# Analysis of Risk and Protective Factors for Arthritis Status and Severity Using Survey Data

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**Abstract:** This study looked at how cigarette smoking, alcohol consumption, obesity, and physical activity are associated with the prevalence and severity of arthritis among adults living in Delaware, U.S. through the analysis of survey data. We examined data from the 2009 Delaware Behavioral Risk Factor Surveillance System (BRFSS). Weighted percentages were calculated for the arthritis-related factors above by arthritis status and activity limitation due to arthritis/joint symptoms, and were analyzed using the Rao-Scott $\chi^2$ test. A multiple logistic regression analysis was performed to determine an odds ratio (OR) while adjusting for gender, age, race/ethnicity, and education. Adult Delawareans self-reporting arthritis were more likely to be former and current smokers than those without self-reported arthritis ($p < 0.001$; OR = 1.58 for former smokers vs. non-smokers; OR = 1.52 for current smokers vs. non-smokers). Moderate and heavy alcohol consumption was associated with lower severity of arthritis ($p < 0.001$; OR = 0.66 for moderate drinking vs. no drinking; OR = 0.50 for heavy drinking vs. no drinking). There was a significant relationship of obesity to both arthritis status ($p < 0.001$; OR = 2.13 for obesity vs. not overweight/obesity) and severity ($p < 0.008$; OR = 1.67 for obesity vs. not overweight/obesity). Furthermore, people having arthritis-related activity limitation were more likely to not meet the current physical activity recommendations ($p = 0.013$; OR = 1.46). It appears that smoking and obesity have a negative impact on the risk and severity of arthritis, whereas alcohol consumption and physical activity may be protective against arthritis. A proper analysis of survey data is essential to truly understand how human behavior impacts people's health.

**Keywords:** Rao-Scott $\chi^2$ test, logistic regression, Behavioral Risk Factor Surveillance System, cigarette smoking, alcohol consumption, obesity, physical activity, odds ratio.

## INTRODUCTION

Arthritis has become a significant public health issue [1]. Currently in the U.S., 22.2% (49.9 million) of adults are estimated to have doctor-diagnosed arthritis, and 42.4% (21.1 million) of those with arthritis have arthritis-attributable activity limitation [2]. It is projected that by 2030, 25% (67 million) and 9.3% (25 million) of all American adults will be diagnosed as arthritis and will have arthritis-attributable activity limitation, respectively [3]. Data show that arthritis was a leading cause of disability among American adults in 2005 [4]. A total cost associated with arthritis and other rheumatic conditions in the U.S. in 2003 was calculated to be $128 billion, including $80.8 billion as a direct cost and another $47.0 billion as an indirect cost [5].

According to research [6-9], there are several risk and protective factors for arthritis. Specifically, it has been suggested that cigarette smoking and obesity can increase the risk of arthritis [6, 7], whereas alcohol consumption and moderate physical activity may protect against developing arthritis [8, 9]. Meanwhile, people engage in multiple behaviors in diverse environments, therefore it is of particular interest to understand how arthritis-related behaviors interact to increase/decrease the risk of arthritis among people in a community. For this aim, we believe that it is important to address issues from a population perspective, and that survey research is especially useful as it enables investigators to identify various behaviors associated with a particular health condition and to generalize results from a sample to a population. On the other hand, surveys generally involve complex sampling method and weighting scheme, which must be taken into account when analyzing survey data. Here, it is our intent to understand risk and protective factors for arthritis, while sharing the process and results of analyzing large-scale survey data. In this study, we examined how cigarette smoking, alcohol consumption, obesity, and physical activity are associated with the prevalence and severity of arthritis, using survey data collected from adults living in Delaware, U.S. through the Behavioral Risk Factor Surveillance System (BRFSS).

## METHODS

### Survey Data

The current study analyzed data from the 2009 Delaware BRFSS. Details of the BRFSS are described

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on the BRFSS website [10]. The BRFSS is a random telephone survey for collecting information on self-reported health behaviors and conditions of non-institutionalized American adults aged 18 years or older. The Centers for Disease Control and Prevention (CDC) administers the BRFSS, while the actual survey is conducted by state health departments nationwide each year.

