# Associations Between Diabetes Management Practices and Health-Related Quality of Life, 2019 Indiana Behavioral Risk Factor Surveillance System Survey

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## Abstract
The objective of this cross-sectional analysis is to identify associations between diabetes management practices and overall health-related quality of life (HRQL) among Indiana residents who reported having been diagnosed with diabetes (N=1,434). Data was collected from the 2019 Indiana Behavioral Risk Factor Surveillance System (BRFSS) survey to assess demographic characteristics along with diabetes self-management and clinical management recommendations as per the American Diabetes Association (ADA). Frequency analysis was conducted to assess differences between demographics and both diabetes management and overall HRQL. Bivariate and multivariate logistic regression models were conducted to assess associations between diabetes management practices and HRQL while accounting for selected confounders including demographics and other health conditions. Multivariate regression modeling results indicated that meeting recommendations for exercise (aOR=2.31 [95% CI 1.65-3.23]) and diabetic retinopathy examinations (aOR=2.31 [95% CI 1.05-5.07]) were significantly associated with reporting better HRQL. Higher levels of self-monitoring of blood glucose in multivariate analysis (aOR=0.74 [95% CI 0.51-1.06]) indicated a negative association with good HRQL, but this association was not statistically significant. Overall higher self-management of diabetes (aOR=1.26 [95% CI 0.92-1.74]) and clinical management of diabetes (aOR=1.14 [95% CI 0.83-1.58]) were associated with higher odds of reporting better HRQL, but these relationships were also not statistically significant. Assessment of these results indicate that while adhering to an overall higher regiment of self-care practices for diabetes management can be beneficial, some self-management practices may not be directly associated with better HRQL and could be confounded by other negative health complications such as mental distress. Furthermore, ensuring that measures are taken to seek medical monitoring for possible retinopathy should be emphasized in addition to engagement in diabetes self-management education (DSME).

## Introduction
Estimates from the Centers for Disease Control and Prevention (CDC) have indicated that approximately 34.2 million Americans are living with Type 1 or Type 2 diabetes, with nearly 21.4% of these cases being undiagnosed [1]. The incidence of diabetes in America is of particular concern, with national estimates placing the rate at around 1.5 million new cases of diagnosed diabetes in the United States every year [2]. Documented risk factors for being diagnosed with diabetes include older age, elevated body mass index (BMI), classification as a racial minority, and family history of high cholesterol or elevated blood pressure [3]. Within the

state of Indiana, the prevalence of diabetes has steadily increased over time. Data collected from the 2014 Behavioral Risk Factor Surveillance System (BRFSS) survey for Indiana have estimated approximately 10.7% of state residents having either diagnosed or undiagnosed cases of diabetes [4]. Additionally, diabetes was listed as being the 7$^{th}$ leading cause of mortality for 2014 in Indiana based on 2014 Indiana vital records data [4]. The high prevalence of diabetes is particularly concerning due to the associated health complications that are linked to diabetes. A wide range of medical complications that can be detrimental to overall health, such as cardiovascular disease, chronic nerve damage and significant damage or impairment to the eyes and limbs, have all been linked to Type 1 or Type 2 diabetes [5].

In addition to the observed associations between diabetes and negative health conditions, high diabetes prevalence has also impacted healthcare spending and use of health services. Due to the chronic nature of diabetes, the need for routine healthcare services for the management of diabetes has become an important topic to monitor. Over time, healthcare expenses have risen for individuals with diabetes and make up a larger proportion of their overall expenses [6]. The increased cost associated with receiving care for diabetes is concerning, and this places even more importance on understanding current barriers to care, such as inability to afford proper services [7, 8]. Increasing diabetes incidence rates in the United States not only increases stress on the healthcare system, but it can also be characterized through significant economic costs. Estimates from 2017 by the American Diabetes Association (ADA) showed that diagnosed cases of diabetes resulted in approximately $327 billion dollars in direct healthcare expenses and indirect productivity costs. This further results in stress upon local government and state healthcare services, such as Medicare and Medicaid, as rising rates of diagnosed diabetes have led to a significantly higher percentage of healthcare costs among individuals relying on Medicare and Medicaid [9].

Additionally, it is important to assess not only the availability of coverage options and services, but also the usage rates of diabetes clinical care and recommended self-management behaviors. Considerations should be made regarding how much access to services is associated with improved HRQL for those with diabetes, as evidence has suggested that increased use of clinical services is not always directly correlated with improved health status [10]. Without an understanding of how often certain management practices are adhered to, it is difficult to properly explain differences between having access to diabetes care and having better health-related quality of life (HRQL). Recommended self-management practices for diabetes care, such as self-glucose monitoring, daily feet checking, participating in diabetes self-management education (DSME) services, and recurrent exercise, are important to consider in addition to clinical examinations, as these usage rates can vary across years [11].

Given the changes to recommended diabetes management practices, it is important to assess not only how often these practices are adhered to but also how adherence may be associated with better HRQL. Current research involving engagement with DSME services has indicated that use of these services may significantly help improve patient knowledge of how to manage their diabetes and help diabetic patients meet key management milestones such as HbA1C levels and lower blood pressure [12, 13]. Adherence to self-management practices such as meeting exercise milestones and checking feet regularly may additionally provide HRQL benefits [14]. In these studies, improvement in feelings of autonomy and control in self-management of diabetes conditions was able to help patients meet their glycemic goals [18]. However, this association

has not been observed to be consistent across the literature. Some evidence in the literature has failed to show improvement in key clinical characteristics of diabetes when adhering to self-management guidelines (e.g., self-monitoring of blood glucose) and may provide no significant benefits as part of a care plan [15]. These differences may also be impacted by demographic characteristics including sex, urban/rural living environments, and employment status, as characteristics such as these have been shown to be associated with adherence to diabetes management recommendations [17,27,28,29,30]. Key gaps in this research include not only differences in an understanding of whether management practices improve HRQL, but also contrasts between stated recommendations and implementation. Several barriers such as cost, time associated with proper clinical examinations, and the complexity of multi-faceted self-management regiments may all impact how well recommendations are satisfied [16]. Given these current gaps and the uncertainty regarding how effective diabetes management practices are in improving HRQL, conducting an analysis for Indiana residents to assess how each individual recommendation is associated with HRQL while accounting for confounding demographics and health conditions is key to identifying which specific recommendations provide the most benefit.

## Objectives

The goal of this cross-sectional analysis is to identify differences in overall HRQL among Indiana adults who are diagnosed with diabetes based on adherence to clinical and self-management practices. This analysis aims to identify associations between the degree of self-management and clinical management of diabetes and HRQL while adjusting for demographic characteristics and other health conditions. Recommendations for clinical and self-management practices for diabetes care are sourced from the 2021 standards established by the American Diabetes Association [19].

## Methods

### *Behavioral Risk Factor Surveillance System (BRFSS)*

The BRFSS survey is a questionnaire developed by the CDC and conducted annually in all 50 U.S. states and several U.S. territories by the respective state health departments [13]. The survey is a randomized, telephone-based questionnaire administered to non-institutionalized adults to inquire about health-related behaviors, health conditions, and demographic information. The survey is comprised of a rotating set of core questions, which are asked across all states, and additional, optional modules that may be selected on a state-by-state basis each year. The survey estimates are weighted by the CDC based upon collected demographic characteristics to ensure estimates are reflective of the known state population.

