

AN ABSTRACT OF THE THESIS OF

Ellen M. Alonso Street for the degree of Master of Science in Nutrition presented on June 4, 2020.

Title: Self-perceived health and chronic conditions among users of supplements with and without botanical ingredients: findings from the 2009-2014 National Health and Nutrition Examination Surveys

Abstract approved:

Ellen Smit

Objective: To describe associations between self-reported general health status, chronic conditions, and use of supplements containing botanicals (SCB) and describe reasons for use among U.S. adult supplement users.

Design: Cross-sectional analysis using data from the 2009-2014 National Health and Nutrition Examination Survey (NHANES). Information on self-reported dietary supplement use and reasons for use were collected with a 30-day recall interview. Self-reported general health status and doctor-informed diagnoses of chronic conditions were assessed using a health status questionnaire. We used weighted multivariate logistic regressions to assess associations between dietary supplement use and perceived health and number of chronic conditions.

Setting: The National Health and Nutrition Examination Survey (2009-2014).

Participants: 16,958 non-institutionalized U.S. adults aged 20 years and older.

Results: Adults who reported excellent or very good self-perceived health were more likely to use SCB than adults with good perceptions of their health. Adults with three or more chronic conditions were more likely to report using SCB than adults with no chronic conditions. The most frequently reported reasons for SWB and SCB use were “personal choice or influenced by advertisements or word of mouth,” to “improve health,” and “specific health conditions.”

Conclusions: While perceptions of health are more positive among adults using SCB, these individuals are also more likely to have a chronic condition and to report taking SCB for reasons related to exercising personal choice, improving health, or addressing specific health conditions. Differentiating SCB from other forms of complementary and integrative therapies may be useful for facilitating a deeper understanding of the reasons for supplement use among distinct user groups.

Keywords: dietary supplements, botanicals, self-perceived health, NHANES

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Self-perceived Health and Chronic Conditions among Users of Supplements with
and without Botanical Ingredients: Findings from the 2009-2014 National Health
and Nutrition Examination Surveys

by

Ellen M. Alonso Street

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APPROVED:

Major Professor, representing Nutrition

Head of the School of Biological and Population Health Sciences

Dean of the Graduate School

I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

Ellen M. Alonso Street, Author

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General Introduction

Over half of the U.S. adult population use dietary supplements, according to findings from the United States National Health and Nutrition Examination Survey (NHANES)⁽¹⁾. Dietary supplement use has been consistently linked to health-supporting habits and more positive self-perceptions of health^(1–13). However, few studies describe self-perceived health among representative samples of U.S. adults who use specific sub-types of supplements, like herbs and botanicals^(14–17). Individuals with chronic conditions are frequent botanical supplement users^(15–34) and because of the complex and poorly understood biological mechanisms, the use of botanical supplements may carry health risks^(35–37). Little is also known about how self-perceived health relates to the use of botanical supplements among this group of users^(14,16,38,39).

The most common reasons for dietary supplement use are to improve or maintain general health^(22,40–43), reasons which are veritably intertwined with one's perception of their health according to health behavior theory^(44–46). But these reasons describe overall dietary supplement use and most studies on botanical supplements do not specify how reasons for use differ by sub-populations of users^(41,43,47–56) and by the type of supplement used^(38,39,57). While there is an existing body of research on reasons for botanical supplement use among adults with chronic conditions, these studies focus on older adults or small samples of botanical users with specific conditions^(15,16,18,20–26,28–34,50,55,58). Little is known about reasons for botanical use among representative samples of U.S. adults with any chronic condition. Botanical supplements present potential risks, whether taken alone or in combination with other supplements or medications due to limited regulatory oversight and a distinct lack of rigorous, clinical evidence and quality assurance testing supporting their efficacy and safety. Using botanical supplements as a health management strategy, alone or in combination with pharmaceuticals, carry potential risks that must be considered, particularly for supplement users with chronic conditions, groups who typically do not report use to health providers, disproportionately increasing the risk for adverse side effects^(2,15,59–65).

Much of the existing research on botanical supplements, self-perceived health, and reasons for use combines herbal and botanical supplements into a broad and diverse category of treatments described as complementary and integrative therapies (CIT)^(24,28,31,59,62,66–82). CIT refers to a wide array of therapies separate from mainstream medical approaches⁽⁸³⁾. Previous

research describing self-perceived health and botanical supplement use among U.S. adults frequently combines botanical supplements with other complementary and integrative modalities, linking poorer self-perceived health to a range of CIT^(28,34,70,72,77,84–87). However, a comparatively smaller body of research examining botanical supplement use separate from other complementary and integrative modalities describes more positive perceptions of health among those using botanical supplements^(14,16,38,39,57). But among these studies, only one included nationally representative results on both self-perceived health and reasons for use⁽¹⁴⁾. By focusing on botanical supplement use and self-perceived health in a nationally representative population of non-institutionalized adults, plus examining the reasons for using these supplements, the present research may contribute valuable information to support future public health education by characterizing vulnerable groups of users.

Previous research on botanical supplement use among nationally representative populations of U.S. adults classify botanical users as those who report using any supplement that contains a botanical ingredient, whether that product is a single-ingredient botanical supplement, or a dietary supplement blend containing multiple dietary ingredients such as vitamins, minerals, amino acids, and herbs or other botanicals⁽⁸⁸⁾. Similarly, our research classifies botanical supplement users as users of supplements containing botanicals (SCB), including any single ingredient botanicals, or any dietary supplement containing one or more botanical ingredients⁽⁸⁹⁾. While dietary supplement blends that contain botanicals are not technically botanical supplements as defined by the Dietary Supplement Health and Education Act of 1994 (DSHEA), our criteria for botanical supplement use are consistent with previous studies. The goal of this research is to determine the association between SCB use and self-perceptions of health, as well as reasons for use, using the 2009-2014 NHANES, which offers a unique opportunity to evaluate this association at the national level. Past literature reports frequent use of botanical supplements among adults with chronic conditions^(15–18,20–26,28–34,90,91) but existing research does not distinguish between the reasons for use among botanical users with and without chronic conditions. Defining and differentiating reasons for use among people with chronic conditions, compared to people without chronic conditions, may contribute useful information for characterizing user groups who may be more susceptible to risks associated with botanical use.

Specific Aims & Hypotheses

The present research will evaluate the following aims:

1. Summarize the existing knowledge in the area of botanical supplement use among U.S. adults as well as previously reported relationships to perceived health status and chronic conditions.
2. Characterize adults who use supplements containing botanicals (SCB) compared to supplements without botanicals (SWB).
3. Determine the association between SCB and perceived health status among US adults participating in three NHANES cycles spanning 2009-2014.
 - 3.1. The hypothesis is that the odds of SCB use will be higher among adults who perceive their health to be poor compared to adults who perceive their health as good.
4. Determine and compare the reasons for using supplements among adults who report SCB use compared to the reasons for using supplements among adults who use SWB.
 - 4.1. The hypothesis is that adults who use SCB will be more likely to report using supplements for specific health conditions, for preventive care, or general health maintenance compared to people who use SWB.
5. Determine and compare the reasons for using SCB among adults who have one or more doctor-informed chronic conditions compared to the reasons for using SCB among adults who do not have any doctor-informed chronic conditions.
 - 5.1. The hypothesis is that adults with one or more chronic conditions will be more likely to report using SCB for a specific health condition and or for preventive care than adults without a chronic condition.

Our literature review informed the development of our hypotheses, drawing from previous research on dietary supplements, botanical supplements, and CIT. Hypothesis 3.1 predicts greater odds of SCB use among adults with poor health perceptions, compared to those who perceive their health as good. This hypothesis was informed by reports of positive associations between SCB use and poorer perceptions of health among younger adults⁽¹⁴⁾ and individuals with chronic conditions⁽²⁸⁾. Previous studies that found greater self-perceptions of health among botanical supplement users included primarily older adults^(16,38,39) therefore, we

believed the diverse age range in our dataset could yield different results, given the greater proportion of younger compared to older adults in our sample. Previous postulations describing CIT users also informed our hypothesis. Adults with chronic conditions may experience prolonged suffering and low self-perceived health while seeking effective therapies which may lead to experimentation with numerous therapeutic approaches, with little improvement in health perceptions until an effective therapy is found^(84,92). Also, among adults with chronic conditions, a subset may be “somatizers,” people who perceive pain or illness without any pathophysiological evidence⁽⁸⁴⁾ and may be more likely to perceive poor health and use CIT to address their conditions. Both somatizers and those in search of effective therapies influenced our expectation of lower self-perceived health among adults with chronic conditions using SCB.

Past research acknowledges specific health conditions as a common reason for botanical supplement use^(15,22,43,47,52,93). With hypothesis 4.1, we anticipated that some individuals may use SCB to address specific health conditions, as well as prevent health conditions and maintain their general health, in line with research describing the commonality of supplement use for health maintenance^(22,40–43,53,94). Among SCB users with one or more chronic conditions, we hypothesized finding a greater frequency of reasons related to treating specific health conditions or for preventative care, compared to SCB users without chronic conditions, a hypothesis informed by several studies describing reasons for botanical supplement use among populations of adults with chronic conditions^(21,50,55).

Characterizing the relationship between self-perceived health and botanical supplement use as well as reasons for use among adults with chronic conditions may help inform future public health education interventions targeted towards users who may be vulnerable to unexplored consequences, namely those with chronic conditions. Interventions encouraging safe botanical supplement use and open communication about use between patient and provider can contribute to an eventual shift towards open communication, supporting quality care, and preventing potential adverse interactions associated with botanical supplement use. By clarifying connections between perceptions of health and reasons for botanical supplement use, the results of this research may help to define health-related characteristics associated with vulnerable populations of supplement users, including those with chronic conditions.