The BRFSS is a large probability sample of the community and incorporates random-digit dialing and specific weighting methodology to ensure that BRFSS data represent a state population. The 2009 BRFSS data were weighted using "a statistical method called post stratification" that is a weighting methodology based on "known proportions of age, race and ethnicity, sex, geographic region within a population" [11]. According to the 2009 BRFSS Overview [12], a general weighting formula was as follows:

FINALWT = STRWT × 1 OVER NPH × NAD × POSTSTRAT

where:

- FINALWT is final weight assigned to each respondent.
- STRWT accounts for differences in the basic probability of selection among strata (subsets of area code/prefix combinations). It is the inverse of the sampling fraction of each stratum. There is seldom a complete correspondence between strata, which are defined by subsets of area code/prefix combinations, and regions, which are defined by the boundaries of government entities.
- 1/NPH is the inverse of the number of residential telephone numbers in the respondent's household.
- NAD is the number of adults in the respondent's household.
- POSTSTRAT is the number of people in an age-by-sex or age-by-race/ethnicity-by-sex category in the population of a region or a state divided by the sum of the preceding weights for the respondents in the same age-by-sex or age-by-race/ethnicity-by-sex category. It adjusts for noncoverage and nonresponse and forces the sum of the weighted frequencies to equal population estimates for the region or state.

**Arthritis Status and Severity**

Arthritis status among people was assessed based on whether or not they had ever been diagnosed as having some form of arthritis, rheumatoid arthritis, gout, lupus, or fibromyalgia by a doctor or other health professional. Responses to the question were coded as "1" (yes) or "0" (no). Those who said yes to the question above were further asked whether or not they had any activity limitations because of arthritis or joint symptoms. Responses to the question were again coded as "1" (yes) or "0" (no).

**Smoking Status**

Respondents were classified and coded by the following smoking status: "0" (non-smoker) for those who have never smoked at least 100 cigarettes in their entire life, "1" (former smoker) for those who have smoked at least 100 cigarettes in their entire life but do not smoke at all at the time of the survey, and "2" (current smoker) for those who have smoked at least 100 cigarettes in their entire life and smoke cigarettes every day or some days at the time of the survey.

**Alcohol Consumption**

Alcohol consumption among people was assessed and coded as follows: "0" (no drinking) if an individual had no alcohol drink in the past 30 days at the time of the survey, "1" (moderate drinking) if a man had up to 2 drinks per day and a woman had up to 1 drink per day during the past 30 days [13], and "2" (heavy drinking) if a man had more than 2 drinks per day and a women had more than 1 drink per day during the past 30 days [14].

**Weight Status**

Body mass index [BMI; BMI ($kg/m^2$) = weight (kg) / height $(m)^2$] was used to categorize respondents regarding their weight status. The BMI criteria and coding scheme used here are: "0" (not overweight/obese) if BMI < 25.0 $kg/m^2$, "1" (overweight) if BMI = 25.0–29.9 $kg/m^2$, and "2" (obese) if BMI ≥ 30.0 $kg/m^2$ [15].

**Physical Activity Level**

Respondents were classified based on whether or not they met the following physical activity recommendations at the time of the survey: moderate physical activity for 30 or more minutes per day on five or more days per week, or vigorous physical activity for

20 or more minutes per day on three or more days per week [16]. Responses to the question were coded as "1" (yes) or "0" (no).

### Data Analysis

SAS 9.2 (SAS Institute Inc., Cary, NC, U.S.) was used for the data analysis. All non-response or missing cases were coded as missing values. Percentages adjusted for sampling weights used in the BRFSS (= weighted percentages) were calculated for smoking status, alcohol consumption, weight status, and physical activity level, along with selected sociodemographic variables (gender, age, race/ethnicity, and education), by arthritis status and severity. These sociodemographic variables were selected, since higher age, female gender, certain genes, and lower levels of education are known to be associated with arthritis [1]. We also included employment status as another sociodemographic variable, in that arthritis especially in early stages could greatly impact employment status [17]. The weighted percentages were then compared using the Rao-Scott $\chi^2$ test. A multiple logistic regression analysis was performed to determine an odds ratio (OR) and 95% confidence interval (CI) for smoking status, alcohol consumption, weight status, and physical activity level by arthritis status and severity, while using sociodemographic variables as covariates. In addition, a statistical interaction was examined between each risk/protective factor for arthritis above and age because of the substantial differences in the prevalence of arthritis and arthritis-related activity limitation by age in the general population (e.g., arthritis prevalence was 7.6% for people aged 18–44 years,