### *Data Cleaning*

All data were derived from the 2019 Indiana Behavioral Risk Factor Surveillance System (BRFSS) survey. Demographic variables selected for review included age, sex, race/ethnicity, education level, employment status, median household income, metropolitan status, and type of healthcare coverage. Demographic categorizations were not changed for weighted prevalence analysis. The primary question of interest from the BRFSS survey involving diabetes status was "*(Ever told you had) diabetes?*" and was initially categorized as either "*yes*," "*no*," "*yes, but only told during pregnancy*," or "*no, pre-diabetes or borderline-diabetes.*" Only responses *of "yes*" were kept to represent respondents with diabetes. Responses of pre-diabetes or gestational diabetes were converted to missing values and not included in the analysis.

*Diabetes Management*

Diabetes self-management practices were composed of four separate variables: blood glucose checks, feet checks, engaging in exercise in the past 30 days, and using diabetes self-management education (Table 1). Diabetes clinical management variables selected for analysis included seeing a doctor for diabetes-based care, receiving a foot examination, receiving an eye examination, receiving an A1C test, and receiving an influenza vaccination (Table 1).

*Table 1. Diabetes Management Variables and Recommendations*

| Variable | Recommendation | BRFSS Question |
|---|---|---|
| **Self-Management** | | |
| Blood Glucose Checks* | Recommended > 1 times a day | About how often do you check your blood for glucose or sugar? |
| Feet Checks* | Recommended daily | Including times when checked by a family member or friend, about how often do you check your feet for any sores or irritations? |
| Exercise* | Recommended | During the past month, other than your regular job, did you participate in any physical activities or exercises such as running, calisthenics, golf, gardening, or walking for exercise? |
| Diabetes Self-Management Education (DSME)* | Recommended | Have you ever taken a course or class in how to manage your diabetes yourself? |
| **Clinical Management** | | |
| Seeing a Doctor for Diabetes-Care ¶ | Once every 3 months if taking insulin and once every 6 months if diabetes managed through diet. | About how many times in the past 12 months have you seen a doctor, nurse, or other health professional for your diabetes? |
| A1C Test† | ≥ 2 times annually | About how many times in the past 12 months has a doctor, nurse, or other health professional checked you for A-one-C? |
| Foot Examination* | ≥ 1 time annually. If evidence of sensory loss or prior ulceration, then recommended at every checkup. | About how many times in the past 12 months has a health professional checked your feet for any sores or irritations? |
| Eye Examination* | Once every 1-2 years of no evidence of retinopathy and once annually if retinopathy present. | When was the last time you had an eye exam in which the pupils were dilated, making you temporarily sensitive to bright light? |
| Influenza Vaccination* | Recommended annually | During the past 12 months, have you had either a flu vaccine that was sprayed in your nose or flu shot injected into your arm? |

* Recommendation sourced from 2021 American Diabetes Association (ADA).
¶ Recommendation is sourced from the 2021 ADA guidelines but is supported by information from Mount Sinai Medical Center regarding insulin use.
† Recommendation sourced from the CDC.

To analyze overall high self-management of diabetes and high clinical management of diabetes, two separate scores were calculated, each accounting for the specific management type. The diabetes management score was derived by adding the number of diabetes self-

management or clinical recommendations satisfied by the respondent to produce an overall estimate. For self-management score, a value > 2 represented high self-management of diabetes, while a score ≤ 2 represented low self-management of diabetes. For the clinical management score, a value > 3 represented a high clinical management of diabetes, while a score ≤ 3 represented low clinical management [20, 24].

*Health-Related Quality of Life*

Health-related quality of life (HRQL) among respondents was based on a summed index of how many total days in the past month the respondent had poor physical health and how many days they had poor mental health. The HRQL variable was then dichotomized into either "Good health" or "Frequent poor health" depending on whether the sum of poor health days was < 14 days or ≥ 14 days, respectively, based on prior research studies which have commonly used this method for calculating HRQL [25].

*Statistical Analysis*

All statistical analyses were conducted using SAS version 9.4 software. All estimates were presented with their respective 95% confidence intervals. Additionally, analyses were only conducted on Indiana respondents who reported having diabetes (i.e., respondents without diabetes or who had a missing response regarding diabetes status were excluded). For all Wald chi-squared tests, a p-value of <.05 was deemed statistically significant.

The calculated self and clinical management scores were initially assessed through frequency analysis, with frequencies calculated for both good and frequently poor health; Wald chi-squared tests were used to detect significant differences. Dichotomized demographic characteristics were analyzed by high/low self and clinical management scores to inform potential confounding assessment. All regression models were conducted using PROC SURVEYLOGISTIC with requisite weight, strata, and cluster variables inputted specifically for the 2019 BRFSS. Logistic modeling began through conducting a bivariate analysis for each management recommendation and demographic variable in comparison to good/poor HRQL. For all unadjusted and adjusted odds ratios, a 95% confidence interval, which did not contain a value of 1.00 was deemed statistically significant. For all logistic models, the response variable was set to be the dichotomous HRQL score with "Frequent Poor Health" as the referent.

The model 1 framework consisted of four unique logistic regression models assessing each of the four diabetes self-management variables as individual predictors while adjusting for demographics and other health conditions. The model 2 framework included five unique logistic regression models assessing each of the five diabetes clinical management variables as individual predictors while demographics and other health conditions. Logistic modeling for A1C testing, eye examinations, foot examinations, and flu vaccinations was additionally adjusted by doctor visits for diabetes care, as this was hypothesized to potentially confound these relationships with HRQL. In contrast, doctors' visits for diabetes care were not adjusted by other clinical practices as these were hypothesized as possible mediators of the association with HRQL based on seeing a doctor for diabetes care. The model 3 framework consisted of two unique logistic regression models assessing the diabetes self-management score and the clinical management score as individual predictors, both controlling for demographics and other health conditions. For all adjusted logistic regression models, each predictor was additionally adjusted by history of

myocardial infarctions (MI) or coronary artery disease (CAD), history of depression, and history of chronic kidney disease (CKD).

## Results

*Demographic Characteristics*

Assessment of the 2019 Indiana BRFSS responses yielded a total analytic sample of 8,894 observations (Supplemental Table 1). Two-way frequency analysis of the Indiana BRFSS sample showed that approximately 12.4% of respondents had at some point been told they have diabetes (N=1,434) and 87.3% not having diabetes (N=7,435), with those responding "yes" to having diabetes not including individuals with pre-diabetes or gestational diabetes.
Bivariate Wald chi-squared analysis of demographic characteristics indicated that a significantly higher percentage of respondents with diabetes were ≥ 65 years old compared to those without diabetes (44.3% vs. 18.1%, p<.0001) and significantly more respondents with diabetes were male compared to respondents without diabetes (53.3% vs. 48.1%, p=.0041). A significantly higher percentage of respondents with diabetes compared to those without diabetes were also Non-Hispanic Black (12.5% vs. 8.2%, p=.0043). Employment status showed significant differences between those with and without diabetes. A significantly higher percentage of respondents without diabetes were currently employed (50.8%) in comparison to only 27.6% of respondents with diabetes. Respondents with diabetes had a higher frequency of retired individuals (37.2% vs. 15.7%) and individuals unable to work (19.9% vs. 6.0%) (p<.0001). This trend was further observed for annual household income, with respondents not having diabetes having higher frequencies of upper-tier incomes compared to respondents with diabetes (p<.0001). Respondents with diabetes also had significantly higher frequencies of individuals with government healthcare plans such as Medicare and Medicaid and fewer individuals with private plans compared to respondents without diabetes (p<.0001).

