

Use of Antibiotics Without a Prescription in the U.S. Population

A Scoping Review

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Background: Use of antibiotics without a prescription may increase unnecessary and inappropriate drug use or doses as well as global risk for antimicrobial resistance.

Purpose: To perform a scoping review of research on the prevalence of nonprescription antibiotic use in the United States and to examine the factors that influence it.

Data Sources: Searches of PubMed, EMBASE, CINAHL, Scopus, and relevant Web sites without language restrictions from January 2000 to March 2019.

Study Selection: Studies reporting nonprescription use of antibiotics, storage of antibiotics, intention to use antibiotics without a prescription, and factors influencing nonprescription use.

Data Extraction: Two reviewers independently screened citations and full texts and performed data abstraction.

Data Synthesis: Of 17 422 screened articles, 31 met inclusion criteria. Depending on population characteristics, prevalence of nonprescription antibiotic use varied from 1% to 66%, storage of antibiotics for future use varied from 14% to 48%, and prevalence of intention to use antibiotics without a prescription was

25%. Antibiotics were obtained without a prescription from various sources, including previously prescribed courses, local markets or stores, and family or friends. Reported factors contributing to nonprescription use included easy access through markets or stores that obtain antibiotics internationally for under-the-counter sales, difficulty accessing the health care system, costs of physician visits, long waiting periods in clinics, and transportation problems.

Limitation: Scarce evidence and heterogeneous methods and outcomes.

Conclusion: Nonprescription antibiotic use is a seemingly prevalent and understudied public health problem in the United States. An increased understanding of risk factors and pathways that are amenable to intervention is essential to decrease this unsafe practice.

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When people use antibiotics without a prescription, they often take unnecessary medication or choose an inappropriate drug or dose. "Avoidable" adverse events and increased risk for inducing antibiotic resistance among colonizing or infecting bacteria may result (1). Nonprescription use includes obtaining and taking antibiotics without a prescription, taking another person's antibiotics, or taking one's own stored antibiotics for an indication other than that for which they were originally prescribed. Unlike most drugs that affect only an individual patient if used incorrectly, misuse of antibiotics can harm others by increasing within-household and even global risk for antimicrobial resistance and secondary contagious sequelae, such as *Clostridioides difficile* infection (1).

Antimicrobial resistance is increasingly recognized as a major threat to global human health (2). Treatment costs for antibiotic-resistant infections have doubled since 2002 and now exceed \$2 billion annually (3). At the individual level, important safety issues related to nonprescription antibiotic use include adverse drug reactions, drug interactions, masking underlying infectious processes, superinfection, and disruption of the healthy microbiome. For example, in nationally representative surveillance data, antimicrobials accounted for 19% of all visits to emergency departments for adverse events in the United States (4).

Although many research initiatives in the United States have focused on reducing inappropriate antibiotic prescribing by health care providers, little work

has addressed overuse of antibiotics and nonprescription use by patients outside the provider-patient relationship (5). To design and deploy interventions to reduce nonprescription antibiotic use, we must first understand its prevalence; characteristics of patients most likely to use antibiotics without a prescription; types of symptoms that trigger nonprescription use; and the provider, organizational, and health system factors driving it.

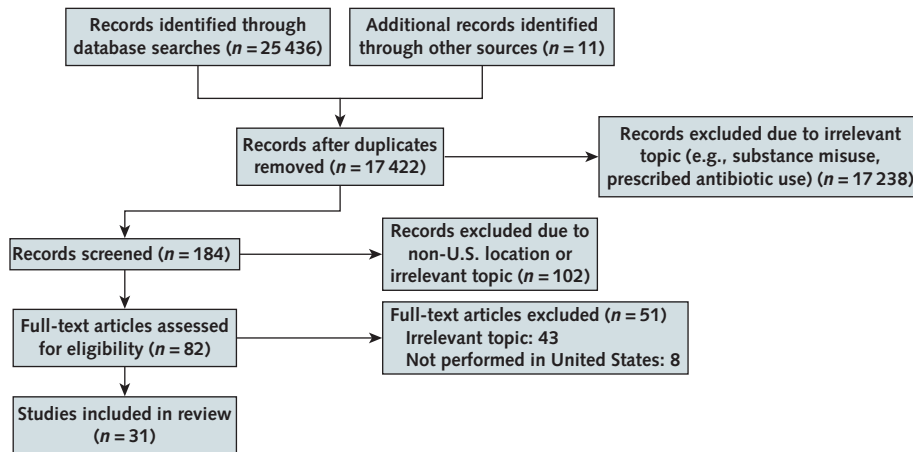
In this scoping review, we systematically mapped research on nonprescription antibiotic use in the United States and identified gaps in knowledge. We sought to answer 2 questions: What are the prevalence, sources, and characteristics of nonprescription antibiotic use in the U.S. population, and what are the factors influencing it?

METHODS

We performed a scoping review because we had a broad purpose, anticipated heterogeneous studies, and intended to identify knowledge gaps. We followed the PRISMA-ScR (Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews) guidelines (6) and the scoping review methods manual developed by the Joanna Briggs Institute (7). We did not develop a formal protocol.

Data Sources and Searches

We searched PubMed, CINAHL, Scopus, and EMBASE without language restrictions from 1 January

Figure 1. Study selection.