Literature Review

Dietary supplements are rising in popularity and comprise a large fraction of the unregulated 36.7 billion dollar nutrition and health product industry^(1,95). Over half of the United States adult population uses dietary supplements, according to data from the U.S. National Health and Nutrition Examination Survey (NHANES)^(1,89). These products are intended to supplement the diet and may contain one or more ingredients including vitamins and minerals, herbs and botanicals, amino acids, and other ingredients⁽⁸⁹⁾. Dietary supplements are easily accessible, minimally regulated products that fall under the purview of the Food and Drug Administration (FDA). Dietary supplements containing “natural” products are categorized as part of a wide variety of complementary and alternative medicines, defined by the National Institute of Health as “those treatments and healthcare practices not taught widely in medical schools, not generally used in hospitals and not usually reimbursed by medical insurance companies”⁽⁸³⁾. Reflective of the growing popularity of integrative therapies, complementary and alternative medicine are no longer considered alternative⁷ and have been recently renamed complementary and integrative care, referred to here as complementary and integrative therapies⁽⁹⁶⁾. Excluding prayer, the use of nonvitamin and nonmineral supplement use, including herbals and botanicals, is the most popular form of CIT among U.S. adults^(79,80,97). A botanical is defined by the Office of Dietary Supplements as a whole plant or any of its parts used for its medicinal or therapeutic properties. Herbs are defined as a subset of botanicals and are therefore included under the umbrella of the label “botanical.” Products made with botanicals used to maintain or improve health may be defined as herbal or botanical products. To be classified as a dietary supplement, an herb or botanical must meet this definition⁽⁸⁹⁾.

Self-Perceived Health and Botanical Supplements

Theoretical models of health behavior link self-perceptions of health to health-supporting behaviors^(44,45), and a number of previous studies have shown a positive association between dietary supplement use and health-supporting habits^(3-5,9-13). Better self-perceptions of health are described among those using CIT, a category of health behaviors including dietary supplements^(6,39,74,98,99). These previous findings suggest a potential correlation between self-perceived health, healthy habits, and botanical supplement use, a popular health management strategy. Previous research establishes a consistent association between botanical use and positive self-perceptions of health among U.S. adults^(14,16,38,39,57,100). although each study samples

distinctly different user populations, with only one recent study among a nationally representative sample of non-institutionalized U.S. adults ages 20 and older⁽¹⁴⁾. These findings support a persistent pattern, but the evidence is not enough to make generalizations to the overall population of U.S. adults given that the studies using nationally representative data rely on self-report^(14,100). The present research utilizes a nationally representative sample of noninstitutionalized U.S. adults participating in the NHANES, characterizing the association between self-perceived health and botanical supplement use as well as reasons for use among adults with chronic conditions. By expanding the body of research on characteristics of botanical supplement users and their reasons for use, our findings may support future public health education interventions promoting safe supplement use, especially among at-risk groups such as those with chronic conditions.

Botanical Supplement Use in the U.S.

The prevalence of dietary supplement use has increased consistently since the 1970s and encompasses a popular area of CIT, with over half of adults in the U.S. using dietary supplements^(1,5,101,102). The estimated prevalence of botanical supplement use in the early 2000s ranges from 15-19%^(15,70,102). comparable to recent prevalence estimates of botanical use among U.S. adults in the 1999-2014 NHANES cycles ranging from 12-18%, with an average prevalence of about 16%⁽⁸⁸⁾. Much of the previous research examining botanical supplements does not specify or delineate between those using single botanicals or any dietary supplement containing botanicals, therefore estimates may reflect botanical supplements alone, supplements blended with botanical ingredients, or a combination of the two.

Existing research on botanical supplement use in the U.S. consistently classifies the majority of users as non-Hispanic white females, and those with high income and educational attainment^(11,15,51,57,99,103). However, compared to users of dietary supplements in general, frequent botanical users often include ethnic minority groups^(15,16,28-33,103,104), specifically American Indians, Alaskan Natives, immigrants, and U.S. Hispanic and Latinx populations^(11,61,67,104-113). Botanical use may also be more common among people who have chronic conditions and among people who do not have access to affordable, culturally appropriate care^(14,15,28,114-116). In the 2002 NHIS, individuals using prescription medications and non-vitamin dietary supplements—a category which included primarily botanicals—were more likely to be female, Hispanic, or non-white, non-Hispanic other, well-educated, a current or

former smoker, and lacking medical insurance⁽⁹⁹⁾. In a separate analysis of the same NHIS cycle year, 25% of adults fraught with financial and cultural barriers, eschewed conventional healthcare in favor of alternative medicine⁽¹¹⁷⁾. Distrust in medical professionals and institutions resulting from a lack of adequate care, frustration with judgment, and otherwise negative, interactions with care providers have been described as potential reasons why patients seek alternative therapies^(14–16,34,70,80,114,117–121).

The popularity of dietary supplements among U.S. adults is well documented and user characteristics are clearly defined. According to previous studies among sub-populations of botanical users, including children, college athletes, older adults, and ethnic minorities, there are notable differences compared to characteristics associated with the general populations of botanical supplement users^(33,122,123). Yet few studies describe reasons for botanical use among representative samples of adults with chronic conditions, a population with greater risk for adverse side effects. To our knowledge, existing research does not describe reasons for botanical supplement use specifically, among representative populations of U.S. adults with chronic conditions, but for smaller populations of patients with specific chronic conditions around the country^(21,50,55). Given the relative popularity of dietary supplements, identifying user characteristics based on the type of supplements used may be an important step in defining at-risk groups.

General Benefits and Risks of Botanical Supplement Use

Humans have long allied themselves with botanicals as powerful tools for healing. Herbs, botanicals, and other forms of plant medicine are fundamental components of indigenous health practices, documented among many cultures^(108,124–130). Much of our current pharmacology is informed by ethnopharmacology, utilizing potent compounds sourced from plants with a variety of actions, often specific to particular parts of the plant⁽¹³¹⁾. Botanicals are commonly used to address a vast range of conditions including acid reflux, gastrointestinal upset, skin infections, sore throat, mental disorders, muscle cramping, and many other maladies^(67,125,127,132–136). Most botanical remedies are well-established and relatively safe to use, without significant contraindications or interactions on their own. However, due to poor product monitoring and labeling practices for dietary supplements sold in the U.S., product safety, quality, and dosage are inconsistent⁽¹³⁷⁾. The methods of extraction, processing, and dose are revealed at the discretion of the manufacturer, which presents further concern for supplements comprised of

numerous botanical ingredients⁽³⁵⁾. The inability to predict safety and quality of botanical supplements presents a risk to consumers for drug-supplement interactions and adverse side effects related to botanical supplement use, particularly for understudied populations and those using multiple over-the-counter or prescription medications.

Limited supplement regulation by the Food and Drug Administration (FDA) presents a challenge for consumers and health professionals in ensuring safety and supporting patient autonomy in health decisions⁽³⁶⁾. Dietary supplements are classified as neither a food, nor a drug and are defined as a broad set of products designed to “supplement the diet,” affecting “structure and function,” processes in the body, or to support “general well-being,”⁽⁸⁹⁾. Dietary supplements posing substantial risk are prohibited under the Dietary Supplement Health and Education Act of 1994 (DSHEA). The FDA's only control over a dietary supplement product is to prove it unsafe, rather than to prove its efficacy. And yet, manufacturers have no responsibility to prove their products as safe or effective. In fact, supplements are not required to be evaluated for efficacy and require submission of minimal data to the FDA regarding safety to support new supplement ingredients⁽³⁶⁾. Pre-marketing supplement safety studies are not currently required by the FDA⁽³⁶⁾. Furthermore, the law allows companies to sell supplements with new ingredients, even if they are deemed unsafe, until courts rule in favor of the FDA⁽³⁶⁾.

While dietary supplement marketing cannot claim to “treat, prevent, diagnose, mitigate, or cure a specific disease,” general health claims, nutrient content claims, and structure-function claims are permitted⁽³⁶⁾. Only products advertising general health claims and structure-function claims require a submission of scientific evidence to the FDA⁽³⁶⁾. The semantic gymnastics of structure-function claims have evolved into a coded means of communicating treatment and disease prevention claims⁽¹³⁸⁾. Supplement marketing claims are typically phrased with intentional ambiguity such that the statement implies efficacy for treating or preventing a disease state, without explicitly stating so. Ironically, the restrictions DSHEA places on statements for disease treatment and prevention have counteractively resulted in user interpretation of supplement use for disease treatment and prevention from intentionally ambiguous and leading verbiage from supplement manufacturers.

Whether alone or combined with prescription medications, herbs, and botanicals can be harmful, especially if health care providers are not aware of use⁽¹³⁹⁾. Botanicals can change

absorption, metabolism, or excretion of a medication and ultimately, the potency of a drug, namely by inducing or inhibiting cytochrome P450 enzymes, responsible for metabolizing drugs and other xenobiotics^(35,137,140,141). Given that many prescription drugs target these enzymes, individuals who use one or more prescriptions concurrently with botanicals are at a greater risk of adverse side effects^(37,142,143). Serious clinical complications can also occur from taking botanicals by themselves, due to potent, biologically active compounds, which can tax internal organs and metabolic processes leading to liver damage, mitochondrial dysfunction, and alterations in lipid metabolism⁽¹³⁹⁾.