**Table 1: Sociodemographic Characteristics by Arthritis Status and Severity**

| | Arthritis status (*N* = 3,969) | | | Activity limitation due to arthritis/joint symptoms (*N* = 1,512) | | |
|---|---|---|---|---|---|---|
| | Yes | No | | Yes | No | |
| Characteristic | 27.5 (0.9) | 72.5 (0.9) | *p*-value[a] | 39.1 (1.7) | 60.9 (1.7) | *p*-value[a] |
| Gender | | | < 0.001 | | | 0.112 |
| Male | 40.9 (1.8) | 50.5 (1.5) | | 37.3 (2.6) | 43.0 (2.4) | |
| Female | 59.1 (1.8) | 49.5 (1.5) | | 62.7 (2.6) | 57.0 (2.4) | |
| Age | | | < 0.001 | | | 0.795 |
| 18-29 years | 4.7 (1.4) | 25.8 (1.7) | | 3.6 (1.4) | 5.5 (2.1) | |
| 30-39 years | 6.9 (1.0) | 19.9 (1.2) | | 7.7 (1.6) | 6.5 (1.2) | |
| 40-49 years | 17.7 (1.5) | 22.2 (1.2) | | 19.3 (2.2) | 16.6 (2.0) | |
| 50-59 years | 21.3 (1.5) | 14.1 (0.9) | | 20.6 (2.2) | 21.7 (2.0) | |
| 60-69 years | 24.4 (1.4) | 10.1 (0.7) | | 24.6 (2.1) | 24.3 (1.8) | |
| ≥ 70 years | 25.0 (1.3) | 7.9 (0.5) | | 24.2 (2.0) | 25.4 (1.8) | |
| Race/ethnicity | | | 0.004 | | | 0.192 |
| White | 80.7 (1.5) | 74.3 (1.4) | | 78.2 (2.3) | 82.3 (2.1) | |
| Black | 12.9 (1.3) | 13.7 (1.1) | | 14.1 (2.0) | 12.1 (1.8) | |
| Hispanic | 2.7 (0.7) | 4.6 (0.8) | | 2.3 (0.8) | 3.0 (1.1) | |
| Other | 3.7 (0.7) | 7.4 (0.9) | | 5.4 (1.3) | 2.6 (0.8) | |
| Education | | | < 0.001 | | | 0.180 |
| Did not graduate from high school | 9.3 (1.0) | 6.3 (0.8) | | 12.1 (1.7) | 7.6 (1.3) | |
| Graduated from high school | 32.1 (1.6) | 26.8 (1.4) | | 31.5 (2.5) | 32.6 (2.2) | |
| Attended college/technical school | 25.8 (1.6) | 24.3 (1.3) | | 24.5 (2.2) | 26.7 (2.2) | |
| Graduated from college/technical school | 32.8 (1.7) | 42.6 (1.5) | | 31.9 (2.4) | 33.1 (2.2) | |
| Employment status | | | < 0.001 | | | < 0.001 |
| Employed | 43.9 (1.8) | 68.9 (1.4) | | 36.2 (2.6) | 48.8 (2.4) | |
| Unemployed | 12.7 (1.3) | 7.9 (0.8) | | 19.6 (2.3) | 8.4 (1.6) | |
| Homemaker/student | 5.2 (0.7) | 10.2 (1.2) | | 4.5 (1.1) | 5.7 (0.9) | |
| Retired | 38.2 (1.6) | 13.0 (0.7) | | 39.7 (2.5) | 37.1 (2.1) | |

Notes: Values given as % (SE).
[a]Rao-Scott $\chi^2$ test.

29.8% for people aged 45–64 years, and 50.0% for people aged ≥ 65 years in the U.S., 2007–2009) [2]. In case of a significant interaction, we performed follow-up logistic regression analyses based on different age groups.

## RESULTS

### Sociodemographics

A total of 4,361 adults responded to the survey. Table **1** shows sociodemographic characteristics of the respondents by arthritis status and severity. Overall, 27.5% of the survey respondents reported that they had doctor-diagnosed arthritis. Of those, 39.1% indicated that they had activity limitation due to arthritis/joint symptoms. Variables shown to be statistically significant ($p < 0.05$ by Rao-Scott $\chi^2$ test) to arthritis status were: gender, age, race/ethnicity, education, and employment status. On the other hand, only employment status was significant to activity limitation due to arthritis/joint symptoms.

### Smoking Status on Arthritis Status and Severity

Smoking was significantly associated with arthritis status ($p < 0.001$ by Rao-Scott $\chi^2$ test; Table **2**). The logistic regression analysis revealed that people with arthritis were more likely to be former smokers (OR = 1.58, 95% CI = 1.25–1.98; reference category = non-smoker) and current smokers (OR = 1.52, 95% CI = 1.12–2.06; reference category = non-smoker) than those without arthritis. Smoking was not a significant variable for arthritis severity.