2000 to 31 March 2019. We used the PRESS (Peer Review of Electronic Search Strategies) checklist to develop the search strategy (8). Search terms and the PubMed search strategy were peer-reviewed by an experienced librarian and are presented in the **Appendix** (available at [Annals.org](https://annals.org)). EMBASE and Scopus searches included gray literature. We used EndNote to remove internal (within a database) and external (between databases) duplicates. We also reviewed the bibliographies of retrieved articles and performed a Google search on 31 March 2019 to identify gray literature.

Study Selection

We used the PCC (Population, Concept, and Context) framework to define eligibility criteria (6). Any type of document (for example, a journal article, letter, or editorial) from a peer-reviewed publication that described nonprescription antibiotic use in a U.S. population was eligible for inclusion. We included documents that reported at least 1 of the following: use of antibiotics obtained without a prescription, use of stored antibiotics for an indication other than that for which they were originally prescribed, storage of antibiotics for possible future use, intention to use antibiotics without medical guidance, or factors influencing nonprescription antibiotic use. No limitations were imposed with regard to study design or language.

Two independent reviewers (L.G. and G.G.) screened titles and abstracts for relevance, without blinding to journal or authors, and then the full texts of all publications deemed potentially relevant. Disagreements on study selection and extraction were resolved by consensus with a third reviewer (B.W.T.).

Data Extraction

Three reviewers (L.G., G.G., and B.W.T.) jointly developed a data charting form that was piloted on 3 articles. Two reviewers (L.G. and G.G.) then independently charted data, discussed results, and updated the data charting form in an iterative process. Modifications included adding new outcomes of interest and popula-

tion subgroups (such as injection drug users). Variables extracted for data charting included authors, year of publication, study design, focus of the article, sample size, population characteristics, and key outcomes and results. We did not critically appraise studies or confirm abstracted data with study investigators.

Data Synthesis

We grouped and summarized study data by population setting because we deemed the health care needs and challenges of some populations (for example, injection drug users) to be distinct from those of others (for example, the general population). We focused on 2 key themes based on the research questions of the study: prevalence of nonprescription antibiotic use, and factors driving it.

Role of the Funding Source

This work was not funded.

RESULTS

Of 17 422 retrieved articles, 31 met inclusion criteria (**Figure 1**). Summary characteristics of studies are presented in **Appendix Tables 1 and 2** (available at [Annals.org](https://annals.org)).

Study Populations and Settings

Four populations were studied: patients or parents of patients outside health care settings (9–16), patients or parents of patients within health care settings (17–20), Hispanic/Latino populations (21–24), and injection drug users (25–28). Three of the 8 studies performed in the general population (for example, people outside a health care setting) used a random-digit dialing telephone survey (10, 11, 14). Other general population studies surveyed patients or their parents waiting for care in emergency departments or primary care clinics (17–20). One study enrolled patients from a sexually transmitted infection (STI) clinic and a county jail (29).

Focus and Outcomes

Several studies focused on the availability of antibiotics without a prescription from flea markets, pet stores, botanical or health food stores, or online (21, 24, 30-35). Others explored nonprescription use from a range of sources, including leftover prescribed courses, markets or stores, family or friends, and antibiotics obtained without a prescription from other countries (9, 11, 15, 16, 18-20, 36). In 1 study, patients in an STI clinic and a county jail were interviewed about self-treatment with antibiotics (29). All studies of injection drug users examined self-treatment of abscesses and injection-related wounds with antibiotics obtained on the street (25-28, 37, 38). Five studies explored factors influencing nonprescription use in Hispanic/Latino populations (22, 24, 31, 33, 39).

There was substantial heterogeneity of outcome measurement across studies. Survey questions relating to use of antibiotics without a prescription used different time frames, ranging from the previous 4 weeks to ever (11, 19). Several studies asked participants about nonprescription use of antibiotics from 1 specific source, such as leftover prescribed antibiotics (9, 12, 13, 17, 40) or antibiotics obtained without a prescription from stores or markets (21, 30, 34). Others (15, 20, 22) asked open-ended questions about potential sources, such as, "Where do you regularly get antibiotics?" Only 1 study explored intention to use antibiotics without a prescription (20).

Prevalence of Nonprescription Antibiotic Use

Figure 2 shows the number of studies done in each of the 4 population groups and the prevalence of nonprescription use reported in these studies. Prevalence estimates varied widely, with general populations surveyed outside health care settings having the widest range. The study with the lowest prevalence from this group involved a predominantly white population in