Each year in the U.S., an estimated 23,000 emergency department visits are attributed to adverse interactions between botanical supplements and drugs⁽¹⁴⁴⁾. Analysis of details from U.S. poison control calls in 1998 showed a greater percentage of severe adverse reactions to supplements among U.S. adults compared to incidents involving other substances⁽¹⁴⁵⁾. The rates of serious adverse reactions were particularly high among those with a history of long-term supplement use⁽¹⁴⁵⁾. Adverse reactions can also occur when herbs and botanicals are taken in excess, when contaminated with toxic substances, when the wrong botanical species is taken by mistake, or when used for the wrong purposes⁽¹³⁷⁾. Many cultures refer to herbs and botanicals as plant medicines, a label which demands respect and honor for the potency of the plant, an attitude notably absent from Western health care systems where rates of botanical use disclosure among patients, beliefs about relative safety, and inquiry about use by health care providers are alarmingly low⁽¹⁴⁶⁻¹⁵²⁾.

Non-Disclosure of Botanical Supplement Use

In 2007, 18% of U.S. adults participating in the NHIS reported using botanical supplements, 45% of whom did not disclose use to their health care provider⁽¹⁵³⁾. Similar rates of non-disclosure reported in the literature range from 25-74%, with limited chart documentation by health care professionals^(154,155). Given the widespread prevalence of chronic disease in the United States⁽¹⁵⁶⁾ and the associated use of pharmacotherapy as a primary treatment modality, this trend is concerning and indicates an increased risk for potential supplement-drug interactions.

Previous studies consistently describe patterns of botanical use non-disclosure among ethnic minority populations, uninsured and low-income adults, and individuals with chronic

conditions^(2,30,43,70,99,108,121,132,146,150,154,157–162). The use of CIT has been linked to an individual's sense of agency and control over managing their health^(57,163,164), which may influence non-disclosure among those who feel strongly about making their own healthcare decisions without advice from medical professionals. Non-disclosure rates are likely complicated by a significant lack of chart documentation, therefore whether or not a discussion about supplement use took place may not be accurately reflected in the medical chart⁽¹⁵⁴⁾.

Some users and their families may be well-informed of the characteristics and risks of plant-based products, especially those with cultural traditions of herbalism, while many others may not have inherited the knowledge, a potential effect of acculturation^(128,165,166). Several studies describe misconceptions among consumers about the relative safety of herbal products^(43,167–170). Users are often unaware of the risk for side effects and drug interactions associated with natural remedies like herbs and botanicals, beliefs which may influence their likelihood of disclosing use⁽¹⁶⁹⁾. The monetization of traditional practices has translated to botanical supplements sold as capsules, in bottles, and in stores, rather than plants foraged in natural environments. These colonized versions of traditional medicines also carry different risks. A lack of product standardization and poor regulatory oversight by individuals without formal training in herbalism can ultimately contribute to contamination, toxicity, or completely ineffective products⁽³⁶⁾. The unpredictable quality of botanical supplements can contribute to harmful side effects which populations of marginalized people may be particularly vulnerable to because of limited health care access, themes of botanical supplement use non-disclosure, limited English proficiency, and concomitant supplement-prescription medication use^(2,108,121,150). Among marginalized groups, pervasive discrimination, combined with historical exploitation for research and medical advancement, contributes to attitudes of distrust towards health care providers and beliefs that botanical supplement use will not be understood or encouraged by providers^(159,171). Such attitudes understandably lead to an unwillingness to discuss complementary approaches, like botanical use, for fear of judgment, discrimination, or even ridicule from health providers^(30,32,39,159,171). Another facet of non-disclosure may be due to non-inclusive definitions for botanical use, which can result in false-negative responses from patients upon inquiry about botanical supplement use⁽³⁰⁾. Health professionals who are unfamiliar with socio-culturally specific botanical definitions may be unable to elicit accurate information from patients on botanical use⁽¹⁰⁸⁾. Failure of health professionals to initiate discussions about

botanical use also compounds the problem^(147,172). The challenges with non-disclosure are two-fold: patients may not feel safe discussing botanical use and fear that their provider will oppose it, and providers may lack the ability to establish rapport and initiate open conversations about botanical supplement use in a socio-culturally sensitive manner.

This lapse in communication can be harmful to patients with limited resources, using botanicals in conjunction with other supplements, or with prescription medications. Health education efforts are necessary to empower patients to collaborate with their health care provider and make safe choices related to botanical supplement use when combined with conventional medical treatments. Identifying correlates associated with at-risk users, such as self-perceived health and reasons for botanical supplement use, may help predict utilization of health care services and precisely identify the target population, a necessary step for developing tailored educational interventions aimed at increasing supplement use disclosure.

Herbs and botanicals have long been used by humans to address health and wellness^(125,126,133,135). However, with the supplement industry's commodification on these ancient plant medicines, botanical products are now easily accessible and woefully underregulated. While some botanical users may research product safety on their own or learn about side-effects during their own experience with the product⁽¹⁶⁷⁾, many users may not be able to access information about product safety or potential risks. Scientific knowledge is a privilege typically reserved for those with access to formal education and training. Public health professionals have an important duty to share knowledge related to safe use and potentially adverse side effects associated with concomitant pharmaceutical and botanical use. Patterns of non-disclosure suggest self-treatment with supplements to complement conventional medical treatments and a clear disconnect between patient and provider on collaborative care plans^(15,17).

Botanicals and Perceived Health Status

While past research has identified distinguishable demographic characteristics of adult supplement users, characteristics associated with botanical users specifically are not well-defined, including self-perceived health^(16,28,38,39,57,70,98,100,163,173). The connection between self-perceived health and botanical supplement use is often obscured by broad categorization of supplements as part of all CIT^(14,16,17,28,74,99,118,163,174). Among studies including botanical supplements within the overall category of CIT, some show a positive association between self-

perceived health and use of CIT^(6,39,74,98,99), while others report the opposite^(28,34,70,72,84–87). Few studies examine the association between self-perceived health and botanical use as separate from other forms of CIT. We found seven studies which describe associations between self-perceived health and botanical use specifically, each with a unique sample^(14–17,38,39,57), Adusumilli and colleagues surveyed patients undergoing elective surgeries about their use of herbal medicines, reasons for use, self-perceived health, and supplement-use disclosure to surgical staff⁽⁵⁷⁾. Yoon and colleagues assessed botanical use, health status, and reasons for use first among a small sample of older non-Hispanic white women⁽³⁸⁾ and later among a small sample of older African American women⁽³⁹⁾, while Bruno and colleagues and Arcury and colleagues focused on characterizing herbal use among a representative sample of elderly adults participating in the 2002 NHIS^(16,17). Kennedy evaluated herbal and natural supplement use among 5,787 adults aged 18 and older using the 2002 NHIS⁽¹⁵⁾. Gardiner and colleagues analyzed 2007 NHIS data of 23,393 U.S. adults 20 years and older⁽¹⁴⁾. Although each study focused on a different user group, all seven found a positive association between botanical use and better self-perceived health. Studies that include botanicals in the overall category of CIT show conflicting relationships between self-perceived health and CIT use. However, the seven studies examining botanical use specifically show consistent positive associations between botanical use and better self-perceived health, suggesting a different relationship between self-perceived health and the type of CIT examined. However, given that only two of the seven studies used a nationally representative sample of U.S. adults of all ages, and the others targeted older adults or individuals undergoing elective surgeries, there is not enough evidence to suggest that this association is generalizable to the U.S. population of adults.

The Behavioral Model of Health Services Use, initially developed by Dr. Ronald Anderson in the 1960s, establishes personal health practices and self-perceptions of health as individual characteristics influencing the utilization of health services⁽⁴⁴⁾. Previous research describes a link between dietary supplement use and health-supporting practices related to diet, exercise, smoking, and alcohol consumption among U.S. adults^(3–5,11–13). Numerous studies describe greater self-perceived health among people using CIT, an umbrella term for health-supporting strategies that includes supplement use^(6,39,74,98,99). Another theory supporting the relationship between supplement use and self-perceived health is the Health Belief Model, initially developed by social psychologists⁽⁴⁵⁾. The theory explains how an individual's

perceptions of health-related costs, benefits, susceptibility to, and severity of potential health-related outcomes influence motivation to pursue health-promoting behaviors⁽⁴⁶⁾. Assuming one has dispensable income, barriers to obtaining botanical supplements are low, as botanicals do not require a prescription to purchase and are sold at a variety of retail locations. While easy access to botanicals may empower individuals to use them as a health management strategy⁽⁵⁷⁾, it also presents an important public health issue because of the inconsistent quality and regulation of these products. External influences, represented by the cues to action construct of the model, include health professionals, media messages, friends, and family members who can all influence individuals to pursue health management strategies, like botanical supplement use, to mitigate susceptibility to disease or manage current health conditions.

Health behavior theories include self-perceptions of health as predictors of health care utilization. Self-perceived health may influence the decision to pursue health-supporting behaviors or health management strategies like botanical supplement use. Armstrong and colleagues describe poorer perceptions of health among adults who expressed distrust in conventional medical systems, even after controlling for sociodemographic characteristics⁽¹⁷⁵⁾. Individuals who show distrust in the conventional biomedical paradigm may be more likely to turn to alternative approaches like CIT. Among botanical users and non-botanical supplement users, patterns of self-perceived health have not been consistently established among representative populations of U.S. adults. Characterizing U.S. adults who use botanical supplements, including how they perceive their health, could support health professionals in tailoring educational interventions promoting safe supplement use.

Botanicals and Chronic Conditions

Compared to botanical supplement users in general, previous studies describe botanical supplement users with one or more chronic conditions as older adults, typically with more wealth and education, as well as notable patterns of concomitant prescription drug and supplement use^(28,99,103,116,176,177). Previous research shows a higher prevalence of supplement use among prescription medication users, including those with chronic conditions and comorbidities^(99,108,116,148,150,178,179). High-dose vitamins and botanical supplements carry potentially harmful side effects due to complex pharmacokinetic actions and interactions with other supplements, dietary components, and pharmaceutical drugs^(35,137,139,140,142,179,180). making adverse side effects a pertinent concern for this population^(2,15,59–65).