Assessment of additional chronic conditions based on diabetes status indicated statistically significant differences for history heart complications (p<.0001), history of depression (p<.0001), and history of chronic kidney disease (p<.0001). In each case, the percentage of respondents with these chronic conditions was significantly higher among those who were diagnosed with diabetes compared to respondents without diabetes.

***Diabetes-Only Sample Analysis***

Analyses of diabetes-only respondents (N=1,434) were conducted for HRQL assessment in addition to clinical and self-management practices for diabetes care (Table 2). Assessment of overall 30-day health for respondents with diabetes indicated that the majority reported good health (63.6%).Weighted frequency analysis of diabetes self-management and diabetes clinical management indicated that low self-management of diabetes was more prevalent compared to low clinical management (55.7% vs. 44.5%). In contrast, higher clinical management of diabetes was more prevalent than higher self-management of diabetes (55.5% vs. 44.3%). Assessment of diabetes management practices was further analyzed by HRQL among respondents with diabetes (Table 2). For diabetes self-management practice, it was observed that a significantly higher percentage of respondents reporting good health engaged in high self-management (48.2%) compared to respondents reporting poor health (41.0%l; p=.044). Clinical management of diabetes did not show a similar degree of difference, and instead indicated nearly equal percentages of high and low clinical management (p=.89).

**Table 2. Diabetes Management Scores Stratified by Health Status among Diabetes-Positive Respondents***

| Score | Total | Good Health | Poor Health | P-Value† |
|---|---|---|---|---|
| Self-Management | | | | **.0442** |
| Low (≤2) | 55.7 [52.5 - 58.9] | 51.8 [47.6-56.1] | 59.0 [53.5-64.5] | |
| High (>2) | 44.3 [41.1 - 47.5] | 48.2 [43.9-52.4] | 41.0 [35.5-46.5] | |
| Clinical Management | | | | .8898 |
| Low (≤3) | 44.5 [41.2-47.7] | 43.6 [39.3-47.8] | 44.1 [38.5-49.7] | |
| High (>3) | 55.5 [52.3-58.8] | 56.4 [52.2-60.7] | 55.9 [50.3-61.5] | |

*** Sample was isolated to only respondents who answered yes to having been told they have diabetes. Values presented represent weighted frequencies with 95% confidence limits using the LLCPWT variable for weighting the selected sample.**
**† P-Values represent values from Wald chi-squared analysis.**

### *Diabetes Self-Management Recommendations*

Weighted frequency analyses for the specific components of both the self-management and clinical management scores were conducted for the total diabetes-positive sample by HRQL (Supplemental Table 3). Among self-management practices, meeting ADA recommendations for daily blood sugar checking (71.2%) and daily feet checking (67.6%) were the most prevalent recommendations met. The only two self-management recommendation frequencies to significantly differ by HRQL were for daily blood sugar checks (p=.0001) and recommended exercise (p<.0001). Recommended exercise in the past 30 days was achieved at a significantly higher frequency among those with reportedly good health (64.9%) compared to poor health (41.6%). In contrast, the frequency of respondents meeting daily blood sugar check requirements was significantly greater among those with poor health compared to good health (78.9% vs. 66.5%; p=.0001). Meeting ADA recommendations for DSME was higher among those with good health (61.4%) compared to poor health (56.3%) but did not indicate a significant difference (p=.14). Furthermore, meeting the ADA recommendation for daily feet checks indicated a higher frequency among those with poor health (70.3%) compared to good health (65.9%) but did not show significance (p=.21).

### *Diabetes Clinical Management Recommendations*

Overall, weighted frequencies of clinical management practices indicated that each recommendation was met more times than not, with receiving an eye exam (94.9%), receiving a foot examination (74.5%), and receiving an A1C test (73.6%) having the highest frequencies of respondents meeting the recommendations (Supplemental Table 3). Wald chi-squared analysis indicated that receiving an eye examination (p=.0055) was significantly different between those with good health (97.2%) and those with poor health (90.9%). Seeing a doctor for diabetes-related care (69.3% vs. 66.6%, p=.41) and receiving an A1C test (76.4% vs. 71.9%, p=.15) were the clinical management practices with higher frequencies among those with poor HRQL compared to good HRQL. While not statistically significant, a higher frequency of respondents met the recommendation for receiving a foot examination among those reporting good health compared to poor health (75.8% vs. 72.4%, p=0.29). Meeting the ADA recommendation for

receiving a flu vaccine offered almost no difference in frequency between those with good health and those with poor health (56.2% vs. 56.3%, p=1.00).

### *Diabetes Management Recommendations and Demographics*

Wald chi-squared analyses were conducted to compare self-management and clinical management scores with demographic characteristics (Table 3). For self-management scores, only metropolitan status and education level showed a significant difference in frequency between and high and low self-management of diabetes, with more respondents living in urban environments having higher self-management scores compared to those living in rural environments (p=.0095) and more individuals having either a college degree or having attended college reporting better self-management of diabetes (p=.0066).

For clinical management scores, the demographics of age (p=.0034), healthcare coverage (p=.0036), and history of CKD (p=.011) were the only characteristics to show statistical significance. Better clinical management scores were identified in older respondents compared younger respondents. Additionally, a higher proportion of respondents with better diabetes clinical management reported having a history of chronic kidney disease.