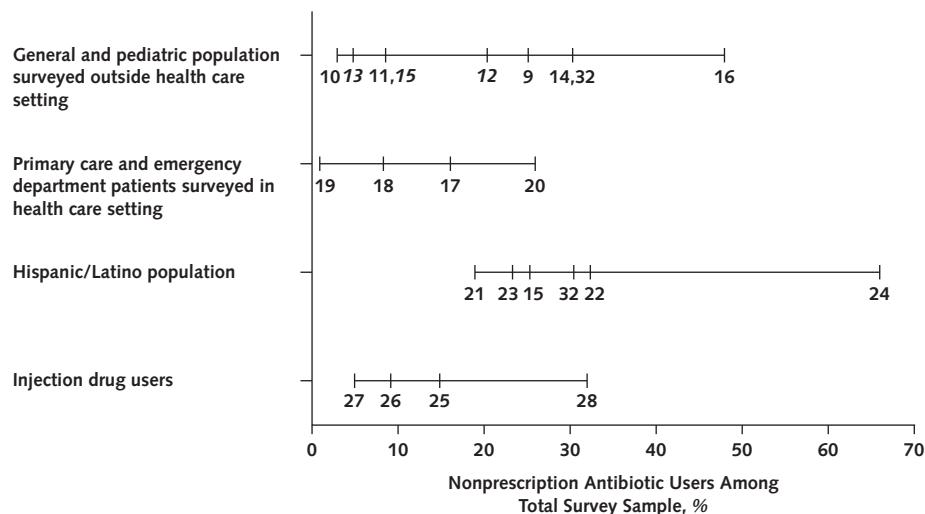
Wisconsin and Minnesota, in which 3% of parents of young children reported that they had used antibiotics for themselves or their children without consulting a physician in the previous 6 months (10). The highest estimate (48%) came from a 2018 national Internet survey of parents about pediatric antibiotic diversion (16). Of 219 (48%) who kept leftover antibiotics, 159 (73%) subsequently diverted them to their child's siblings, unrelated children, and unrelated adults (16). Among patients or parents of patients surveyed in health care settings, the lowest reported prevalence was 1% from a study of an adult urban population (19), and the highest estimate (25%) was from a study in primary care patients (20).

Several studies (15, 21-24) reported that nonprescription antibiotic use was prevalent in Hispanic/Latino populations. The lowest prevalence (19%) was reported in a 2005 survey that included predominantly uninsured Latino patients visiting clinics in South Carolina (21). The highest prevalence (66%) was reported in a 2014 survey of Latino migrant workers in Florida (24). In studies of injection drug users, the prevalence of nonprescription antibiotic use to treat abscesses and injection-related wounds varied from 5% to 32% (25-28).

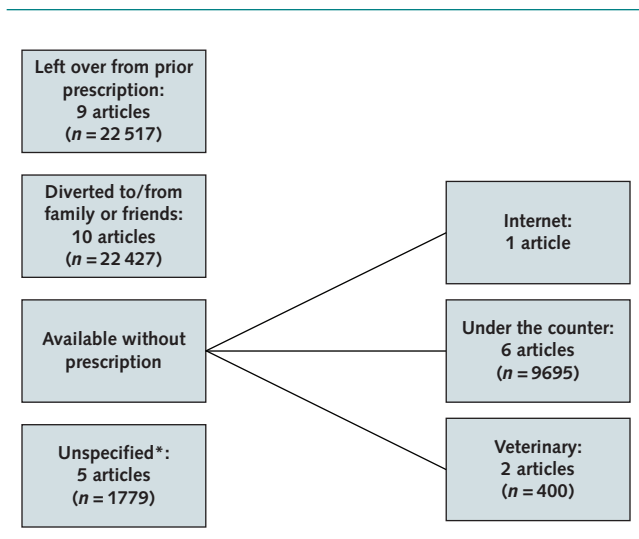
Sources and Types of Nonprescription Antibiotics

Figure 3 shows sources of nonprescription antibiotics, the number of articles reporting each source, and the number of respondents contributing to the evidence about each source. Leftover antibiotics from a prior prescription and antibiotics prescribed to a family member or friend were the most commonly reported sources. Both were specific items on national population surveys (15, 16). For example, a 2018 Internet survey that included predominantly white parents of young children found that 48% of parents saved left-

Figure 2. Prevalence of nonprescription antibiotic use reported in available publications.



Numbers correspond to reference citations. Italics indicate national surveys.

Figure 3. Sources of nonprescription antibiotics.

Studies in which the sample unit was not an individual (e.g., bodegas, pet stores, tweets) were not included in cumulative sample sizes.

* Ambiguous source, such as "obtained on the street" or "outside a formal health care setting."

over antibiotics and 73% subsequently diverted them, most often to their child's siblings, unrelated children, unrelated adults, and themselves (16). Antibiotics also were available without a prescription from the Internet (35) and veterinary sources (34) and were sold under the counter (15, 20–22, 24, 30–32, 39).

Only 2 studies examined the type of antibiotics used without a prescription (20, 30). In a survey of availability of antibiotics in stores in New York, investigators found that antibiotics offered without a prescription included ampicillin, tetracycline, erythromycin, and amoxicillin (30). In our 2016 study in Texas, we found that amoxicillin was the most commonly reported antibiotic for nonprescription use, followed by azithromycin, ciprofloxacin, ampicillin, trimethoprim-sulfamethoxazole, tetracycline, ofloxacin, and amoxicillin-clavulanate (20). In 3 studies that queried about infection types or symptoms associated with nonprescription use, sore throat, cough, earache, cold, and painful urination were most commonly reported (17, 18, 20).