Previous studies describe the commonality of dietary supplement use among adults with chronic conditions^(13,15–18,20–26,28–34,86,90,91,100,115,116,181,182). Three state-specific health surveys note a greater prevalence of supplement use among adults with chronic conditions, compared to adults without chronic conditions^(86,181,182). Using nationally representative data from the 2005-2008 NHANES cycles, Farina and colleagues listed multivitamins containing botanicals as the third most prevalent type of dietary supplement used by adults with any doctor-informed medical condition⁽¹¹⁶⁾. Notably, a third of the sample population in this study reported using prescription medications concomitantly with multivitamins containing botanicals⁽¹¹⁶⁾, supporting previous evidence describing concurrent drug and supplement use among adults with chronic conditions^(2,116,150,183). Recent literature on botanical supplement use among U.S. adults with chronic conditions remains limited in the number of representative comparisons: only three studies over the past two decades use nationally representative samples to assess the prevalence of any botanical use between adults with and without chronic conditions^(17,28,115). Yu and colleagues analyzed herbal supplement use among female 2000 NHIS participants and found a significantly greater likelihood of herbal supplement use among women with chronic conditions compared to those without⁽¹¹⁵⁾. Using the 2002 NHIS, Arcury and colleagues reported a significantly higher percentage of elderly herbal supplement users with five or more chronic conditions compared to those without chronic conditions⁽¹⁷⁾. Falci and colleagues focused specifically on adults with chronic conditions in the 2012 NHIS, noting greater nonvitamin or herbal therapy use among adults with multiple chronic conditions, compared to adults with one or no chronic conditions (22% vs 14%)⁽²⁸⁾. Results from these studies, combined with previous findings using NHANES data⁽¹¹⁶⁾ indicate a notable frequency of botanical-containing supplement use among adults in the U.S. with chronic conditions, more so than among adults without chronic conditions.

Commonly cited reasons for dietary supplement use in the U.S. are related to improving or maintaining overall health^(40,41,49,53,54,184). But studies describing reasons for botanical supplement use among U.S. adults with chronic conditions are not well defined due to a lack of distinction between botanicals and other forms of CIT, as well as non-differentiated responses between users with and without chronic conditions^(14–17,57,70,80,117,120,121). Previous research describes dissatisfaction with conventional medicine, high costs associated with allopathic treatments, autonomy, and personal beliefs as reasons for using CIT, reasons that differ from

those reported by U.S. dietary supplement users overall. Among populations of adult botanical users, two studies report the popularity of botanical supplement use to treat acute and chronic health conditions^(14,15), and four cite the unaffordability of conventional treatments and the belief that botanicals complement conventional treatments as common reasons for use⁽¹⁴⁻¹⁷⁾. Among adults awaiting elective surgery, Adusumilli and colleagues, found that respondents used botanicals for treating chronic medical problems, exerting personal autonomy and spiritual beliefs⁽⁵⁷⁾. Additionally, patients reported dissatisfaction with conventional care and easy accessibility as reasons for using botanical products⁽⁵⁷⁾. The commonality of using botanicals to treat chronic and acute conditions and to support or replace conventional treatments may also be common among users with chronic conditions. However, there is a need for further representative research defining and delineating the reasons for botanical use among adults with chronic conditions.

As more people embrace complementary and integrative approaches to care, including the use of herbal and botanical supplements, the issue of botanical supplement safety remains a concern for those who do not involve their health care provider in their decisions to use supplements. The potential for adverse outcomes is particularly pronounced for individuals with chronic conditions, especially those with concurrent pharmaceutical use and patterns of supplement use non-disclosure. Regardless of personal or professional views on botanical supplement efficacy, health care professionals must prioritize accurate assessments of supplement use for patients with chronic conditions to provide effective diagnoses and support patient compliance to treatment plans. Information regarding patient reasons for botanical use may help establish patient-provider connections, but few studies have examined reasons for botanical use among U.S. adults with chronic conditions. The present research will address this gap in knowledge, contributing insight into reasons for botanical supplement use among those with chronic conditions, and expanding existing knowledge of user characteristics.

Summary

As one of the most popular CIT used by U.S. adults^(79,80,97), botanical supplements are a common health-management strategy, frequently used to treat acute and chronic conditions, complement conventional treatments, or used in place of more expensive conventional treatments^(14-17,57). Despite the relative popularity of these products and reported use for acute and chronic conditions, many users do not disclose supplement use to health care

providers^(153,154). Non-disclosure by patients or failure to document supplement use by health professionals has potentially harmful effects, especially among populations with chronic conditions or those using pharmaceuticals in conjunction with botanical supplements^(99,108,116,146,148,150,178,179). Current studies do not differentiate reasons for use by chronic disease status among botanical supplement users^(14–16,57).

The breadth of published literature on supplement use in the U.S. focuses on the broader, general category of dietary supplements, with limited research defining characteristics of botanical users, reasons for botanical use, and how botanical usage patterns differ from overall dietary supplement use, particularly among users with chronic conditions^(14,16,28,39). This information could provide useful insight into reasons for use among at-risk populations, informing future public health education interventions targeting at-risk groups of botanical supplement users. Previous research calls for the “unbundling” of supplement usage by supplement type to gain further understanding of how determinants of supplement use differ based on categorical classifications⁽¹⁰²⁾. Previous research on botanical supplement use has targeted specific subpopulations or has been limited due to small sample sizes^(16,39). Currently, little is known about the prevalence of botanical supplement use and reasons for use among U.S. adults with chronic conditions. While some studies include adult users with chronic conditions, findings do not focus exclusively on adults with chronic conditions or distinguish differences in reasons for use between those with and without chronic conditions^(14–16,38,39). The present research will contribute to gaps in knowledge regarding associations between self-perceived health and botanical use among a representative sample of U.S. noninstitutionalized adults who participated in NHANES. This research will also contribute to the current understanding of reasons for botanical supplement use by differentiating reasons for use between individuals with and without chronic conditions. By characterizing botanical users and their reasons for use, these findings may inform future public health education interventions targeting at-risk user groups, namely those with chronic conditions. Interventions encouraging safe botanical supplement use and discussions about use between patient and provider can contribute to an eventual shift towards open communication, supporting quality care, and preventing potential adverse interactions associated with botanical supplement use.

Research Manuscript

Self-perceived health and chronic conditions among users of supplements with and without botanical ingredients: findings from the 2009-2014 National Health and Nutrition Examination Survey

Abstract

Objective: To investigate associations between self-reported general health status, chronic conditions, and use of supplements containing botanicals (SCB) and describe reasons for use among U.S. adult supplement users.

Design: Cross-sectional analysis using data from the 2009-2014 National Health and Nutrition Examination Survey (NHANES). Information on self-reported use of SCB and supplements without botanicals (SWB) and reasons for use were collected with a 30-day recall interview. Self-reported general health status and doctor informed diagnoses of chronic conditions were assessed using a health status questionnaire. We used weighted multivariate logistic regressions to assess associations between dietary supplement use and perceived health and number of chronic conditions.

Setting: The National Health and Nutrition Examination Survey (2009-2014).

Participants: 16,958 non-institutionalized U.S. adults, 20 years of age and older.

Results: Adults who reported excellent or very good self-perceived health were more likely to use SCB than adults with good perceptions of their health. Adults with three or more chronic conditions were more likely to report using SCB than adults with no chronic conditions. The most frequently reported reasons for SWB and SCB use were “personal choice or influenced by advertisements or word of mouth,” to “improve health,” and “specific health conditions.”

Conclusions: While perceptions of health are more positive among adults using SCB, these individuals are also more likely to have a chronic condition and to report taking SCB for reasons related to exercising personal choice, improving health, or addressing specific health conditions. Differentiating SCB from other forms of complementary and integrative therapies may be useful for facilitating a deeper understanding of the reasons for supplement use among distinct user groups.

Keywords: dietary supplements, botanicals, self-perceived health, NHANES

Introduction

According to data from the U.S. National Health and Nutrition Examination Survey (NHANES), over half of the U.S. adult population use dietary supplements, an umbrella term covering a vast range of products including vitamin, mineral, herbal, and botanical supplements and supplements like amino acids or other isolated compounds^(1,2). A large body of research on dietary supplement use in the U.S. characterizes frequent users as older, white, female, those with higher income, those with higher educational attainment, and those who exhibit health-supporting behaviors^(2,3,12–14,4–11). Additional research shows that ethnic minorities and individuals with chronic conditions in the U.S. are also frequent botanical supplement users^(15–23). Further, botanical supplement use is associated with non-disclosure to health professionals^(3,24–28), presenting a potential risk for those with concomitant prescription medication use, an alarmingly common trend among U.S. adults^(24,28–32).

Self-perceived health has been previously identified as a correlate of complementary and alternative medicine use⁽³³⁾, now referred to as complementary and integrative care, which encompasses interventions not taught in medical school and not generally available in U.S. hospitals⁽³⁴⁾. Alternative health practices that are complementary to allopathic care include dietary supplements and products containing herbs and botanicals. Some studies have investigated the relationship between self-perceived health and an array of complementary therapies including botanical supplements, describing a positive association between poor or fair self-perceived health status and complementary and integrative therapy use among U.S. adults^(15,24,35–40). Notably, past research also describes an increased likelihood of complementary and integrative therapy use among individuals with chronic conditions^(35,41–47). Yet, studies examining characteristics of supplement use such as perceived health, particularly among those with chronic conditions, are not well defined, with varied results by population and supplement type^(15,35,48,49). To date, the few studies that examine botanical supplement use exclusively all report positive associations between greater self-perceptions of health and botanical supplement use among U.S. adults^(18,21,23,50–53).