**Table 3. Demographic Characteristics Stratified by Diabetes Management Level ***

| Demographic | High Self-Management ‡ | Low Self-Management ‡ | P-Value | High Clinical Management § | Low Clinical Management § | P-Value † |
|---|---|---|---|---|---|---|
| **Age** | | | .1583 | | | **.0338** |
| **18-24** | 0.28 [0.00-0.84] | 1.55 [0.00-3.69] | | 0.67 [0.00-1.97] | 1.39 [0.00-3.60] | |
| **25-34** | 2.44 [0.68-4.19] | 5.26 [2.23-8.29] | | 2.27 [0.40-4.13] | 6.19 [2.72-9.65] | |
| **35-44** | 11.7 [7.51-15.9] | 7.12 [4.41-9.83] | | 7.52 [4.75-10.3] | 11.2 [7.04-15.3] | |
| **45-54** | 16.0 [12.3-19.7] | 15.2 [12.0-18.4] | | 14.3 [11.2-17.4] | 17.1 [13.3-21.0] | |
| **55-64** | 27.4 [23.2-31.6] | 25.0 [21.4-28.5] | | 26.6 [23.0-30.3] | 25.3 [21.2-29.4] | |
| **65+** | 42.2 [37.5-46.8] | 45.9 [41.7-50.1] | | 48.6 [44.5-52.8] | 38.8 [34.2-43.4] | |
| **Sex** | | | .9568 | | | .4960 |
| **Male** | 53.2 [48.4-58.1] | 53.4 [49.1-57.7] | | 52.3 [48.2-56.5] | 54.6 [49.6-59.6] | |
| **Female** | 46.8 [41.9-51.6] | 46.6 [42.3-50.9] | | 47.7 [43.5-51.8] | 45.4 [40.4-50.4] | |
| **Education** | | | **.0066** | | | **.0416** |
| **Elementary or Less** | 1.95 [0.40-3.51] | 5.50 [3.12-7.89] | | 1.94 [0.57-3.31] | 6.41 [3.52-9.30] | |
| **Some High School** | 8.95 [5.20-12.7] | 14.2 [10.7-17.8] | | 10.5 [7.50-13.6] | 13.6 [9.16-18.0] | |
| **High School Graduate** | 36.8 [32.2-41.4] | 38.1 [33.9-42.2] | | 38.2 [34.2-42.2] | 36.6 [31.9-41.3] | |
| **Some College** | 35.4 [30.6-40.1] | 28.0 [24.1-31.9] | | 33.6 [29.5-37.7] | 28.4 [23.8-32.9] | |
| **College Graduate** | 17.0 [13.9-20.1] | 14.2 [11.7-16.6] | | 15.7 [13.3-18.1] | 15.0 [11.9-18.2] | |
| **Income** | | | .2181 | | | .0652 |
| **<$10,000** | 5.24 [3.02-7.45] | 8.17 [4.83-11.5] | | 4.48 [2.63-6.32] | 9.86 [5.77-13.9] | |
| **<$15,000** | 8.08 [5.12-11.0] | 8.32 [5.62-11.0] | | 7.68 [5.19-10.2] | 8.89 [5.65-12.1] | |
| **<$20,000** | 9.97 [6.95-13.0] | 15.4 [11.5-19.3] | | 13.6 [10.2-16.9] | 12.1 [8.21-16.1] | |
| **<$25,000** | 15.4 [11.0-19.8] | 12.8 [9.85-15.7] | | 14.4 [11.2-17.6] | 13.4 [9.27-17.6] | |
| **<$35,000** | 12.2 [8.71-15.7] | 10.9 [7.94-13.8] | | 10.1 [7.40-12.8] | 13.2 [9.44-17.1] | |
| **<$50,000** | 12.5 [8.81-16.3] | 13.0 [9.64-16.4] | | 14.2 [10.8-17.7] | 11.0 [7.29-14.6] | |
| **<$75,000** | 13.8 [10.1-17.5] | 14.1 [10.7-17.5] | | 12.9 [9.88-15.8] | 15.4 [11.2-19.6] | |
| **≥$75,000** | 22.8 [18.2-27.3] | 17.3 [13.4-21.2] | | 22.7 [18.6-26.8] | 16.1 [11.9-20.2] | |
| **Employment** | | | .4450 | | | .1851 |
| **Employed for Wages** | 29.9 [25.2-34.6] | 26.6 [22.4-30.7] | | 27.2 [23.2-31.2] | 29.1 [24.2-34.1] | |
| **Self-Employed** | 6.36 [4.01-8.71] | 4.30 [2.52-6.07] | | 5.30 [3.36-7.25] | 5.10 [2.97-7.23] | |
| **Out of Work > 1 year** | 2.55 [1.07-4.02] | 2.51 [0.61-4.41] | | 2.17 [0.69-3.65] | 2.98 [0.89-5.07] | |
| **Out of Work < 1 Year** | 1.79 [0.39-3.18] | 1.37 [0.14-2.61] | | 0.70 [0.01-1.40] | 2.63 [0.75-4.51] | |
| **Homemaker** | 4.98 [2.80-7.16] | 3.25 [1.86-4.64] | | 3.56 [1.94-5.17] | 4.61 [2.67-6.54] | |
| **Student** | 0.29 [0.00-0.87] | 0.72 [0.00-2.04] | | 0.68 [0.00-1.99] | 0.34 [0.00-0.93] | |
| **Retired** | 35.6 [31.1-40.1] | 39.6 [35.6-43.6] | | 41.3 [37.2-45.3] | 33.5 [29.1-37.9] | |
| **Unable to Work** | 18.5 [14.5-22.6] | 21.7 [17.9-25.5] | | 19.1 [15.8-22.5] | 21.7 [17.1-26.4] | |
| **Metropolitan Status** | | | **.0095** | | | .7218 |
| **Urban** | 96.0 [94.5-97.5] | 92.6 [90.6-94.7] | | 94.4 [92.6-96.1] | 93.9 [91.8-95.9] | |
| **Rural** | 3.96 [2.45-5.46] | 7.35 [5.30-9.41] | | 5.63 [3.90-7.36] | 6.12 [4.05-8.19] | |
| **Healthcare Coverage** | | | .9422 | | | **.0036** |
| **Employer Plan** | 30.0 [25.2-34.8] | 28.6 [24.2-32.9] | | 28.2 [24.0-32.3] | 30.7 [25.6-35.8] | |
| **Personal Plan** | 8.08 [5.26-10.9] | 7.08 [4.82-9.33] | | 6.79 [4.85-8.73] | 8.58 [5.31-11.9] | |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Medicare** | 42.9 [37.9-47.9] | 43.7 [39.3-48.1] | | 48.7 [44.4-53.1] | 35.8 [30.8-40.8] | |
| **Medicaid** | 12.1 [8.80-15.5] | 13.2 [9.38-16.9] | | 8.81 [6.26-11.4] | 18.0 [13.2-22.8] | |
| **TRICARE, VA, Military** | 3.96 [1.97-5.94] | 3.23 [1.73-4.73] | | 3.45 [1.79-5.10] | 3.73 [1.92-5.55] | |
| **Tribal Health Services** | 0.20 [0.00-0.59] | 0.26 [0.00-0.76] | | 0.24 [0.00-0.70] | 0.22 [0.00-0.65] | |
| **Other or None** | 2.79 [1.10-4.48] | 4.06 [1.97-6.14] | | 3.81 [1.82-5.81] | 2.98 [1.27-4.70] | |
| **History of MI or CHD** | | | | | | |
| **Yes** | | | .3554 | | | .8044 |
| **No** | 19.6 [16.0 - 23.2] | 22.0 [18.4 - 25.6] | | 21.2 [18.0 - 24.4] | 20.6 [16.5 - 24.7] | |
| | 80.4 [76.8 - 84.0] | 78.0 [74.4 - 81.6] | | 78.8 [75.6 - 82.0] | 79.4 [75.3 - 83.5] | |
| **Depression** | | | .3626 | | | .2984 |
| **Yes** | 26.1 [21.8 - 30.4] | 28.9 [24.9 - 32.9] | | 29.1 [25.4 - 32.8] | 25.9 [21.2 - 30.6] | |
| **No** | 73.9 [69.6 - 78.2] | 71.1 [67.1 - 75.1] | | 70.9 [67.2 - 74.6] | 74.1 [69.4 - 78.8] | |
| **CKD** | | | .5221 | | | **.0112** |
| **Yes** | 12.9 [9.8 - 16.0] | 11.6 [9.1 - 14.1] | | 14.4 [11.5 - 17.2] | 9.4 [6.8 - 12.0] | |
| **No** | 87.1 [84.0 - 90.2] | 88.4 [85.9 - 90.9] | | 85.6 [82.8 - 88.5] | 90.6 [88.0 - 93.2] | |