Factors Influencing Nonprescription Antibiotic Use

Figure 4 shows factors that were found to influence nonprescription antibiotic use in qualitative studies. Most of these studies were performed in Spanish-speaking Hispanic/Latino immigrants (22, 24, 31, 33, 39). In a focus group study in a Latino neighborhood in New York City, easy access to antibiotics through bodegas and other independent stores and having relatives and friends who shared antibiotics from countries where they can be obtained without a prescription were identified as factors influencing nonprescription use (22). In addition, lack of health insurance, legal status, and long waiting periods in clinics were barriers to physician visits (22). A focus group study of adult Latino immigrants in South Carolina uncovered the belief that

physician visits for a diagnosis and prescription were unnecessary when the patient was familiar with their symptoms and when the symptoms had previously responded to antibiotic treatment (39). Immigrants from Central or South America and Latino migrant workers reported access to injectable antibiotics from Latino markets, which were administered by persons with no medical training (31). Participants felt comfortable buying antibiotics from Latino markets because they could get what they needed without the cost and inconvenience of seeing a physician to obtain a prescription (31). The main reasons for nonprescription antibiotic use among Mexican migrant workers in California who participated in in-depth interviews was their occupational vulnerability, fear of losing their job or a day of pay (33). Migrant workers also cited difficulties in accessing the U.S. health care system, transportation to and from medical facilities, and fear of deportation as barriers to seeking treatment and reasons for obtaining antibiotics without a prescription (24).

Some of the factors identified in studies of Hispanic/Latino populations were also reported in studies of injection drug users, such as easy access to antibiotics, relatives or friends providing antibiotics, long waiting periods in clinics, costs of physician visits and antibiotics, and difficulty accessing the health care system (37). An additional factor that surfaced in 2 of the studies in drug users was concern about being mistreated or judged by health care providers (37, 38). Embarrassment about seeking treatment for an STI influenced interviewees' decisions to use nonprescription antibiotics in the study performed in the STI clinic and the county jail (29).

DISCUSSION

This scoping review of the literature on nonprescription antibiotic use in the United States suggests that its prevalence varies from 1% (among patients visiting clinics) (19) to 66% (among Latino migrant workers) (24). The prevalence of storage of antibiotics varied from 14% (20) to 31% (14), and the prevalence of intended use of nonprescription antibiotics was 25% in the only study that addressed this subject (20).

Our findings align with results from studies in other developed countries. Southern and eastern European countries that report high levels of antibiotic resistance also have high prevalence of nonprescription antibiotic use (41, 42). Studies performed in Australia (43) and New Zealand (44) found high prevalence of nonprescription antibiotic use and antibiotic storage among Korean, Egyptian, and Chinese immigrants. Although a few studies conducted in Europe have explored predictors of nonprescription antibiotic use (42, 45), the results may not be generalizable to the United States because of differences in health care systems and population characteristics. Our literature searches identified only 1 systematic review that included U.S. data (1). This 2011 review included 3 studies performed in the United States, all of which are covered in our scoping review.

We identified several important gaps in the available literature. First, studies on the prevalence of nonprescription antibiotic use in the general U.S. population are lacking. Much of the literature on prevalence of and factors driving nonprescription use is focused on certain population subgroups, such as Hispanic/Latino populations or injection drug users. The focus on Hispanic/Latino populations may be due to their ties to countries in which antibiotics can be purchased without a prescription and the assumption that they have limited access to health care. Likewise, the focus on drug users may derive from preconceived expectations about hesitation to seek care in this population. These ideas may be misplaced because we found evidence that various forms of nonprescription antibiotic use occurred in all socioeconomic and demographic groups studied to date.

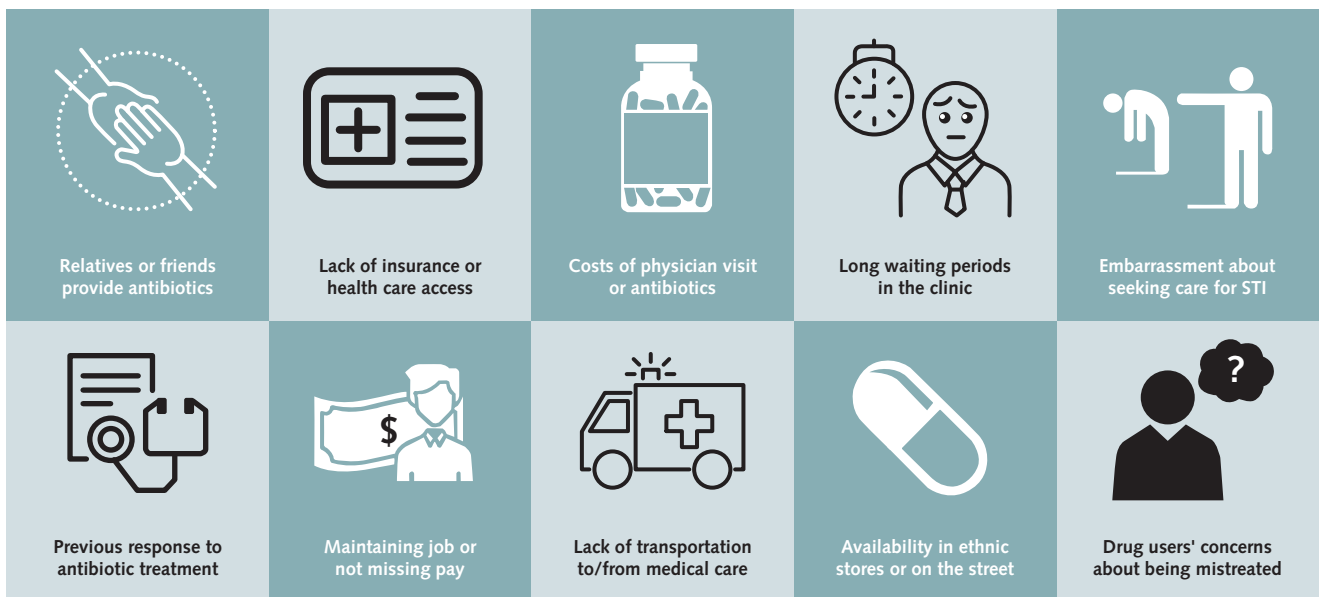
Second, evidence on how to intervene to decrease nonprescription antibiotic use is limited. We found only 1 published intervention that tried to decrease nonprescription use (32). This mass media campaign targeting a Latino population was not effective in decreasing the number of antibiotics purchased without a prescription in or outside the United States (32). In fact, the percentage of respondents who bought antibiotics without a prescription in the United States increased from 19% in the preintervention period to 31% in the postintervention period, suggesting that the intervention may have increased awareness of the availability of antibiotics without a prescription (32). The failure of this intervention suggests that more rigorous identification of risk factors (such as health care system or clinical encounter factors), specification of a conceptual causal model, and preliminary exploration to ascertain which pathways may be amenable to intervention are essential

