy; and minimum class probability should be >0.10 to prevent overfitting. Based on the optimal LCA model, each individual was assigned to their most likely symptom pattern class (exclusive classification) [12-15]. Symptom patterns were named according to their characteristic conditional probabilities. Logistic regression analysis was conducted with antibiotic self-medication and non-prescription purchasing behaviors as dependent variables, using the mild symptoms group as reference to examine the influence of symptom patterns on behavior (Model 1). Models 2 and 3 were subsequently adjusted for antibiotic knowledge and demographic characteristics, respectively, to ensure robustness. All analyses were performed using Stata 17.0 for descriptive and logistic regression analyses and Mplus 8.0 for latent class analysis, with significance level set at α=0.05.

Results

2.1 Demographic Characteristics of Survey Respondents

Among the 815 participants, 319 were male and 496 were female. Age distribution was: 307 (37.76%) aged 19–39 years, and 463 (56.81%) with education level of high school or below. Annual household income was below 60,000 yuan for 502 participants (61.60%). A total of 796 participants (97.77%) had medical insurance, primarily the New Rural Cooperative Medical Scheme (n=342, 41.96%). Medical background (self or family member) was reported by 144 participants (17.67%), and 404 (49.57%) reported having chronic diseases. Detailed demographic characteristics are presented in .

2.2 Symptom Occurrence in Upper Respiratory Tract Infections

When experiencing URTIs, participants reported an average of (4.8$±$2.9) symptoms. The five most common symptoms were cough (n=573, 70.31%), sneezing (n=461, 56.56%), nasal congestion (n=440, 53.99%), watery nasal discharge (n=405, 49.69%), and headache (n=356, 43.68%). Less common symptoms included pharyngeal swelling (n=54, 6.63%), chills (n=67, 8.22%), and breathing difficulty (n=70, 8.59%). Full details are provided in .

2.3 Latent Class Analysis of URTI Symptoms

Using individual URTI symptoms as manifest variables, we constructed latent class models specifying 1–5 latent classes. The 4-class model showed the smallest AIC, BIC, and aBIC values, the highest entropy, and significant LMT results, indicating significantly better fit than the 3-class model. The 5-class model

showed significant overfitting. Therefore, we identified four distinct URTI symptom patterns. Model fit indicators are detailed in .

Based on the optimal LCA model, we plotted the conditional probability distributions of symptom occurrence for each pattern [Figure 1: see original paper]. Class 1 showed high probabilities for nearly all symptoms and was named the "diverse symptoms group" (n=39, 11.41%). Class 2 was characterized by prominent systemic symptoms such as headache and fatigue, named the "systemic symptoms group" (n=124, 15.21%). Class 3 exhibited predominant nasopharyngeal symptoms (sneezing, nasal congestion) and was named the "nasopharyngeal symptoms group" (n=282, 34.60%). Class 4 showed overall lower symptom probabilities compared to other groups and was named the "mild symptoms group" (n=316, 38.77%).

2.4 Demographic Characteristics Across Symptom Pattern Groups

Based on LCA results, participants were classified into four symptom pattern groups. Demographic characteristics differed significantly across groups, with age and education level significantly influencing symptom pattern classification ($P<0.05$). Detailed distributions are presented in .

2.5 Influence of Symptom Patterns on Antibiotic Use Behavior

Regarding antibiotic use behavior, 30.06% of participants (n=245) obtained antibiotics through non-prescription pharmacy purchases, and 14.72% (n=120) used antibiotic self-medication for URTIs. Public knowledge about rational antibiotic use was low, with an average score of (2.3$±$1.7) points.

Using non-prescription antibiotic purchasing (1=yes, 0=no) and antibiotic self-medication (1=yes, 0=no) as outcome variables, and the mild symptoms group as reference, logistic regression analysis revealed that the nasopharyngeal symptoms group had significantly higher odds of non-prescription antibiotic purchasing (OR=1.538, $P<0.05$) compared to the mild symptoms group. This association remained significant after adjusting for antibiotic knowledge and demographic characteristics. No significant differences in antibiotic self-medication behavior were observed across symptom pattern groups ($P>0.05$). In addition to symptom patterns, age and medical insurance type significantly affected non-prescription antibiotic purchasing behavior ($P<0.05$). Antibiotic knowledge level significantly influenced both self-medication behavior (OR=0.869, $P<0.05$) and non-prescription purchasing behavior (OR=1.155, $P<0.05$). Detailed results are presented in .

Discussion

3.1 Main Findings

Antimicrobial resistance poses a severe threat to population health, and rational antibiotic use among the public is critically important. This study collected

data on common URTI symptom patterns and the prevalence of antibiotic self-medication and non-prescription purchasing in Chongqing through cluster random sampling. Using LCA, we identified four potential URTI symptom patterns and examined their relationships with demographic characteristics and antibiotic self-medication behaviors. The results show that antibiotic self-medication and non-prescription purchasing for URTIs are relatively common, affecting 14.72% and 30.05% of the population, respectively. Additionally, URTIs present with diverse symptom patterns, classified as "diverse symptoms group," "systemic symptoms group," "nasopharyngeal symptoms group," and "mild symptoms group." Although most participants exhibited nasopharyngeal (34.60%) or mild (38.77%) symptoms, regression analysis revealed that individuals with nasopharyngeal symptoms had significantly higher rates of non-prescription antibiotic purchasing. This effect remained significant after adjusting for antibiotic knowledge and demographic factors, demonstrating that URTI symptom patterns significantly influence public antibiotic use behavior.