Reasons for supplement use among U.S. adults are described by numerous studies dating back to the late 1980s with reasons related to improving or maintaining general health status commonly reported^(54,55,64–69,56–63). Comparatively fewer studies examine reasons for botanical supplement use separate from other supplement types or other complementary and integrative therapies^(18,70–77). Among research describing reasons for botanical supplement use among U.S. adult users with chronic conditions, treating specific conditions^(9,18,77–79) and complementing conventional care^(21,43,60) are common reasons for use. To our knowledge, no study to date has used nationally representative data to

compare reasons for supplement use between adults with and without chronic conditions or between those using botanical supplements and those using non-botanical supplements. This aspect of our research may contribute useful information for further characterizing supplement users in the U.S. These distinct differences and gaps in the literature led us to build on what is currently known by determining the associations between using supplements containing botanicals (SCB) and perceived health and chronic conditions, as well as characterizing reasons for using SCB and supplements without botanicals (SWB) in a representative sample of U.S. adults. This study expands the published findings beyond general dietary supplement users to include the characteristics associated with the use of SCB compared to SWB.

Methods

Study design and participants

NHANES is a nationally representative survey using extensive interviews, examinations, and specimens to assess health and nutrition across a representative sample of the non-institutionalized U.S. population. About 5,000 participants are selected to participate each year, with oversampling of minority groups. Institutionalized people including incarcerated, homeless, or hospitalized individuals are excluded. All data used in the present study were derived from the NHANES 2009-2010, 2011-2012, and 2013-2014 cycles and include data on respondent supplements use, reasons for use, and perceptions of general health status. After excluding 578 participants with non-positive sample weights and 11 with missing information for dietary supplement use, the total sample consisted of 16,958 adults aged 20 years and older.

Dependent variable

The use of SCB and SWB was assessed using the 30-day dietary supplement and antacid use questionnaire and during the Mobile Examination Center (MEC) interview, both conducted by a trained NHANES interviewer. For the dietary supplement and antacid use questionnaire, participants reported the names of any supplements they used, and interviewers recorded information about dietary supplement product containers observed during interviews conducted at the participants home and in the MEC to cross-check self-reported data. Information obtained from the labels is stored in the NHANES Dietary Supplement Database. Our research focused on any dietary supplements with an emphasis on supplements containing one or more botanical ingredients, defined by the NIH Office of Dietary Supplements as a whole plant or herb or any of its parts used for its medicinal or therapeutic properties⁽¹⁾. Using the NHANES Dietary Supplement Database: Product Information dataset, the variable quantifying the number of botanicals in each supplement was used to identify any dietary

supplement containing at least one botanical ingredient, categorized as SCB, and all others were categorized as SWB.

Independent variables

Self-perceived health was assessed using the Current Health Status questionnaire conducted in the MEC. Trained interviewers asked participants, “Would you say [your] health in general is...” with response options of “Poor,” “Fair,” “Good,” “Very Good,” or “Excellent,” which we consolidated into three categories: “Fair or poor,” “Good,” and “Excellent or very good,” as implemented in previous studies^(4,63). Our analyses also evaluated chronic disease using self-reports collected during the household interview, describing physician-diagnosed conditions including asthma, psoriasis, celiac disease, gout, congestive heart failure, coronary heart disease, angina, heart attack, stroke, emphysema, thyroid issues, bronchitis, liver issues, cancer, diabetes, hypertension, and high cholesterol. We created a chronic disease index⁽⁸⁰⁾, summing affirmative responses for each condition and categorizing the sum into none, 1-2, or 3 or more chronic conditions.

A total of 1,787 participants (9.2%) had missing data on the perceived general health variable, and 2,191 (12.5%) had missing data on one or more of the chronic conditions. We compared the characteristics of participants with missing data on either the perceived general health variable or chronic conditions (n=4,262) to adults with complete data. Adults with missing data were less likely to be non-Hispanic White (55.9% vs. 69.2%), less likely to use supplements (59.9% vs. 45.4%), more likely to have low income (33.7% vs. 22.0%), and more likely to have less than a high school education (24.7% vs. 15.2%). Among those with missing data for perceived general health, non-respondents were more likely to be female (61.2% vs. 51.0%), while those with missing data for at least one chronic condition were more likely to be male (51.6% vs. 47.6%).

Reasons for using supplements

Self-reported reasons for supplement use were only reported by supplement users and exclude participants who did not report supplement use (n=8,696). The NHANES dietary supplement and prescription medication section of the household interview includes numerous reasons for supplement use, therefore we condensed reasons for use into eight distinct categories: (i) addressing specific health conditions; (ii) preventing health conditions; (iii) improving general health; (iv) maintaining general health; (v) influencing weight change; (vi) exercising personal choice or influence by advertisements or word of mouth; (vii) using at the advice of a doctor; or (viii) other.

Covariates

During the NHANES household interview, demographic and socioeconomic characteristics were collected using a computer-assisted self-interview. NHANES combines self-reported race and ethnicity into categories defined as non-Hispanic White, non-Hispanic Black, Hispanic, Mexican American, and other race/multi-racial. Age at the time of the interview was recoded into seven categories (20-24, 25-34, 35-44, 45-54, 55-64, and 65+), as implemented in previous studies^(3,81-83). Educational attainment was categorized as less than high school, high school graduate/GED or equivalent, some college or associate's degree, and college graduate and higher. Our estimation of income used the poverty to income ratio (PIR), calculated as a ratio of family income to poverty guidelines⁽⁸⁴⁾. We reported PIR as a range of values between 0 and 5, with 0-1.30 representing low income, 1.31-3.5 representing middle income, and greater than 3.5 indicating high income. These ranges have been implemented in similar studies and outlined by the federal Supplemental Nutrition Assistance Program (SNAP) as a program eligibility criterion^(4,85). Survey cycles were distinguished by the data collection period (2009-2010, 2011-2012, 2013-2014). Sampling weights were combined to create a new weight variable, adjusted for the number of survey cycle years, as outlined in the NHANES analytic guidelines. We used the SURVEYFREQ procedure with the Rao-Scott modified chi-squared test to assess weighted prevalence estimates of dietary supplement use across survey cycle years. No significant differences were found, and the survey cycle variable was excluded from the final model.

Statistical approach

Descriptive statistics were reported as weighted percentages and unweighted frequencies for all categorical variables. Differences between groups for categorical variables were evaluated by Rao-Scott modified chi-square p-values. We assessed the frequency of responses for each of the eight supplement use reason categories to determine patterns of reasons for supplement use. Multivariate logistic regression was used to model the associations between the type of supplement used (dependent variable) and perceived health status and chronic disease index (independent variables), unadjusted and adjusted for covariates, using forward selection models. Multicollinearity of the independent variables was assessed by examining tolerance and variance inflation factor characteristics in the full model, which included the main outcome, exposures, and covariates. Unadjusted and adjusted odds ratios along with 95% confidence intervals are reported with statistical significance set at the $p < 0.05$ level. All analyses were conducted using SAS version 9.4 (SAS Institute, Cary, NC, USA) incorporating sample weights, primary sampling unit, and strata according to the NHANES Analytical Guidelines,

accounting for differential non-responses and planned oversampling, producing nationally representative estimates of the non-institutionalized U.S. adult population.

Results

We found that 51.9% of the sample reported using dietary supplements over a 30-day period. A total of 14.3% of adults reported using any SCB, and 37.6% reported using only SWB. Table 1 shows the unweighted sample sizes and weighted percentages for the demographic characteristics for non-supplement users, users of SCB, and users of SWB. SCB and SWB users were more likely to be older, White, female, and more educated; have higher income; report excellent or very good general health status; and report a chronic condition than non-supplement users. Adults using SCB were more likely to be younger than 65, identify as non-Hispanic White, and report higher educational attainment and household income compared to adults using SWB.

Our analyses revealed positive associations between perceived general health status and chronic conditions and supplement use (Table 2). Adults who reported excellent or very good health were more likely to report use of SCB (adjusted odds ratio (aOR) 1.48, 95% confidence interval (CI) 1.28-1.74) and SWB (aOR 1.25, 95% CI 1.11-1.41) than adults who reported good health, after adjusting for covariates. Adults who reported any chronic condition were also more likely to report using any supplement. Specifically, the odds of using SCB among adults with 1 to 2 chronic conditions was 1.38 times (95% CI: 1.13-1.69), and among adults with three or more chronic conditions, 1.49 times (95% CI: 1.11-1.99) the odds of using SCB among adults without any chronic conditions. Similarly, the odds of using SWB among adults with 1 to 2 chronic conditions was 1.33 times (95% CI: 1.14-1.55) and among adults with three or more chronic conditions 1.62 times (95% CI: 1.32-2.00) the odds of using SWB among adults without chronic conditions.

The reasons for supplement use are shown in Figures 1 and 2. Reasons related to exercising personal choice, improving general health, and treating specific health conditions were most frequently reported between all supplement users. The most frequently reported reason for those using SCB, regardless of the presence or absence of chronic conditions, was using supplements for “personal choice or influenced by advertisements or word of mouth” (93.3%), followed by “improve general health” (84.2%), and “specific health conditions” (64.7%). SWB users reported doctors’ advice as a reason for supplement use more frequently than SCB users (39.0% vs. 30.4%). Compared to SCB users without chronic conditions, more SCB users with chronic conditions reported using supplements at the advice of a doctor (37.0% vs. 16.1%). Using supplements for “preventative care,” was more frequently cited as a reason among users of SCB compared to those using SWB (64.7% vs. 48.4%).