steps in developing interventions. The factors driving nonprescription antibiotic use likely differ across population subgroups, so further research is necessary before interventions can be designed properly.

Our review also uncovered questions that are not addressed in the current literature. For example, we do not know what percentage of overall antibiotic use is represented by nonprescription use, and no study quantified the effect of nonprescription use on antibiotic resistance rates in the United States. In a recent meta-analysis exploring global prevalence of bacterial resistance of *Escherichia coli* in pediatric urinary tract infections across multiple countries, higher prevalence of resistance in several countries was attributed to availability of over-the-counter antibiotics (46). Only 2 of the included studies reported the classes of antibiotics that were most commonly used without a prescription, and few looked at symptoms or illnesses most likely to trigger nonprescription use. It is surprising that, although our review encompassed literature published between 2000 and 2019, we did not find a time-related evolution in the focus of studies or populations studied, despite the considerable increase in awareness of antibiotic resistance over that period.

The main limitation of our scoping review is possible publication bias. Some of the published studies were likely performed in populations with particularly high rates of nonprescription antibiotic use, and some studies may have not been published because the results did not show nonprescription use to be a prevalent problem. In addition, the heterogeneity of study designs, measurements, and populations introduced challenges to capturing key details and interpreting results.

Figure 4. Factors influencing nonprescription use of antibiotics.



STI = sexually transmitted infection.

In summary, our scoping review mapped the published literature on the prevalence of nonprescription antibiotic use and factors influencing it in the United States. Nonprescription antibiotic use is clearly a public health problem in all racial/ethnic groups, but many aspects are understudied. The need to focus on nonprescription antibiotic use in community-based antimicrobial stewardship programs is urgent. Future studies should develop standardized measures and methods to quantitate nonprescription antibiotic use and explore potentially modifiable factors that contribute to this unsafe practice.

From Baylor College of Medicine, Houston, Texas (L.G., G.G., R.Z.); University of Pennsylvania, Philadelphia, Pennsylvania (S.J.); Boston University School of Medicine, Boston, Massachusetts (M.K.P.); and Michael E. DeBakey Veterans Affairs Medical Center and Baylor College of Medicine, Houston, Texas (J.L.R., B.W.T.).

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Collection and assembly of data: L. Grigoryan, G. Germanos, S. Juneja, B.W. Trautner.

APPENDIX: PUBMED SEARCH TERMS

#1 "Anti-Bacterial Agents"[Mesh] OR "Anti-Infective Agents"[Mesh] OR "anti-bacterial agents"[Pharmacological Action] OR antibiotic[Title/Abstract] OR antibiotics[Title/Abstract] OR antibioticassociated[Title/Abstract] OR "antimicrobial"[tiab] OR "prescription drugs"[MeSH Terms] OR prescription[Title/Abstract] OR prescriptions[Title/Abstract] OR ("prescription"[Title/Abstract] AND "drugs"[Title/Abstract]) OR "prescription drugs*"[Title/Abstract] OR "Behind-the-Counter Drugs"[Mesh] OR "behind the counter*"[tiab] OR "medication*"[tiab]

AND

#2 "Self Medication"[Mesh] OR "Prescription Drug Misuse"[Mesh] OR "Drug Misuse"[Mesh] OR "Prescription Drug Diversion"[Mesh] OR "Prescription Drug Overuse"[Mesh] OR "Substance-Related Disorders"[Mesh] OR "self medication"[Title/Abstract] OR "self medicate"[Title/Abstract] OR "self medicated"[Title/Abstract] OR "self medicates"[Title/Abstract] OR "self medicating"[Title/Abstract] OR "self medication"[Title/Abstract] OR "self medicative"[Title/Abstract] OR "self medicators"[Title/Abstract] OR "drug misuse"[Title/Abstract] OR "prescription misuse"[Title/Abstract] OR