### Alcohol Consumption on Arthritis Status and Severity

A significant association was observed between alcohol consumption and arthritis status or severity ($p < 0.001$ by Rao-Scott $\chi^2$ test; Table **2**). According to the logistic regression analysis, there was a tendency that the odds of having arthritis for people who consumed alcohol moderately (OR = 0.78, 95% CI = 0.61–1.01; reference category = no drinking) or heavily (OR = 0.79, 95% CI = 0.59–1.05; reference category = no drinking) was less than the odds for those not consuming alcohol. Moreover, the odds of having activity limitation due to arthritis/joint symptoms for people reporting moderate alcohol consumption (OR = 0.66, 95% CI = 0.46–0.96; reference category = no drinking) or heavy alcohol consumption (OR = 0.50, 95% CI = 0.32–0.77; reference category = no drinking) was significantly less than the odds for those not consuming alcohol.

### Weight Status on Arthritis Status and Severity

BMI was significant to both arthritis status and severity ($p < 0.01$ by Rao-Scott $\chi^2$ test; Table **2**). The results of the logistic regression analysis showed that people with arthritis were about one and a half times as likely to be overweight (OR = 1.43, 95% CI = 1.10–1.86; reference category = not overweight/obese) and twice as likely to be obese (OR = 2.13, 95% CI = 1.60–2.82; reference category = not overweight/obese) as those without arthritis. Furthermore, people having arthritis-related activity limitation were more likely to be overweight (OR = 1.50, 95% CI = 1.01–2.24; reference category = not overweight/obese) and obese (OR = 1.67, 95% CI = 1.13–2.46; reference category = not overweight/obese) than their counterparts.

### Physical Activity Level on Arthritis Status and Severity

The proportion of people who met the physical activity recommendations was significantly lower among the respondents with arthritis and among those with activity limitation due to arthritis/joint symptoms than their counterparts ($p < 0.05$ by Rao-Scott $\chi^2$ test; Table **2**). However, the logistic regression analysis indicated that physical activity level was not a significant predictor of arthritis status after adjusting for the sociodemographic variables as well as smoking status, alcohol consumption, and weight status. In contrast, people with arthritis-related activity limitation were about 1.5 times more likely to not meet the physical activity recommendations (OR = 1.46, 95% CI = 1.07–2.00; reference category = meet recommended physical activity) than those without such limitation even after adjusting for the covariates above. Because the results of the Rao-Scott $\chi^2$ test and logistic regression analysis were not consistent, we further performed a moderator analysis [18, 19] by examining interactions between physical activity level and the other three risk and protective factors. There were no significant interactions between physical activity level and smoking status, alcohol consumption, or weight status, indicating that moderation effects of these three factors on physical activity level were unlikely.

### Interactions between Risk/Protective Factors and Age

There was a significant interaction between smoking status and age in terms of arthritis status (=

**Table 2: Risk and Protective Factors by Arthritis Status and Severity**

| | Arthritis status (*N* = 3,969) | | | Activity limitation due to arthritis/joint symptoms (*N* = 1,512) | | |
|---|---|---|---|---|---|---|
| | Yes | No | | Yes | No | |
| Potential risk/protective factor | 27.5 (0.9) | 72.5 (0.9) | *p*-value[a] | 39.1 (1.7) | 60.9 (1.7) | *p*-value[a] |
| Smoking status | | | < 0.001 | | | 0.382 |
| Non-smoker | 42.1 (1.8) | 57.7 (1.5) | | 40.6 (2.6) | 43.0 (2.4) | |
| Former smoker | 39.3 (1.7) | 24.1 (1.2) | | 38.4 (2.6) | 39.9 (2.3) | |
| Current smoker | 18.6 (1.4) | 18.2 (1.2) | | 21.0 (2.2) | 17.1 (1.9) | |
| Alcohol consumption | | | < 0.001 | | | < 0.001 |
| No drinking | 52.4 (1.8) | 38.8 (1.5) | | 61.8 (2.6) | 46.5 (2.4) | |
| Moderate drinking | 27.2 (1.6) | 34.3 (1.5) | | 24.9 (2.3) | 28.5 (2.2) | |
| Heavy drinking | 20.4 (1.6) | 26.9 (1.4) | | 13.3 (1.8) | 25.0 (2.2) | |
| Weight status (body mass index[b]) | | | < 0.001 | | | 0.008 |
| Not overweight/obese | 26.3 (1.6) | 41.0 (1.6) | | 21.0 (2.2) | 29.7 (2.3) | |
| Overweight | 36.3 (1.7) | 35.3 (1.5) | | 36.0 (2.6) | 36.5 (2.3) | |
| Obese | 37.4 (1.8) | 23.7 (1.2) | | 43.0 (2.6) | 33.8 (2.4) | |
| Recommended physical activity[c] | | | < 0.001 | | | 0.013 |
| Yes | 43.7 (1.8) | 53.7 (1.6) | | 38.2 (2.7) | 47.3 (2.5) | |
| No | 56.3 (1.8) | 46.3 (1.6) | | 61.8 (2.7) | 52.7 (2.5) | |