We subsequently compared reasons for supplement use among adults with and without chronic conditions. Among those using SWB, the most frequently reported reason was to “improve general health” (73.9%), followed by “personal choice or influenced by advertisements or word of mouth” (69.6%), and “specific health conditions” (48.4%). While 69.8% of adults with chronic conditions used SCB for a specific health condition, this reason was reported less frequently (54.9%) among adults who did not have chronic conditions. Further, we found that 37.0% of adults with chronic conditions used SCB at the advice of a doctor, and the frequency of this response was also lower for adults without chronic conditions (16.1%).

Discussion

The prevalence of SCB use was approximately 14.3%, and adults using SCB were more likely to have better self-reported health status. Our findings that supplement users were more likely to be older, white, female, more educated, and wealthy than non-supplement users mirror results described in previous studies^(4,30,63,86,87). Complementary and integrative resources, including SCB, are typically out-of-pocket expenses and are likely more economically accessible for populations with more disposable income, which may account for the higher prevalence of SCB use among higher-income adults in our sample⁽⁸⁸⁾. Our findings also showed a greater likelihood of any supplement use among adults with chronic conditions, with the strongest association between SWB use and adults who reported three or more chronic conditions. This result is consistent with previous research describing supplement use among adults with chronic conditions^(23,30,89) and studies showing a positive association between chronic disease and the use of complementary therapies^(15,18–20,87,90,91).

To our knowledge, this study is the first to compare reasons for supplement use between SCB and SWB users and those with and without chronic conditions, using a nationally representative sample of U.S. non-institutionalized adults. The most frequently reported reasons in our study also ranked high in previous research investigating reasons for any type of dietary supplement use^(60,85,92–96). In the current study, those using SWB frequently cited a desire to improve health as a reason to use supplements, a reason commonly identified in other studies^(63,70,74,97–99). Although a popular reason among both SCB and SWB users, SCB users reported using supplements for “personal choice or influenced by advertisements and word of mouth,” with the greatest frequency, a finding consistent with a frequently cited desire for autonomy in caring for oneself^(38,96,100). This desire for autonomy is also described in previous studies examining reasons for complementary and integrative therapy utilization, including supplement use^(35,101).

Adults who perceived their health as excellent or very good were more likely to report using either SWB or SCB. These results were consistent with those reported by previous studies investigating dietary supplement use, including botanical supplement use specifically, among diverse populations of U.S. adults^(21,23,50–53,102,103). While a significant body of literature examines relationships between self-perceived health and a broad array of complementary and integrative therapies, these studies aggregate supplement use with many other dissimilar approaches and modalities and show poorer perceptions of health among users^(15,37,38,40,43,91,104,105). Perceived health status could potentially motivate the use of complementary and integrative therapies overall, as individuals with poor self-perceived health may struggle to treat their health conditions, reject conventional therapies, or may be unable to afford conventional medical care, continuously searching for alternative therapies to provide them with the relief they seek.

While there may be some merit in the comparisons between the existing body of literature describing self-perceived health and complementary and integrative, it must be noted that these bodies of literature are not exactly comparable due to lack of distinction between SCB and other forms of complementary and integrative therapies. Many studies include all supplements as part of complementary and integrative therapies, finding lower self-perceived health among users^(37–40,106), while few others examine botanical supplement use exclusively and show higher perceptions of health^(21,23,50–53). Despite a larger body of work associating complementary and integrative care approaches with poorer self-perceptions of health, the small number of studies examining botanical supplements specifically show the opposite association, with greater self-perceptions of health among those using botanicals^(21,23,50–53). Poorer self-perceptions of health may be associated with other forms of complementary and integrative therapies besides SCB, given the existing evidence and popularity of supplement use among adults with chronic conditions, demonstrated by our study and several others, associations which may be influenced by disease state^(15,23,107). Our findings further distinguish the association between self-perceived health and use of SCB, separate from other complementary and integrative therapy use, show positive self-perceptions of health among U.S. adult supplement users, and suggest the potential value of differentiating between SCB and other forms of complementary and integrative therapies.

Due to the challenges of comparing the two similar yet disparate bodies of literature, further research should examine the relationship between self-perceived health and botanical supplements distinct from other complementary therapies. Differentiating how self-perceived health differs

depending on the type of complementary and integrative therapy used may be useful for characterizing user groups and valuable for informing public health education efforts.

Limitations & Strengths

Due to the cross-sectional nature of the data, we cannot identify causal relationships between supplement use and general health self-perceptions or chronic conditions, a common limitation cited among previous studies on this topic^(4,85,95,104,106,108). While missingness for our independent variables was 9-12%, participants with missing data for self-perceived health or chronic conditions were less likely to use supplements and more likely to have a lower income and less education and thus were similar to our non-supplement user group. Supplement use is only assessed over a 30-day period in the NHANES interview and may also be subject to reporting bias. Even so, the interview presents a veritable strength, as it is conducted in the participant's home where the interviewer can verify the supplement information. In recent years, the NHANES response rate has declined, potentially resulting in individuals with more interest more likely to participate. A notable strength of our research is the utilization of a large, nationally representative sample of the U.S. population with the incorporating sampling design factors to account for nonresponse and selection bias. These characteristics allow our findings to be generalizable to the general non-institutionalized U.S. population of adults 20 years of age and older.

Conclusion

Our research found a positive association between self-perceived health and the use of supplements, with a stronger association for users of SCB. Given the challenges of isolating the relationship between various specific complementary and integrative therapies and outcomes of interest, future research that examines differences in self-perceived health by therapy type is needed. Our research also adds new information about reasons for supplement use among adults with chronic conditions, which improves the understanding of users' motivations and may be leveraged in both clinical and public health efforts targeted to distinct groups of supplement users.

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Table 1. Demographics and characteristics: weighted frequencies and percentages for variables under consideration stratified by dietary supplement use among U.S. adults from the National Health and Nutrition Examination Survey cycles 2009-2014 (n=16,958)

	Non-supplement users		Users of supplements that contains botanicals		Users of supplements that do not contain botanicals		X ² p-value ^c
	(n=8,696)		(n=2,092)		(n=6,170)		
Characteristics ^a	<i>n</i>	(%) ^b	<i>n</i>	(%) ^b	<i>n</i>	(%) ^b	
Sex							<0.0001
Male	4710	54.5	931	44.2	2569	41.3	
Female	3986	45.5	1161	55.8	3601	58.7	
Age (years)							<0.0001
20-24	1068	13.5	124	6.4	356	6.3	
25-34	1782	22.3	281	14.3	749	13.6	
35-44	1723	21.5	325	15.8	915	15.7	
45-54	1555	19.0	391	21.4	955	18	
55-64	1252	13.0	428	20.9	1166	20.3	
65+	1316	10.8	543	21.2	2029	26.1	
Race-Ethnicity							<0.0001
Mexican American	1495	11.8	229	5.3	646	5.5	
Other Hispanic	925	7.1	204	4.8	517	4.3	
Non-Hispanic White	3202	59.2	1082	76.2	2969	72.7	
Non-Hispanic Black	2098	14.2	319	6.6	1229	9.7	
Other race/multi-racial	976	7.7	258	7.1	809	7.8	
Educational Attainment ^d							<0.0001
Less than high school	2625	22.2	284	8.5	1282	13.5	
High school graduate / GED or equivalent	2086	23.8	383	17.6	1290	20.3	
Greater than high school	3972	54.0	1424	73.9	3588	66.2	
Income [§]							<0.0001
Low-income	3314	31.2	447	13.7	1654	19.1	
Middle-income	2776	36.8	670	31.8	2013	34	
High-income	1796	32.0	856	54.5	1962	46.9	
Perceived health status							<0.0001
Excellent or v Very g Good	2484	38.4	868	52.5	2069	44.9	
Good	3142	41.6	755	35	2198	37.7	
Fair or p Poor	2021	20.0	328	12.4	1306	17.4	
Chronic Disease Index [‡]							<0.0001
No chronic conditions	2629	38.5	458	25.2	1205	23.2	
1-2 chronic conditions	2858	40.2	870	46	2223	41.9	
3+ chronic conditions	1747	21.3	586	28.8	2191	34.9	

Table 1 (continued)

^aN missing for characteristics (not included in calculations): perceived health status (n=1,787), income (n=1,470), education (n=23), chronic disease index (n=2,191)

^bColumn percentages for variables will not add to 100 due to rounding. Percentages are weighted, sample sizes are unweighted.

^cP-value for chi-square test of independence between supplement use/non-use and each exposure and covariate.

[§]Poverty Income Ratio recoded as low (0-1.30), middle (1.31-3.5), and high (>3.5) income

[‡]Self report of chronic diseases coded into an index of three categories including asthma, psoriasis, celiac disease, arthritis, gout, coronary heart disease, congestive heart failure, stroke, heart attack, angina, emphysema, thyroid problems, bronchitis, liver conditions, cancer, diabetes, hypertension or high cholesterol.

Table 2: Odds of supplement use among SCB users and SWB users (versus non-supplement users) by self-reported perceived health status and chronic disease status among U.S. adults from the NHANES cycles 2009-2014 (n=12,272)

Characteristic	SCB Users		SWB Users	
	Crude	Adjusted ^a	Crude	Adjusted ^a
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
<i>Perceived Health</i>				
Excellent or Very Good	1.63 (1.41-1.88)	1.48 (1.25-1.74)***	1.29 (1.15-1.46)	1.25 (1.11-1.41)***
Good [†]	1	1	1	1
Fair or Poor	0.74 (0.61-0.90)	0.88 (0.69-1.14)	0.96 (0.84-1.10)	0.97 (0.80-1.16)
<i>Chronic Disease</i>				
3+	2.06 (1.64-2.59)	1.49 (1.11-1.99)**	2.71 (2.28-3.23)	1.62 (1.32-2.00)***
1-2	1.74 (1.44-2.12)	1.38 (1.13-1.69)**	1.72 (1.47-2.02)	1.33 (1.14-1.55)***
None [†]	1	1	1	1

Abbreviations: SCB, supplements containing botanicals; SWB, supplements without botanicals; NHANES, National Health and Nutrition Examination Survey; CI, confidence interval; OR, odds ratio.