"medication misuse"[Title/Abstract] OR "antibiotic misuse"[Title/Abstract] OR "prescription abuse"[Title/Abstract] OR "medication abuse"[Title/Abstract] OR "antibiotic abuse"[Title/Abstract] OR "medication overdose"[Title/Abstract] OR "medication overuse"[Title/Abstract] OR ("prescription"[Title/Abstract] AND "drug"[Title/Abstract] AND "diversion"[Title/Abstract]) OR "prescription drug diversion"[Title/Abstract] OR "drug diversion"[Title/Abstract] OR "drug diversions"[Title/Abstract] OR "prescription diversion"[tiab] OR "medication diversion"[tiab] OR "self-treat"[tiab] OR "self-administer*"[tiab] OR "selfadminister*"[tiab] OR "self-administration*"[tiab] OR "selfadministration*"[tiab] OR "self-prescription*"[tiab] OR "self-treatment"[tiab] OR misuse[tiab] OR misuses[tiab] OR overuse[tiab] OR overuses[tiab] OR abuse[tiab] OR abuses[tiab] OR abusing[tiab] OR nonprescribed[tiab] OR nonprescription[tiab] OR "non-prescription"[tiab] OR "non-prescriptions"[tiab] OR "not prescribed"[tiab] OR non-prescribed[tiab]

AND

#3 "United States"[Mesh] OR United States[All Fields] OR "United States of America"[All Fields] OR USA[All Fields] OR "U.S.A."[All Fields] OR American[All Fields] OR Americans[All Fields] OR "appalachian region"[MeSH Terms] OR Appalachia*[All Fields] OR "great lakes region"[MeSH Terms] OR "great lakes"[All Fields] OR "mid-atlantic region"[MeSH Terms] OR "Mid-Atlantic"[All Fields] OR "Midwestern United States"[Mesh] OR midwest*[All Fields] OR "new england"[MeSH Terms] OR "northwestern united states"[MeSH Terms] OR Northwestern*[All Fields] OR "pacific states"[MeSH Terms] OR "pacific northwest"[All Fields] OR "southeastern united states"[MeSH Terms] OR southeast* [All Fields] OR "southwestern united states"[MeSH Terms] OR southwest*[All Fields] OR "district of columbia"[MeSH Terms] OR "Washington D.C."[All Fields] OR "alabama"[MeSH Terms] OR Alabama[All Fields] OR "alaska"[MeSH Terms] OR Alaska[All Fields] OR "arizona"[MeSH Terms] OR Arizona[All Fields] OR "arkansas"[MeSH Terms] OR Arkansas[All Fields] OR "california"[MeSH Terms] OR California[All Fields] OR "colorado"[MeSH Terms] OR Colorado[All Fields] OR "connecticut"[MeSH Terms] OR Connecticut[All Fields] OR "delaware"[MeSH Terms] OR Delaware[All Fields] OR "florida"[MeSH Terms] OR Florida[All Fields] OR "georgia"[MeSH Terms] OR Georgia[All Fields] OR "hawaii"[MeSH Terms] OR Hawaii[All Fields] OR "idaho"[MeSH Terms] OR Idaho[All Fields] OR "illinois"[MeSH Terms] OR Illinois[All Fields] OR "indiana"[MeSH Terms] OR Indiana[All Fields] OR "iowa"[MeSH Terms] OR Iowa[All Fields] OR "kansas"[MeSH Terms] OR Kansas[All Fields] OR "kentucky"[MeSH Terms] OR Kentucky[All Fields] OR "louisiana"[MeSH Terms] OR Louisiana[All Fields] OR "maine"[MeSH Terms] OR Maine[All Fields] OR "maryland"[MeSH Terms] OR Maryland

d[All Fields] OR "massachusetts"[MeSH Terms] OR massachusetts[All Fields] OR "michigan"[MeSH Terms] OR Michigan[All Fields] OR "minnesota"[MeSH Terms] OR Minnesota[All Fields] OR "mississippi"[MeSH Terms] OR Mississippi[All Fields] OR "missouri"[MeSH Terms] OR Missouri[All Fields] OR "montana"[MeSH Terms] OR Montana[All Fields] OR "nebraska"[MeSH Terms] OR Nebraska[All Fields] OR "nevada"[MeSH Terms] OR Nevada[All Fields] OR "new hampshire"[MeSH Terms] OR "New Hampshire"[All Fields] OR "new jersey"[MeSH Terms] OR "New Jersey"[All Fields] OR "new mexico"[MeSH Terms] OR "New Mexico"[All Fields] OR "new york"[MeSH Terms] OR "New York"[All Fields] OR "north carolina"[MeSH Terms] OR "North Carolina"[All Fields] OR "north dakota"[MeSH Terms] OR "North Dakota"[All Fields] OR "ohio"[MeSH Terms] OR Ohio[All Fields] OR

"oklahoma"[MeSH Terms] OR Oklahoma[All Fields] OR "oregon"[MeSH Terms] OR Oregon[All Fields] OR "pennsylvania"[MeSH Terms] OR Pennsylvania[All Fields] OR "rhode island"[MeSH Terms] OR "Rhode Island"[All Fields] OR "south carolina"[MeSH Terms] OR "South Carolina"[All Fields] OR "south dakota"[MeSH Terms] OR "South Dakota"[All Fields] OR "tennessee"[MeSH Terms] OR tennessee[All Fields] OR "texas"[MeSH Terms] OR texas[All Fields] OR "utah"[MeSH Terms] OR Utah[All Fields] OR "vermont"[MeSH Terms] OR Vermont[All Fields] OR "virginia"[MeSH Terms] OR Virginia[All Fields] OR "washington"[MeSH Terms] OR Washington[All Fields] OR "west virginia"[MeSH Terms] OR "West Virginia"[All Fields] OR "wisconsin"[MeSH Terms] OR Wisconsin[All Fields] OR "wyoming"[MeSH Terms] OR Wyoming[All Fields]