Notes: Values given as % (SE).
[a]Rao-Scott $\chi^2$ test.
[b]Not overweight/obese: < 25.0 kg/m$^2$, Overweight: 25.0–29.9 kg/m$^2$, Obese: ≥ 30 kg/m$^2$.
[c]Moderate physical activity for ≥ 30 minutes/day on ≥ 5 days/week, or vigorous physical activity for ≥ 20 minutes/day on ≥ 3 days/week [16].

outcome). A notable difference between the overall results and those of the follow-up analyses by different age groups was that smoking was not significantly associated with increased odds of having arthritis among people aged 18–29 years as well as among those aged 60 years and older. No significant interactions were observed between the other risk/protective factors and age.

Regarding arthritis severity (= outcome), we found a significant interaction between each risk/protective factor and age. The follow-up logistic regression analyses revealed that smoking status, alcohol consumption, weight status, and physical activity level were not significant to the regression model for the groups of people at ages ranging from 18 to 49 years. Meanwhile, these risk and protective factors were significant to predicting arthritis severity among people aged 50 years and older, which was consistent with the overall results.

## DISCUSSION

According to the results of our data analysis, arthritis is more common among current and former smokers in adult Delawareans. In addition, people with arthritis and those having activity limitation due to arthritis/joint symptoms are less likely to consume alcohol compared with their counterparts. Obesity is associated with arthritis status and severity. These findings are still statistically significant after adjusting for common sociodemographic variables and other risk and protective factors of arthritis. People with arthritis are less likely to meet the current physical activity recommendations, however the results are not significant if the covariates above are accounted for. Those having arthritis-related activity limitation are also less likely to meet the physical activity recommendations, which is statistically significant even after adjusting for the covariates.

In this study, current and former smokers are at increased risk of arthritis. Several epidemiological studies have also reported the similar results [20-22]. The findings in our study as well as the studies above could suggest that smoking is a risk factor for arthritis. On the other hand, the mechanism by which smoking increases the risk of arthritis appears to be complex and is not clearly understood [23]. It has been

proposed that smoking may alter the immune system and productions of sex hormones, affecting the pathogenesis and activity of arthritis [23]. Specifically, smoking has been shown to be associated with increased levels of rheumatoid factors [24, 25], key markers for rheumatoid arthritis severity [6]. Therefore, promoting smoking cessation in the general public may be an important step in reducing the risk and severity of arthritis.

Alcohol consumption was associated with arthritis status and severity. In particular, the results of our study indicate that not consuming alcohol may especially increase the severity of arthritis. Recent findings from case-control studies showed that there was an inverse relationship between alcohol consumption and arthritis risk or severity [8, 26]. It is unknown how alcohol consumption reduces the risk and severity of arthritis. One proposed theory is that alcohol works as an immunomodulating agent, inducing anti-inflammatory and analgesic effects [8]. Clearly, more research is needed to investigate the potential benefits of alcohol consumption on arthritis status and severity.

Studies have pointed out that obese people have a greater risk of arthritis [7, 22]. Thus, it is not surprising that in our study people classified as overweight and obese show increased prevalence and severity of arthritis. It appears that excess body weight/fat accelerates the development and progression of arthritis both mechanically and metabolically [7]. For instance, it is possible that excess body weight/fat causes malalignment and cartilage defects in joints [27]. In addition, excess body weight/fat may stimulate the production of cartilage turnover biomarkers that increase the risk of osteoarthritis, such as cartilage oligomeric matrix protein [28] and collagen type II degeneration products [29], as well as the production of leptin, an adipose tissue-derived hormone potentially responsible for the pathophysiology of osteoarthritis [30]. Felson *et al*. [31] reported that the reduction of BMI by 2 units or more resulted in a decrease in the odds of developing osteoarthritis by nearly 50%. A randomized trial showed that weight reduction by 10 % among patients with arthritis could improve physical function by 28% [32]. Hence, weight reduction could be an essential component of the prevention and management of arthritis.