*p<0.05. **p<0.01. ***p<0.001

^aResults from logistic regression adjusted for sex, age, education, race/ethnicity, household income, perceived health and diagnosis of chronic diseases

[†] Reference group

Table 3. Demographics and characteristics: frequencies and percentages for variables under consideration stratified by perceived general health respondents and perceived general health non-respondents among U.S. adults from the National Health and Nutrition Examination Survey cycles 2009-2014

	All (n=16958)		Perceived General Health Non- respondents (n=1787) ^a		Perceived General Health Respondents (n=15171) ^a		X ² p-value ^c
	<i>n</i>	(%) ^b	<i>n</i>	(%) ^b	<i>n</i>	(%) ^b	
<i>Dietary Supplement Use</i>							<0.0001
No supplement use	6170	37.6	1049	56.4	7647	47.3	
Botanical supplement use	2092	14.3	141	9.8	1951	14.8	
Non-botanical supplement use	8696	48.1	597	33.8	5573	38.0	
<i>Sex</i>							<0.0001
Male	8210	48.1	719	38.8	7491	49.0	
Female	8748	51.9	1068	61.2	7680	50.1	
<i>Age</i>							<0.0001
20-24	1548	9.7	145	8.4	1403	9.9	
25-34	2812	17.9	347	21.7	2465	17.5	
35-44	2963	18.5	451	27.7	2512	17.6	
45-54	2901	19.0	307	17.2	2594	19.2	
55-64	2846	16.8	238	12.8	2608	17.2	
65+	3888	18.0	299	12.2	3589	18.6	
<i>Race</i>							<0.0001
Mexican American	2370	8.5	267	10.5	2103	8.3	
Other Hispanic	1646	5.7	168	7.0	1478	5.6	
Non-Hispanic White	7253	66.7	589	54.3	6664	68.0	
Non-Hispanic Black	3646	11.4	429	15.6	3217	11.0	
Other race/multi-racial	2043	7.6	334	12.7	1709	7.1	
<i>PIR</i> (n=15488) (n=1529) (n=13959)							<0.0001
0-1.3	5415	24.1	676	33.8	4739	23.2	
1.31-3.5	5459	35.0	481	32.1	4978	35.3	
>3.5	4614	40.9	372	34.0	4242	41.6	
<i>Chronic Disease Index[‡]</i> (n=14767) (n=1493) (n=13274)							<0.0001
No chronic conditions	4292	30.6	567	40.1	3725	29.7	
1-2 chronic conditions	5951	41.7	604	41.2	5347	41.8	
3+ chronic conditions	4524	27.7	322	18.7	4202	28.6	
<i>Household Education Level</i> (n=16935) (n=1782) (n=15153)							<0.0001
Less than high school	4191	17.0	557	23.2	3634	16.4	
High school graduate / GED or equivalent	3759	21.6	374	20.5	3385	21.7	
Greater than high school	8985	61.4	851	56.3	8134	61.9	

Table 3 (continued)

^a Sample sizes with missing observations will be listed above the counts for each respective group

^b Column percentages for variables will not add to 100 due to rounding

^c P-value for chi-square test of independence between respondents and non-respondents for each exposure and covariate.

[†] Self report of chronic diseases coded into an index of three categories

Table 4. Demographics and characteristics: frequencies and percentages stratified by chronic disease respondents and chronic disease non-respondents among U.S. adults from the National Health and Nutrition Examination Survey cycles 2009-2014 (n=16,958)

	All (n=16958)		Chronic Disease ^a Non-respondents (n=2,191) ^b		Chronic Disease ^a Respondents (n=14,767) ^b		X ²
	n	(%) ^c	n	(%) ^c	n	(%) ^c	p-value ^d
<i>Dietary Supplement Use</i>							<0.0001
No supplement use	8696	48.1	1462	64.0	7234	46.2	
Botanical supplement use	2092	14.3	178	9.5	1914	14.9	
Non-botanical supplement use	6170	37.6	551	26.5	5619	38.9	
<i>Perceived General Health Status</i>							
Excellent or Very Good	5421	43.0	594	39.0	4827	43.4	
Good	6095	39.1	757	40.0	5338	39.0	
Fair or Poor	3655	17.9	546	21.1	3109	17.5	
<i>Sex</i>							
Male	8210	48.1	1149	51.6	7061	47.6	
Female	8748	51.9	1042	48.4	7706	46.6	
<i>Age</i>							<0.0001
20-24	1548	9.7	392	19.8	1156	8.5	
25-34	2812	17.9	552	29.5	2260	16.5	
35-44	2963	18.5	412	18.9	2551	18.5	
45-54	2901	19.0	308	13.9	2593	19.6	
55-64	2846	16.8	231	8.2	2615	17.9	
65+	3888	18.0	296	9.7	3592	19.0	
<i>Race</i>							0.0002
Mexican American	2370	8.5	551	14.8	1819	7.7	
Other Hispanic	1646	5.7	264	7.7	1382	5.5	
Non-Hispanic White	7253	66.7	843	56.6	6410	68.0	
Non-Hispanic Black	3646	11.4	379	12.8	3267	11.3	
Other race/multi-racial	2043	7.6	154	8.1	1889	7.6	
<i>PIR</i>							
	(n=15488)		(n=1920)		(n=13568)		
0-1.3	5415	24.1	913	34.5	4502	22.8	
1.31-3.5	5459	35.0	704	39.8	4755	34.4	
>3.5	4614	40.9	303	25.7	4311	38.2	
<i>Household Education Level</i>							<0.0001
	(n=16935)		(n=2182)		(n=14753)		
Less than high school	4191	17.0	818	27.3	3373	15.7	
High school graduate / GED or equivalent	3759	21.6	565	26.6	3194	21.0	
Greater than high school	8985	61.4	799	46.1	8186	63.3	

Table 4 (continued)

PIR = Poverty Income Ratio

^a Self-report of chronic diseases coded into an index of three categories

^b Sample sizes with missing observations will be listed above the counts for each respective group

^c Column percentages for variables will not add to 100 due to rounding

Table 5: Original variables for supplement use reasons as described in NHANES cycles 2009-2014, recategorized into seven distinct reasons categories.

<i>Specific Health Conditions</i>	For good bowel/colon health, for prostate health, for mental health, for teeth/prevent cavities, for heart health/cholesterol, for eye health, for healthy joints/arthritis, for skin health/dry skin/hair and nails, for bone health, for pregnancy/breastfeeding, for anemia/low iron, to maintain blood sugar/diabetes, for kidney and bladder health, for respiratory health/asthma, for allergies, for menopause/hot flashes, for muscle related uses, for relaxation/stress/sleep, for nervous system health, for liver health/detoxification, for thyroid health/gout, for support after surgery, headaches and dizziness.
<i>Preventative Care</i>	To prevent health problems, to prevent colds, boost the immune system.
<i>Improve General Health</i>	To improve my overall health, to get more energy, improve digestion, low levels in blood, to supplement my diet/food not enough.
<i>Maintain General Health</i>	To maintain health (to stay healthy).
<i>Weight Loss/Gain</i>	For weight loss, to build muscle, weight gain.

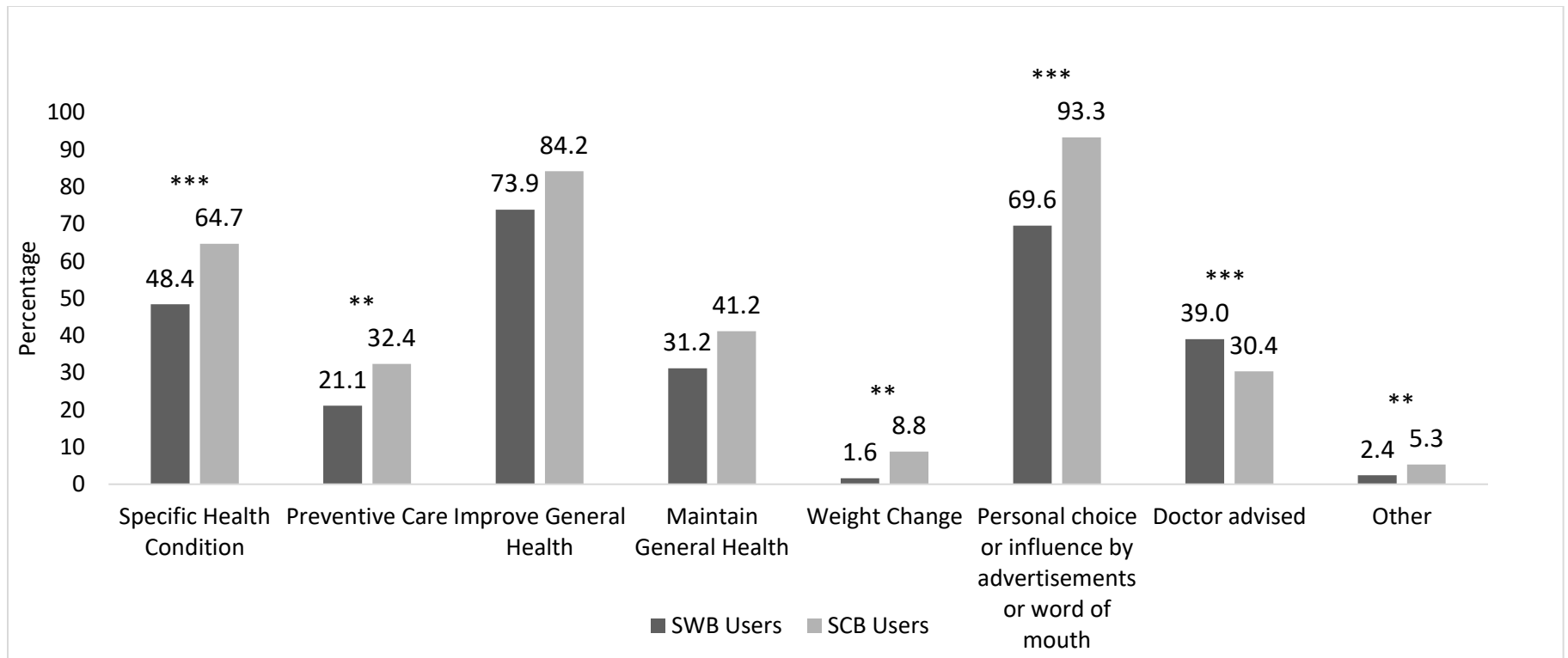


Figure 1 – Reasons for supplement use among supplement containing botanical (SCB) users and supplement without botanicals (SWB) users