***Among those with Diabetes (N=1,434)**
**†Bolded p-values indicate significance at a .05 level**
**‡Self-Management score consisted of summation index including self monitoring of blood sugar, self feet checks, exercise, and DSME**
**§Clinical management score consisted of summation index including seeing a doctor for diabetes care, A1C testing, foot examinations, eye examinations, and flu vaccinations.gf**

### *Health-Related Quality of Life and Demographics*

Wald chi-squared analysis of HRQL by demographic characteristics (Supplemental Table 4) indicated significant differences in reported health based on age (p=.0024), sex (p=.032), education level (p<.0001), annual household income (p<.0001), history of heart complications (p<.0001), history of depression (p<.0001), and history of chronic kidney disease (p<.0001). Respondents who were male, possessed a college degree, had higher annual incomes, and possessed a private insurance plan indicated higher relative proportions of reporting good health compared to their counterparts. Furthermore, the prevalence of comorbidities including heart disease, chronic kidney disease, and depression were also significantly higher among diabetes-positive respondents who reported worse HRQL. Differences in education level and healthcare coverage type were unable to be determined due to missing values for students with low HRQL and those covered by Tribal health Services with low HRQL.

### *Unadjusted Analysis*

Odds ratio estimates for the association between ADA recommendations with HRQL were calculated both through bivariate and multivariate analyses (Supplemental Table 2). In bivariate analysis, satisfying the recommendation of engaging in exercise was significantly associated with good HRQL (OR=2.52 [95% CI 1.90-3.35]). In surprising contrast, the odds of reporting good health were reduced significantly when the recommendation of daily blood sugar checks was satisfied (OR=0.58 [95% CI 0.44-0.77]). Engagement in DSME (OR=1.23 [95% CI 0.93-1.62]) and having a higher overall self-management score (OR=1.35 [95% CI 0.97-1.88]) also indicated higher associations with good HRQL, but these predictors were not statistically significant. Unadjusted analysis of meeting the recommendation for daily feet checking showed a statistically insignificant negative association with good HRQL (OR=0.83 [95% CI 0.63-1.08]).

Bivariate assessment of clinical management variables indicated significant associations with good HRQL when the recommendation for receiving an eye exam (OR=3.64 [95% CI 1.80-7.33]) was satisfied. Meeting the recommendation for receiving a foot exam was associated with higher HRQL but did not show statistical significance (OR=1.16 [95% CI 0.86-1.56]). Higher clinical score was associated with good HRQL but did not present a significant result (OR=1.04 [95% CI 0.75-1.46]).

***Adjusted Analysis***

Three separate logistic regression model frameworks were conducted to assess associations between diabetes self-management, clinical management, and self and clinical management overall scores in association with HRQL (Table 4.).

The model 1 framework consisted of each self-management practice assessed as individual predictors and each being adjusted by age, sex, education, employment status, and other chronic conditions. Recommended exercise was the only significant self-management practice associated with good HRQL when holding age, sex, employment, education, and other health conditions constant (aOR=2.31 [95% CI 1.65-3.23]). Management practice of engaging in DSME (aOR=1.31 [95% CI 0.93-1.83]) was not statistically significant but did indicate higher associations with good HRQL when holding demographics and other health conditions constant. As with the unadjusted model, recommended daily glucose checks showed a negative association with good HRQL (aOR=0.74 [95% CI 0.51-1.06]) at a statistically insignificant level when holding demographics and other health conditions constant. Meeting the recommendation for daily feet checking was also met with reduced odds of reporting better HRQL (aOR=0.80 [95% CI 0.54-1.06]) yet similarly, did not show significance when holding demographics and other health conditions constant.

The model 2 framework assessed each clinical management practice individually as predictors while adjusting each for age, sex, education, employment status, and other chronic conditions. Results from model 2 indicated that meeting the recommendation for eye examinations (aOR=2.31 [95% CI 1.05-5.07]) was significantly associated with reporting good HRQL when holding demographics and other health conditions constant. Meeting recommendations for seeing a doctor for diabetes care (aOR=1.09 [95% CI 0.67-1.78]), receiving a foot examination (aOR=1.30 [95% CI 0.87-1.97]), and receiving a flu vaccine (aOR=1.26 [95% CI 0.89-1.79]) indicated increased odds of reporting good health but failed to be significant at the $\alpha<.05$ level when holding demographics and other health conditions constant. The recommendation for receiving A1C tests (aOR=0.87 [95% CI 0.59-1.30]) was insignificant but interestingly indicated a negative association with reporting good HRQL when the recommendation was met when holding demographics and other health conditions constant.

The model 3 framework involved assessment of the scores for self-management and clinical management of diabetes each individually as predictors while adjusting for age, sex, education, employment status, and other chronic conditions. Adjusted logistic regression for both management scores failed to show any statistically significant estimates at the $\alpha=.05$ level but did indicate that that higher self-management scores (aOR=1.26 [95% CI 0.92-1.74]) and higher clinical management scores (aOR=1.14 [95% CI 0.83-1.58]) were associated with reporting good HRQL when holding demographics and other health conditions constant.

**Table 4. Odds Ratios for Diabetes Management Practices in Association with Health-Related Quality of Life**

| Variable | Unadjusted - OR [95% Confidence Limit] | Adjusted OR – Model 1* | Adjusted OR – Model 2† | Adjusted OR – Model 3¶ |
|---|---|---|---|---|
| **Self-Management** | | | | |
| **Daily Blood Sugar Check** | **0.58 [0.44 - 0.77]** | 0.74 [0.51 - 1.06] | - | - |
| **Daily Feet Check** | 0.83 [0.63 - 1.08] | 0.80 [0.54 – 1.18] | - | - |

| | | | | |
|---|---|---|---|---|
| **Recommended Exercise** | **2.52 [1.90 - 3.35]** | **2.31 [1.65 – 3.23]** | - | - |
| **Use of DSME** | 1.23 [0.93 - 1.62] | 1.31 [0.93 – 1.83] | - | - |
| **Self-Management Score** | 1.35 [0.97 - 1.88] | - | - | 1.26 [0.92 – 1.74] |
| | | **Clinical Management** | | |
| **Seeing a Doctor for Diabetes Care** | 0.91 [0.69 - 1.21] | - | 1.09 [0.67 – 1.78] ‡ | - |
| **A1C Test** | 0.86 [0.64 - 1.15] | - | 0.87 [0.59 – 1.30] § | - |
| **Foot Examination** | 1.16 [0.86 - 1.56] | - | 1.30 [0.87 – 1.97] § | - |
| **Eye Examination** | **3.64 [1.80 - 7.33]** | - | **2.31 [1.05 – 5.07] §** | - |
| **Flu Vaccination** | 0.99 [0.75 – 1.34] | - | 1.26 [0.89 – 1.79] § | - |
| **Clinical Management Score** | 1.04 [0.75 - 1.46] | - | - | 1.14 [0.83 – 1.58] |

* All self-management variables were adjusted by age, sex, education, employment, MI/CAD, depression, and CKD
† All clinical management variables were adjusted by age, sex, education, employment, MI/CAD, depression, and CKD
‡ Seeing a doctor for diabetes care was adjusted by each clinical management practice to account for possible confounding in addition to the interaction between eye examinations and flu vaccinations.
§ Recommendations were adjusted by seeing a doctor for diabetes care in addition to demographics.
¶ Both self-management and clinical management scores were adjusted by age, sex, education, employment, MI/CAD, depression, and CKD