People with arthritis and those having arthritis-related activity limitation are less likely to meet the current physical activity recommendations than their counterparts. If sociodemographic variables along with smoking status, alcohol consumption, and weight status are accounted for, there is no significant difference in meeting the physical activity recommendations between people with and without arthritis. It may be that lower physical activity levels among people with arthritis are the consequences of arthritis and/or other factors, such as age. In our data, arthritis is more common among older people, and people tend to become less physically active as they age [33]. On the other hand, the presence of arthritis-related activity limitation is associated with a lower likelihood of meeting the physical activity recommendations even if adjusting for the covariates above. It is reasonable to assume that people would be less physically active if they had activity limitation due to arthritis/joint symptoms. This could explain the association of physical activity level to arthritis severity independent of the sociodemographic characteristics and other risk and protective factors of arthritis in our study. Yet, research shows that physical activity can reduce pain, improve function, and decrease the risk of disability associated with all forms of arthritis [34]. Thus, promoting physical activity among people with arthritis may be key to better management of arthritic conditions.

We observed that the relationships between arthritis and some of the risk/protective factors examined in this study (i.e., smoking status, alcohol consumption, weight status, and physical activity level) were age-dependent. For example, few factors above were associated with arthritis status and severity among the groups of people aged younger than 50 years. One reason, we speculate, to potentially explain this observation is that sample sizes of those having arthritic conditions among younger age groups were relative small. There were 21 (out of 279), 56 (out of 428), and 180 (out of 691) respondents self-reporting arthritis among the groups aged 18–29 years, 30–39 years, and 40–49 years, respectively, compared to much larger numbers among older age groups: 298 (out of 768) respondents for those aged 50–59 years, 445 (out of 857) respondents for those aged 60–69 years, and 488 (out of 885) respondents for those aged ≥ 70 years. Small sample sizes for the case of disease (i.e., arthritis = yes) make it difficult to accurately predict disease outcome, resulting in wider confidence intervals. It is also interesting that the risk and protective factors above were not significantly associated with arthritis status among people aged 60 years and older, either. This may be because people at

these ages are more likely to have osteoarthritis, as it is a degenerative disease and can be caused primarily by aging [35], potentially decreasing the impact of other risk and protective factors for arthritis.

There are limitations associated with the current study. First and foremost, the data in this study were obtained from self-reports, which is also the case with most survey data. For this type of data, recall bias is a concern, as researchers rely on a respondent's cognitive ability to recall his/her behaviors. Second, detailed information about certain behaviors were not collected in the 2009 BRFSS (e.g., how much current smokers smoke, what type of physical activity people engage in). Third, the BRFSS did not include the question about type of self-reported arthritis (e.g., rheumatoid arthritis, osteoarthritis). Etiology and symptoms are different depending on type of arthritis [1]. Lastly, this is an observational, cross-sectional study; therefore, we cannot establish causal relationships between the risk/protective factors examined in this study and arthritis status/severity. Furthermore, there may be other confounding factors influencing arthritis status and severity that were not included in our data analysis. It is possible that the BRFSS data is subject to selection bias, thus using propensity scores, for example, may be useful in reducing bias and confounding effects when analyzing complex survey data [36, 37].

It is necessary to take into account complex sampling method and weighting scheme when analyzing survey data. In this study, we used the Rao-Scott $\chi^2$ test and a multiple logistic regression analysis, and adjusted data for sampling weights, along with sociodemographic variables, to appropriately interpret the data. As stated previously, survey research using large-scale survey data, such as BRFSS data, is well suited for examining various health-related behaviors and conditions. Hence, we believe that the data analysis and findings presented here have important implications with respect to how researchers can examine and interpret survey data despite the shortcomings inherent to survey research.

## CONCLUSIONS

Cigarette smoking, alcohol consumption, obesity, and physical activity are all associated with the prevalence and severity of arthritis. It is possible that smoking and obesity increase the risk and severity of arthritis, whereas alcohol consumption and physical activity may attenuate its risk and severity. Further research, including prospective cohort studies, is needed to determine the true absolute risk of developing arthritis, so that healthcare professionals can design effective prevention strategies. We believe that a proper analysis of survey data can help us truly understand how human behavior impacts people's health.

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