Appendix Table 1. Descriptive Summary of Studies Performed in the General Population, From Oldest to Most Recent

Study, Year (Reference)	Location	Population Characteristics	Approach and Study Design	Sample Size, n	Focus of the Study	Outcome Measurement
Ceaser and Wurtz, 2000 (9)	Illinois	Adults	Quantitative Interviews of randomly selected adults on a city street	101	Leftover antibiotics from a previous prescribed course	Respondents reported ever saving, taking, and sharing antibiotics from a prescribed course that was not completed
Richman et al, 2001 (17)	New Jersey	ED patients	Quantitative Survey of a convenience sample of ED patients	1363	Leftover antibiotics from a previous prescribed course	Respondents reported ever using leftover prescribed antibiotics without consulting a physician
McDonald et al, 2001 (29)	North Carolina	STI clinic and county jail	Qualitative Ethnographic interviews	20 interviewees in STI clinic 16 interviewees in county jail	Self-treatment with antibiotics obtained without a prescription and reasons for self-treatment	NA
Edwards et al, 2002 (18)	New Jersey	Parents of children aged <18 y in ED	Quantitative Survey of a convenience sample of parents of ED patients	801	Leftover, previously prescribed antibiotics administered to children	Parents administered antibiotics to a child without consulting a physician
Belongia et al, 2002 (10)	Minnesota and Wisconsin	Adults and parents of children aged <5 y	Quantitative Telephone surveys using random-digit dialing	275 parents of children aged <5 y 405 adults	Use of antibiotics for themselves or their children for respiratory illnesses without consulting a physician*	Respondents reported using antibiotics in the prior 6 mo without consulting a physician
Goff et al, 2002 (34)	Washington, DC	Pet superstores	Quantitative Survey of pet store employees	2 pet stores	Availability of antibiotics without a prescription in pet stores	Pet store employee confirmed that antibiotics could be purchased without a prescription in the store
Vanden Eng et al, 2003 (11)	Connecticut, Minnesota, Oregon, California, Georgia, Maryland, New York	Adult population	Quantitative Telephone surveys using random-digit dialing	10 780	Use of antibiotics without seeing a health care provider*	Respondents reported using antibiotics prescribed for a previous illness or for someone else in the previous 4 wk
Larson and Grullon-Figueroa, 2004 (30)	New York	Private independent pharmacies, grocery stores, delicatessens, bodegas, botanical or health food stores	Quantitative Survey of store employees	34 stores in Hispanic neighborhoods 37 stores in black neighborhoods 30 stores in white neighborhoods	Availability of antibiotics without a prescription in stores	Pharmacy or store employee confirmed that antibiotics could be purchased without a prescription in the store
Mainous et al, 2005 (21)	South Carolina	Latino patients attending clinics and their companions	Quantitative Interviewer-administered survey in English and Spanish	219	Purchase of antibiotics without a prescription in the United States and transportation of nonprescribed antibiotics from abroad	Respondents reported buying antimicrobials without a prescription in the United States and bringing them from other countries

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Appendix Table 1—Continued

Study, Year (Reference)	Location	Population Characteristics	Approach and Study Design	Sample Size, n	Focus of the Study	Outcome Measurement
Larson et al, 2006 (22)	New York	Hispanic community members and employees of local bodegas	Mixed methods Interviewer-administered survey in Spanish (quantitative component) and focus groups (qualitative component)	Quantitative: 25 employees; 5 bodega women with health insurance; 6 Latina women without health insurance	Antibiotics obtained without a prescription and storage of antibiotics	Interviewees reported getting antibiotics without a prescription from stores in the United States and abroad, using leftover antibiotics from previous prescriptions, and storing antibiotics at home
Mainous et al, 2008 (39)	South Carolina	Adult Latino immigrants	Qualitative Focus groups in Spanish	Three focus groups: 28	Factors affecting Latino adults' use of antibiotics without a prescription	NA
Coffman et al, 2008 (31)	North Carolina	Immigrants from Central or South America	Qualitative Focus groups in Spanish	Three focus groups: 19	Self-prescription practices and use of antibiotics without medical advice	NA
Goldsworthy et al, 2008 (12)	National survey	Persons aged 12–44 y in public spaces in cities	Quantitative One-on-one interviews in English and Spanish	700	Prescription medication-sharing behavior (loaning and borrowing)	Respondents reported borrowing or loaning antibiotics
Mainous et al, 2009 (32)	South Carolina	Latino adults	Quantitative Before-and-after controlled study using surveys in Spanish	219 (preintervention) 229 (postintervention) 243 (control community)	Evaluation of the effect of an educational intervention on nonprescription antibiotic use in a Latino community	Percentage of respondents who bought antibiotics without a prescription
Mainous et al, 2009 (35)	South Carolina	Internet vendors selling antibiotics without a prescription	Quantitative Internet search using 2 major search engines (Google and Yahoo!), with the keywords "purchase antibiotics without a prescription" and "online"	138 vendors	Internet vendors that would sell antibiotics with or without a prescription to a buyer in the United States	Number of Internet vendors that would sell antibiotics without a prescription
Goldsworthy and Mayhorn, 2009 (13)	National survey	Adolescents aged 12–17 y in public spaces in urban and suburban locations	Quantitative One-on-one interviews in English and Spanish	594	Prescription medication-sharing behavior (loaning and borrowing)	Respondents reported loaning or borrowing antibiotics
Landers et al, 2010 (23)	New York	Latino female heads of households participating in a trial on upper respiratory infections	Quantitative Interviewer-administered survey in Spanish	100	Self-medication with antibiotics*	Respondents reported self-medication with antibiotics for themselves or their children
Scanfeld et al, 2010 (40)	National internet search	Twitter updates mentioning antibiotics	Qualitative Review of Twitter status updates	1000 Twitter status updates	Cases of potential misuse or misunderstanding of antibiotics	Combinations: "leftover + antibiotics" "share + antibiotics" "extra + antibiotics"