3.2 Comparison with Existing Research

The prevalence of antibiotic self-medication and non-prescription purchasing observed in this study is similar to but slightly lower than national levels. Previous domestic research reported prevalence rates of 35% and 47% for self-medication and non-prescription purchasing, respectively, with notably higher rates in western China compared to central and eastern regions [16]. Our findings in Chongqing show lower prevalence than both national and western regional levels. Given China's recent intensified efforts to promote rational antibiotic use, curtail physician over-prescription, and strengthen pharmacy regulations against non-prescription antibiotic sales, these changes may reflect the effectiveness of such measures. However, 14.72% and 30.06% of the public still engage in antibiotic self-medication or non-prescription purchasing for URTIs. Research indicates that pharmacies may circumvent regulations through fraudulent prescriptions or online consultations [16], and with public knowledge about rational antibiotic use generally insufficient, effective interventions to curb irrational use remain urgently needed.

This study demonstrates that URTI symptom patterns significantly influence non-prescription antibiotic purchasing behavior. Previous research has shown close relationships between symptoms and healthcare-seeking behavior [17]. Our finding that nasopharyngeal symptoms significantly increase non-prescription purchasing may be explained by several mechanisms: (1) Symptom patterns influence perceived disease severity, and nasopharyngeal symptoms are perceived as more severe than mild symptoms but not severe enough to require immediate medical consultation, prompting self-medication [18]; (2) Symptoms such as nasal discharge and sore throat often occur concurrently and significantly impact daily life, creating strong desire for symptom relief [19], which leads to higher rates of irrational antibiotic use—consistent with findings from a European survey [20]. Therefore, clinicians should prioritize antibiotic education for URTI

patients with nasopharyngeal symptoms, and pharmacy staff should recognize these patients as a key target group for self-medication prevention. Since URTIs are typically viral, patients with nasopharyngeal symptoms generally should not receive antibiotics.

Public knowledge about rational antibiotic use remains low. However, our findings suggest that disease symptom patterns are more strongly associated with self-medication and non-prescription purchasing behaviors than knowledge level alone. Previous studies have shown inconsistent relationships between knowledge and rational antibiotic use: some indicate that increased knowledge reduces irrational use [21-22], while others find that knowledge alone may be insufficient or even counterproductive [23-24]. Our study suggests that improving knowledge specifically about symptom recognition and disease understanding may represent a new direction for promoting rational antibiotic use, though the effectiveness of this approach requires further investigation.

3.3 Research Value and Limitations

Existing research suggests that URTI symptom characteristics may influence public disease management approaches. However, due to the complexity and co-occurrence of multiple symptoms, the public may exhibit latent symptom patterns. Prior studies lack empirical data exploring how disease characteristics affect disease coping strategies, particularly irrational antibiotic use. Our study systematically collected data on URTI symptom patterns through cluster random sampling, objectively identified latent symptom patterns using LCA, and examined their effects on antibiotic self-medication and non-prescription purchasing through logistic regression. The combined use of LCA and logistic regression effectively identifies latent URTI patterns and objectively evaluates their behavioral impacts.

However, this study has several limitations: (1) The sample was drawn from the general public in Chongqing and limited to URTIs. Caution is needed when generalizing the identified symptom patterns and their behavioral effects to other regions or diseases; (2) The study used self-reported responses, which may be subject to recall bias and social desirability effects, potentially diverging from actual behaviors; (3) The cross-sectional design precludes causal inferences about the relationships between symptom patterns and antibiotic use behaviors.

3.4 Policy Recommendations

First, clinicians and pharmacists should understand common URTI symptom patterns and their characteristics to help the public correctly interpret symptoms and avoid unrealistic expectations about antibiotics. Second, public education should focus on improving knowledge about symptom recognition and disease understanding, as this may reduce irrational antibiotic expectations for specific symptom patterns [16]. Third, regulatory oversight of non-prescription

antibiotic sales should be strengthened, including enhanced training for pharmacy staff to reduce unauthorized antibiotic dispensing [25-26].

This study classified URTI patients into four symptom pattern groups, verified differences in their population distribution, and demonstrated that symptom patterns significantly influence non-prescription antibiotic purchasing. To reduce irrational antibiotic use, clinicians, pharmacists, and health educators should understand these common symptom patterns and focus on patients with nasopharyngeal symptoms to help them correctly understand their illness and reduce inappropriate antibiotic use.

Author Contributions: ZHANG Xinyi was responsible for data analysis, interpretation, and manuscript writing and revision. WANG Xi, WANG Dan, DUAN Lixia, and LIN Rujiao contributed to data collection and manuscript revision. LIU Chenxi was responsible for study design, quality control, and final approval of the manuscript.

Conflict of Interest: The authors declare no conflicts of interest.

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Note: Figure translations are in progress. See original paper for figures.