## Discussion

The objective of this report was to analyze what factors may be associated with good or poor overall quality of health among people with diabetes. This was accomplished through both unadjusted analysis and adjusted analysis through the calculation of logistic regression models involving each recommendation as predictors. Adjusted modeling of diabetes self-management recommendations indicated that individuals with diabetes who engaged in some form of exercise in the prior month had a nearly 2.3 times higher odds of reporting overall better health than those who do not exercise. This represented one of the strongest relationships with good HRQL among all included recommendations. The significant odds of reporting good HRQL with regards to meeting exercise recommendations is in line with current research in this field, as prior research has indicated that higher levels of physical activity may improve glycemic control and blood pressure management [21]. Benefits of exercise on HRQL for diabetes patients are especially related to cardiovascular health, which is associated with diabetes status. Engagement in aerobic and resistance exercises has been linked to improved cardiac functioning involving proper blood vessel activity and cardiac output [22]. Other key cardiovascular health characteristics such as blood pressure, insulin resistance, and fat mass have also been shown to be reduced in diabetic patients when adhering to recommended exercise patterns. Better physical activity adherence has also been shown to offer improvement in mental health for diabetic patients involving better self-esteem and reduced depressive symptoms [23].

While other self-management recommendations did not have significant associations with good HRQL, assessment of overall diabetes self-management score indicated that respondents who reported higher adherence to self-management guidelines also demonstrated higher adjusted odds of having better heath quality. This suggests that maintaining an overall degree of diabetes self-management may provide observable benefits to self-reported HRQL. While overall adherence to personal diabetes guidelines may overall suggest higher odds of good HRQL, the lack of statistical significance for individual guidelines outside of exercise suggests a need for further investigation into these standards. Conclusions regarding overall self-management score and

clinical management score therefore may be problematic. Calculation of the management scores was based on dichotomizing into high and low overall management based on the median scores among respondents with diabetes. However, the lack of statistical significance indicates that drawing concrete conclusions from the third regression model using the management score would be inappropriate. Conducting separate analysis to compare the self and clinical management scores with both physical and mental HRQL scores individually may help identify unique effects in comparison to only assessing overall HRQL. Future studies may necessitate reworking the management scores to better evaluate their accuracy.

Of particular interest is the reduced odds of good HRQL when the recommendation of daily blood glucose checking was met. This suggests a possibly more complex relationship between daily glucose monitoring and reported health. Previous research on this subject has indicated that regular self-monitoring of blood glucose greater than once per day may be associated with increased levels of depressive symptoms along with distressed mental health, even though metabolic control was identified to be higher [31]. Of note with these previous findings is that individuals not taking insulin exhibited greater increases in mental health distress with regards to increased glucose monitoring, while individuals taking insulin did not experience the same effect on mental health. Additional studies have found that among those with Type 2 diabetes there was not a significant improvement in quality of life based upon the frequency of self-monitoring blood glucose [32]. Evidence from the PRISMA (Prospective Randomized Trial on Intensive SMBG Management Added Value in Noninsulin-Treated T2DM Patients) indicated that among non-insulin treated Type 2 diabetics, regular self-monitoring of blood glucose was not associated with worsening HRQL [33]. This may be significantly confounded by demographics and other diabetes factors, such as age, sex, and diabetes duration, which may have associations with worse HRQL [33]. These confounding demographics could also however be associated with age. The higher percentage of retirees, higher incomes, higher prevalence of Medicaid users, and higher prevalence of other chronic conditions among respondents with diabetes could be reflective of older demographics. While this analysis did account for history of depression, the observed negative pattern between self-monitoring of glucose and poor HRQL was still present (albeit, statistically insignificant). Possible mechanisms for such observations have been described but should be investigated further in the context of Indiana diabetics, particularly, in this case, among those with type 2 diabetes, as this study was unable to account for different types of diabetes.

While the effects of living with diabetes on physical wellbeing are apparent through either increased risk factors for retinopathy and peripheral neuropathy or poor glucose levels, the effects on mental health can be debilitating. Evidence has suggested that the likelihood of becoming diagnosed with clinical depression increases by nearly two-fold when an individual is diagnosed with diabetes [35]. Due to the need for self-management of diabetes to be at the forefront of diabetes care, this places additional mental stress upon individuals with diabetes as they must balance a range of care regiments, including glucose monitoring, diet, and physical activity. This indicates an increased need for engaging diabetic patients with DSME services, as previous evidence has suggested that engagement in DSME may be beneficial for coping with diabetes conditions, care regiments, and distress associated with diabetes along with improving adherence to helpful lifestyle behaviors [36]. While this study did not indicate a significant association between DSME and overall HRQL, further analysis assessing physical and mental

HRQL individually along with adjustment for variables such as diet and other chronic conditions could help identify more informative results in the future.

Among clinical diabetes management recommendations, it was noted that only meeting the recommendation for having an eye examination demonstrated statistical significance when analyzed in model 2. Furthermore, a lack of statistical significance was present for the adjusted odds ratio involving clinical diabetes management. Previous research suggests that satisfying clinical guidelines would benefit HRQL, but these findings do not support such evidence. While overall higher clinical management did indicate improved odds of reporting better HRQL, the lack of statistical significance suggests that either a re-assessment of the scoring method may be needed or that other possible confounders could exist that affect this association.

Meeting the recommendation for receiving an eye examination to test for retinopathy and seeking a doctor's visit for diabetes care was the most associated with reporting good HRQL. Diabetic retinopathy is a condition in which blood vessels within the retina are weakened which can lead to impairment of vision or even blindness [34]. Due to the severity of diabetic retinopathy, there is evidence from this study that receiving timely examinations to identify if diabetic retinopathy is present may help improve reported HRQL. Ensuring that patients with diabetes can receive such eye examinations to test for diabetic retinopathy is vital and identifying barriers to receiving proper clinical care should be explored. Prior research has suggested that key barriers to patients receiving diabetic retinopathy examinations can include a lack of understanding of insurance benefits and a poor knowledge of the importance to receive such tests [37]. To help improve HRQL for Indiana residents living with diabetes, it is important to identify methods for improving patient education on the importance of clinical checkups to help mitigate the long-term effects of diabetes.

**Limitations**

A major limitation of this study was the inability to account for Type 1 and Type 2 diabetes. As described previously, some differences in association between glucose monitoring and HRQL could be modified significantly by Type 1 or Type 2 diabetes along with whether insulin is used. Due to various studies reporting either reduced HRQL or no change in HRQL based upon diabetes type or insulin use, the effect of glucose self-monitoring requires additional attention in future BRFSS studies. The 2019 BRFSS questionnaire did not provide any questions which specifically asked whether the respondent had ever been diagnosed with Type 1 or Type 2 diabetes, which would be an important question to consider for future surveys to help more accurately assess how Type 1 and Type 2 patients differ in health characteristics and demographics.