P-value for chi-square tests of independence between SCB and SWB user groups: ** $p < 0.01$, *** $p < 0.001$

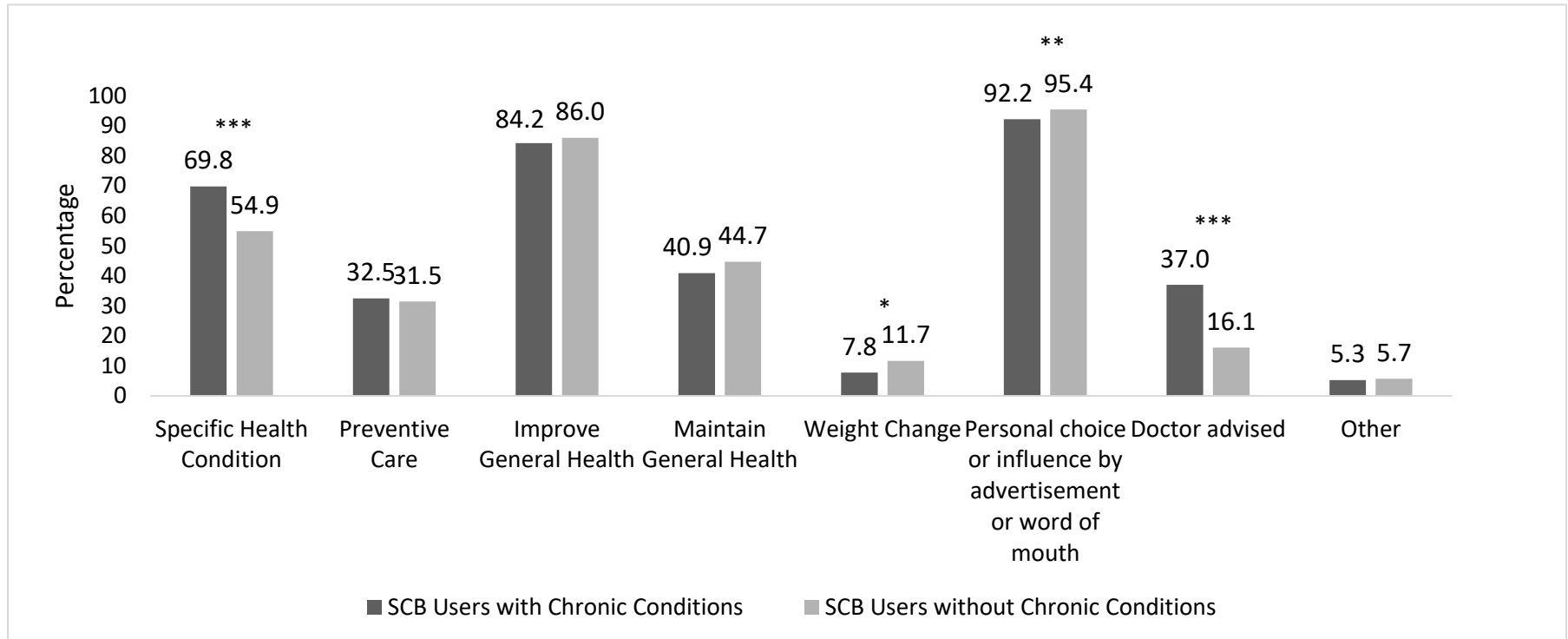


Figure 2 – Reasons for use of supplements containing botanicals (SCB) among users with and without chronic conditions
P-value for chi-square test of independence between SCB users with and without chronic conditions. * $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$

General Conclusion

For people with chronic conditions, botanical supplement use presents potential risks due to largely unexplored metabolic interactions with other supplements, drugs, and foods⁽³⁵⁾. A significant body of research describes botanical supplement use among various subpopulations of users. However, we were unable to locate studies using nationally representative data to define self-perceived health and reasons for botanical supplement use among U.S. adults with chronic conditions. This includes research comparing reasons for botanical supplement use between users with and without chronic conditions. Herbal and botanical supplement use, when examined separately from other CIT, have been positively associated with self-perceived health among U.S. adults^(14–17,38,39,57). Yet, when botanical supplement use and self-perceived health are examined along with other complementary and integrative modalities, associations linking self-perceived health to the use of CIT become convoluted, with disparate results across study populations^(6,28,34,39,70,72,74,84–87,98,99). Past research describing reasons for supplement use has included overall dietary supplement users and to a lesser extent, botanical supplement users with chronic conditions. Often, reasons for botanical use are not distinguished from reasons for any dietary supplement use. These gaps, along with the relative dearth of literature describing self-perceived health among representative samples of botanical supplement users inspired our intentions behind this research. In addition to (1) summarizing existing knowledge in the area of botanical supplement use among U.S. adults, this research aimed to (2) characterize those who use SCB compared to SWB, and (3) determine the direction of the association between self-perceived health status and use of SCB in our study population. The last two aims focused on (4) determining and comparing reasons for use among SCB and SWB users as well as (5) reasons among SCB users with and without chronic conditions.

The resulting outcomes of this analysis identified more positive perceptions of health among adults using SCB. These individuals were also more likely to have a chronic condition and more likely to report taking SCB for exerting personal choice, treating specific health conditions, and improving health. Our findings for the association between self-perceived health and SCB use mirror previous research but conflict with our initial hypothesis, that those with poorer perceptions of health would be more likely to use SCB, informed by previous

characterizations of younger botanical users and users with chronic conditions, described by previous research^(14,28).

Additionally, we found a greater frequency of reasons related to exerting personal choice, improving health, and addressing specific health conditions among both SCB and SWB users. We predicted that SCB users would be more likely to report using supplements for specific health conditions, preventative care, or general health maintenance compared to people who use SWB, a hypothesis informed by the popularity of using botanical supplements for specific health conditions, preventing specific conditions^(15,22,43,47,52,93) or maintaining health^(22,40–43,53). Our hypothesis for reasons among SCB users with chronic disease drew from previous research among botanical users with chronic conditions^(21,50,55). Although absent from our initial hypotheses, SCB users with chronic conditions reported using supplements for personal reasons, indicating a level of self-autonomy in health management, reflecting health management theories and previous research describing motivations for CIT use^(84,94,163,164,185).

Limitations

Due to the cross-sectional design of the dataset, this research does not prove causality and limits our ability to assess relationships between self-perceived health and supplement use. Longitudinal parallel design studies are needed to tease apart the interplay between these variables and determine whether self-perceptions of health were already more positive prior to SCB use, or if self-perceived health increased after SCB use began. Our dataset exhibited significant missingness for our main exposures, self-perceived health, and chronic conditions, weakening the generalizability of our findings. We acknowledge that these findings must be interpreted with caution. We addressed missingness in our dataset by comparing those with missing data for self-perceived health and chronic conditions to those without missing data to identify differences between respondents and non-respondents as well as inform future methodology using multiple imputation. For future research, this challenge would be feasibly addressed using multiple imputation to replace missing values with values from respondents with similar characteristics, identified in our comparison of responders and non-responders for self-perceived health and chronic conditions (see Tables 3 and 4).

Future Directions

Results from this study's literature review describe an overall lack of documentation and significant supplement use nondisclosure between U.S. adults with chronic conditions and their primary care providers. Although this topic extends beyond the scope of this research, the frequency of the reason "doctor advised," reported among our sample of adults with chronic conditions reporting SCB use indicates the likelihood that conversations about supplement use are happening between doctors and their patients, and non-disclosure may be more closely related to lack of documentation rather than a lack of discussion. Future research on the nature of conversations occurring during primary care visits may be an insightful avenue for exploring the root of nondisclosure rates, a crucial aspect of safe supplement use for vulnerable groups. Furthermore, the notable popularity of using any botanical supplement for reasons related to personal choice, influence by advertisements or word of mouth among adults with chronic conditions supports deeper exploration into the connections between health-management behaviors and autonomy among adults with chronic conditions.

Broader Impacts

In conclusion, our findings may contribute to future public health education efforts by describing those who are more likely to use botanicals, especially those with chronic conditions. Also, our findings contribute new information to the body of literature describing reasons for botanical supplement use among representative samples of U.S. adults with chronic conditions. Since our study clearly differentiates reasons for supplement use between SCB and SWB users, and between SCB use among those with and without chronic conditions, our findings support future comparisons of SCB and SWB user groups, and further exploration of the motivations behind SCB use among users with and without chronic conditions. Because our study investigates reasons for use and characteristics associated with SCB use among adults with chronic conditions, our findings contribute to further differentiation between SCB use and other forms of CIT. While this research focuses specifically on self-perceived health and reasons for supplement use, our findings may inform the broader genre of public health research, from informing research investigating the impacts of health-beliefs and health behaviors on healthcare utilization to improving educational interventions promoting safe supplement use.

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