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Appendix Table 1—Continued

Study, Year (Reference)	Location	Population Characteristics	Approach and Study Design	Sample Size, n	Focus of the Study	Outcome Measurement
Ward et al, 2011 (19)	Philadelphia, Pennsylvania	Patients in ED, internal medicine, and general medicine	Quantitative Interviewer-administered survey	641	Patterns of borrowing of prescription medications, including antibiotics	Respondents reported ever using an antibiotic without a prescription (borrowing)
Horton and Stewart, 2012 (33)	California	Mexican migrant farm workers	Qualitative In-depth interviews in Spanish	23	Reasons for self-medication with antibiotics*	NA
Wiczorkiewicz et al, 2013 (14)	Illinois	Adult residents of Cook County	Quantitative Telephone interviews via random-digit dialing in English and Spanish	445	Storage of antibiotics*	Respondents reported that they stored antibiotics at home
Sánchez, 2014 (24)	Florida	Latino migrant workers participating in Project Salud (aimed at engaging this community in implementation of an HIV prevention intervention)	Mixed methods Structured questionnaire using audio computer-assisted self-interview (quantitative component) and focus groups in Spanish (qualitative component)	Quantitative: 278 Qualitative: 24	Self-reported use of antibiotics without a prescription and factors associated with nonprescription antibiotic use	Respondents reported use of antibiotics without a prescription, including injected antibiotics, in the previous 12 mo
Francois Watkins et al, 2015 (15)	National U.S. survey	Adult consumers living in the United States, including Hispanic consumers	Quantitative CDC national Internet survey in English and Spanish using both random-digit dialing and address-based sampling methods	4044 consumers in 2012 3502 consumers in 2013 1000 Hispanic consumers in 2013	Antibiotics obtained from leftover stored courses, neighborhood grocery store, or family member	Respondents reported obtaining antibiotics not prescribed by a clinician from leftover stored antibiotics; a neighborhood grocery store, or a friend or family member
Zoorob et al, 2016 (20)	Texas	Adult patients in the waiting rooms of a private primary care clinic and 2 public primary care clinics	Quantitative Self-administered survey in English and Spanish	400	Nonprescription antibiotic use, including actual use in the storage of antibiotics, and intended nonprescription use	Respondents reported nonprescription use of systemic antibiotics in the previous 12 mo, storage of antibiotics at home, and intended use of nonprescribed antibiotics
Kahan, 2018 (16)	National survey via Amazon Mechanical Turk	Parents	Quantitative Anonymous online survey	496	Antibiotic diversion	Saving leftover antibiotics and diverting antibiotics from the child to whom they were prescribed to the child's siblings and parents, unrelated children, and adults

CDC = Centers for Disease Control and Prevention; ED = emergency department; NA = not available; STI = sexually transmitted infection.
 * One of the research questions.

Appendix Table 2. Descriptive Summary of Studies Performed in Injection Drug Users

Study, Year (Reference)	Location	Population Characteristics	Approach and Study Design	Sample Size, n	Focus of the Study	Outcome Measurement
Binswanger et al, 2000 (25)	California	Injection drug users in Urban Health Study	Quantitative Interviewer-administered survey	169	Self-treatment with antibiotics purchased on the street*	Respondents reported treating an abscess with antibiotics acquired on the street
Starrels et al, 2009 (37)	Philadelphia, Pennsylvania	Injection drug users	Qualitative Focus groups	28	Obtaining of antibiotics from nonprovider sources and poor adherence to prescribed antibiotics	NA
Roose et al, 2009 (26)	Washington, DC	Injection drug users	Quantitative Interviewer-administered survey	101	Acquiring antibiotics without a prescription*	Respondents reported acquiring antibiotics without a prescription
Fink et al, 2013 (27)	California	Injection drug users	Quantitative Interviewer-administered survey	457	Self-medication with illegally purchased antibiotics	Illegally purchased antibiotics
Summers et al, 2018 (28)	Massachusetts and California	Injection drug users	Mixed methods Interviews (qualitative component) and follow-up survey (quantitative component)	Quantitative: 85 Qualitative: 12	Taking nonprescribed antibiotics*	Taking nonprescribed antibiotics in previous year
Harris et al, 2018 (38)	Philadelphia, Pennsylvania	Injection drug users	Qualitative Semistructured in-depth interviews	19	Self-medication with antibiotics purchased on the street*	NA

NA = not available.

* One of the research questions.