Furthermore, the cross-sectional design of the study is a significant limitation. This is because this design prevented any analysis of temporal associations between diabetes management practices and HRQL. Both the outcome and predictors were assessed simultaneously which limits the ability to draw predictions regarding causal relationships between the variables of interest. Additionally, risk of bias involving non-responses and missing data from the questions limits the ability to ensure that the sample is completely representative of the true population. Missing answers and non-response could introduce bias if respondents failed to answer certain types of questions which could skew the data if individuals of a particular health status or background answer questions more frequently. Social-desirability bias related to the health

information and practices collected in the BRFSS survey could also have affected the results, which involves underreporting of und-desirable health behaviors [38]. This could include respondents providing more favorable answers involving their reported adherence to daily management practices, such as glucose monitoring or feet checks, which could skew towards higher reported frequency of performing these practices. Self-reporting of additional behaviors including monthly exercise may also be biased by more respondents claiming to have met the favorable outcome.

## Conclusions

The analysis of diabetes self-management and clinical management recommendations to assess HRQL for those living with diabetes indicates that engaging in exercise and receiving important eye examinations are associated with improved HRQL among those with diabetes. Maintaining a high level of self-management and clinical management of one's diabetes may be associated with better reported HRQL and is recommended to be emphasized in public heath interventions. It is further recommended that future studies and public health research in the state of Indiana consider differences in engagement with DSME and barriers to receiving diabetes clinical care. Additionally, future studies on this topic could be advanced through investigation of Type 1 and Type 2 diabetes and associations with HRQL and management adherence.

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## Appendix

**Supplemental Table 1. Diabetes Prevalence Stratified by Demographic Characteristics***

| | Weighted Frequency (%) [95% Confidence Limit] † | | | |
|---|---|---|---|---|
| **Characteristic** | **Total (N=8,894)** | **Diabetes Positive (N=1,434)** | **Diabetes Negative (N=7,435)** | **P-Value ¶** |
| **Age (Years)** | | | | |
| **18-24** | 13.2 [12.0 – 14.4] | 1.0 [0.0 – 2.2] | 15.0 [13.6 – 16.3] | <.0001 |
| **25-34** | 16.7 [15.5 – 17.9] | 4.0 [2.1 – 5.9] | 18.5 [17.2 – 19.7] | |
| **35-44** | 15.9 [14.9 – 16.9] | 9.1 [6.8 – 11.5] | 16.9 [15.8 – 18.0] | |
| **45-54** | 16.0 [15.1 – 16.9] | 15.5 [13.1 – 18.0] | 16.1 [15.1 – 17.1] | |
| **55-64** | 16.8 [16.0 – 17.6] | 26.0 [23.3 – 28.7] | 15.5 [14.6 – 16.4] | |
| **65+** | 21.4 [20.5 – 22.2] | 44.3 [41.2 – 47.3] | 18.1 [17.3 – 18.9] | |
| **Sex** | | | | |
| **Female** | 51.2 [49.9 – 52.6] | 46.7 [43.5 – 49.9] | 51.9 [50.4 – 53.4] | .0041 |
| **Male** | 48.8 [47.4 – 50.2] | 53.3 [50.1 – 56.5] | 48.1 [46.6 – 49.6] | |
| **Race/Ethnicity** | | | | |
| **White ‡** | 79.2 [78.1 – 80.4] | 77.0 [74.0 – 79.9] | 79.7 [78.4 – 80.9] | .0043 |
| **Black ‡** | 8.7 [7.9 – 9.5] | 12.5 [10.0 – 15.0] | 8.2 [7.3 – 9.0] | |
| **Hispanic** | 3.1 [2.6 – 3.6] | 2.9 [1.6 – 4.2] | 3.1 [2.5 – 3.7] | |
| **Other Race ‡** | 0.9 [0.7 – 1.1] | 1.2 [0.7 – 1.7] | 0.9 [0.7 – 1.1] | |
| **Multiracial ‡** | 6.1 [5.4 – 6.8] | 4.4 [3.0 – 5.8] | 6.3 [5.6 – 7.1] | |
| **Highest Education Level** | | | | |
| **No School** | 0.6 [0.4 - 0.8] | 0.5 [0.1 - 0.8] | 0.6 [0.4 - 0.8] | <.0001 |
| **Elementary** | 0.1 [0.0 - 0.1] | 0.1 [0.0 - 0.3] | 0.0 [0.0 - 0.1] | |
| **Some High School** | 3.0 [2.5 - 3.5] | 3.8 [2.3 - 5.2] | 2.9 [2.3 - 3.5] | |
| **High School Graduate or GED** | 9.1 [8.2 - 10.1] | 11.8 [9.2 - 14.4] | 8.7 [7.7 - 9.7] | |
| **Some College §** | 33.2 [31.9 - 34.5] | 37.4 [34.3 - 40.4] | 32.6 [31.3 - 34.0] | |
| **College Graduate §** | 30.5 [29.2 - 31.7] | 31.1 [28.1 - 34.2] | 30.4 [29.1 - 31.8] | |
| | 23.5 [22.5 - 24.5] | 15.3 [13.4 - 17.2] | 24.7 [23.6 - 25.8] | |
| **Employment Status** | | | | |
| **Employed for Wages** | 47.8 [46.5 – 49.2] | 27.6 [24.5 – 30.6] | 50.8 [49.3 – 52.2] | <.0001 |
| **Self-Employed** | 8.3 [7.6 – 9.0] | 5.1 [3.7 – 6.5] | 8.8 [8.0 – 9.6] | |
| **Out of Work (≥1 Year)** | 1.9 [1.5 – 2.3] | 2.5 [1.3 – 3.7] | 1.8 [1.4 – 2.2] | |
| **Out of Work (<1 Year)** | 2.8 [2.2 – 3.3] | 1.5 [0.62 – 2.4] | 3.0 [2.3 – 3.6] | |
| **Homemaker** | 5.5 [4.8 – 6.1] | 4.0 [2.7 – 5.2] | 5.6 [5.0 – 6.3] | |
| **Student** | 5.6 [4.8 – 6.4] | 0.52 [0.00 – 1.3] | 6.3 [5.4 – 7.2] | |
| **Retired** | 18.4 [17.6 – 19.2] | 37.2 [34.3 – 40.1] | 15.7 [14.9 – 16.5] | |
| **Unable to Work** | 7.8 [7.1 – 8.4] | 19.9 [17.2 – 22.7] | 6.0 [5.4 – 6.7] | |
| **Income** | | | | |
| **<$10,000** | 4.1 (3.5 – 4.7] | 5.5 [3.8 - 7.1] | 3.9 [3.3 - 4.6] | <.0001 |
| **$10,000 - $15,000** | 3.9 [3.3 – 4.4] | 6.6 [5.0 - 8.2] | 3.5 [2.9 - 4.0] | |
| **$15,000 - $20,000** | 5.7 [5.0 – 6.3] | 10.3 [8.3 - 12.4] | 5.0 [4.4- 5.6] | |
| **$20,000 - $25,000** | 7.8 [7.0 – 8.5] | 11.2 [9.1 - 13.3] | 7.2 [6.5 - 8.0] | |
| **$25,000 - $35,000** | 8.5 [7.7 – 9.2] | 9.2 [7.4 - 11.0] | 8.4 [7.6 - 9.2] | |
| **$35,000 - $50,000** | 11.5 [10.6 – 12.3] | 10.2 [8.2 - 12.3] | 11.7 [10.8 - 12.6] | |

| | | | | |
|---|---|---|---|---|
| **$50,000 - $75,000** | 13.4 [12.5 – 14.3] | 11.2 [9.2 - 13.2] | 13.7 [12.7 - 14.7] | |
| **≥$75,000** | 25.3 [24.1 – 26.4] | 15.8 [13.4 - 18.2] | 26.7 [25.4 - 28.0] | |
| **Urban/Rural Status** | | | | .1484 |
| **Urban** | 93.2 [92.5 - 93.8] | 94.2 [92.9 - 95.4] | 93.0 [92.3 - 93.7] | |
| **Rural** | 6.8 [6.2 - 7.5] | 5.8 [4.6 - 7.1] | 7.0 [6.3 - 7.7] | |
| **Healthcare Coverage** | | | | <.0001 |
| **Yes** | 88.2 [87. 2- 89.1] | 94.0 [92.4 - 95.7] | 87.3 [86.3 - 88.4] | |
| **No** | 10.8 [9.8 - 11.7] | 5.3 [3.7 - 7.0] | 11.5 [10.5 - 12.6] | |
| **Type of Coverage** | | | | |
| **Employer Plan** | 40.1 [38.8 - 41.4] | 26.0 [23.1 - 29.0] | 42.2 [40.7 - 43.6] | <.0001 |
| **Family Plan** | 7.5 [6.8 - 8.2] | 6.7 [5.1- 8.3] | 7.6 [6.8 - 8.4] | |
| **Medicare** | 20.0 [19.1 - 20.9] | 38.6 [35.5 - 41.6] | 17.4 [16.5 - 18.3] | |
| **Medicaid** | 8.0 [7.2 - 8.8] | 11.3 [9.0 - 13.6] | 7.5 [6.7 - 8.4] | |
| **TRICARE, VA, or Military** | 2.1 [1.7 - 2.5] | 3.2 [2.1 - 4.3] | 2.0 [1.6 - 2.4] | |
| **Tribal Health Services #** | 0.3 [0.2 - 0.4] | 0.2 [0.0 - 0.5] | 0.3 [0.2 - 0.5] | |
| **Other Source** | 3.1 [2.6 - 3.7] | 3.0 [1.8 - 4.3] | 3.2 [2.6 - 3.7] | |
| **None** | 0.1 [0.0 - 0.2] | 0.0 [0.0 - 0.1] | 0.1 [0.0 - 0.2] | |
| **History of MI or CHD** | | | | <.0001 |
| **Yes** | 7.4 [6.8 - 7.9] | 20.9 [18.4 - 23.5] | 5.5 [4.9 - 6.0] | |
| **No** | 92.6 [92.1 - 93.2] | 79.1 [76.5 - 81.6] | 94.5 [94.0 - 95.1] | |
| **Depression** | | | | <.0001 |
| **Yes** | 21.0 [19.8 - 22.1] | 27.6 [24.7 - 30.6] | 20.0 [18.8 - 21.2] | |
| **No** | 79.0 [77.9 - 80.2] | 72.4 [69.4 - 75.3] | 80.0 [78.8 - 81.2] | |
| **CKD** | | | | <.0001 |
| **Yes** | 3.4 [3.0 - 3.8] | 12.1 [10.2 - 14.1] | 2.2 [1.8 - 2.6] | |
| **No** | 96.6 [96.2 - 97.0] | 87.9 [85.9 - 89.8] | 97.8 [97.4 - 98.2] | |

*** Percentages may not add up to 100% due to missing responses. Responses which were listed as "Don't Know/Not Sure" or "Refused" were classified as missing values in the analysis.**
**† Frequencies were weighted using the LLCPWT variable from the BRFSS. 95% confidence limits for each stratified frequency are presented in brackets.**
**¶ Calculated Wald chi-squared p-value.**
**‡ Non-Hispanic.**
**§ Includes technical school.**
**# Includes Alaska Native and Indian health services**

**Supplemental Table 2. Diabetes Management and HRQL Scores Among Respondents with Diabetes[*]**

| Score | | Weighted Frequency (%) [95% Confidence Limits] |
|---|---|---|
| Health Score[†] | | |
| | Good HRQL | 63.1 [59.8-66.3] |
| | Poor HRQL | 36.9 [33.7-40.2] |
| Self-Management[¶] | | |
| | Low Self-Management | 55.7 [52.5 - 58.9] |
| | High Self-Management | 44.3 [41.1 - 47.5] |
| Clinical Management[‡] | | |
| | Low Clinical Management | 44.5 [41.2-47.7] |
| | High Clinical Management | 55.5 [52.3-58.8] |

*** Sample size is derived from Indiana respondents who reported having been told they have diabetes (N=1,434).**
**† Health score comprised a summed total of the number of days with poor physical health and the number of days with poor mental health in the past 30 days. Good health was defined as <14 days with poor physical/mental health and frequently poor health was defined as ≥14 days with poor physical/mental health.**
**¶ Self-Management of diabetes was scored based on four variables of interest: daily blood sugar checks, daily feet check, use of diabetes education, and exercise in the past 30 days. Values were compared to 2021 ADA guidelines. Low self-management was defined as self-management score <3 and high self-management was defined as ≥3.**

**‡ Clinical management of diabetes was scored based on five variables: visiting a doctor specifically for diabetes care, A1C testing, foot examination by a physician, retinopathy examination, and receiving an influenza vaccine. Values were compared to a mixture of 2021 ADA guidelines and recommendations from the CDC and Cleveland Clinic. Low clinical management was defined as a score <3 and scores ≥3 was defined as high clinical management.**

**Supplemental Table 3. Prevalence of Recommended Diabetes Management Practices***

| Management Practice | Total † | Good HRQL † | Poor HRQL † | P-Value ‡ |
|---|---|---|---|---|
| **Self-Management** | | | | |
| **Daily Blood Sugar Check** | 71.2 [68.1-74.2] | 66.5 [62.4-70.6] | 78.9 [74.6-83.2] | **.0001** |
| **≥1 time daily** | 28.8 [25.8-31.9] | 33.5 [29.4-37.6] | 21.1 [16.8-25.4] | |
| **<1 time daily** | | | | |
| **Daily Feet Check** | | | | |
| **≥1 time daily** | 67.6 [64.2-70.9] | 65.9 [61.7-70.2] | 70.3 [64.9-75.6] | .2129 |
| **<1 time daily** | 32.4 [29.1-35.8] | 34.1 [29.8-38.3] | 29.7 [24.4-35.1] | |
| **Exercise in Past 30 Days** | 56.3 [53.1-59.6] | 64.9 [60.9-68.8] | 41.6 [36.2-47.0] | **<.0001** |
| **Yes** | 43.7 [40.4-46.9] | 35.1 [31.2-39.1] | 58.4 [53.0-63.8] | |
| **No** | | | | |
| **Diabetes Education** | | | | |
| **Yes** | 59.5 [56.3-62.8] | 61.4 [57.3-65.5] | 56.3 [50.9-61.7] | .1411 |
| **No** | 40.5 [37.2-43.7] | 38.6 [34.5-42.7] | 43.7 [38.3-49.1] | |
| **Clinical-Management** | | | | |
| **Seen Doctor for Diabetes** | 67.6 [64.5-70.7] | 66.6 [62.7-70.5] | 69.3 [64.2-74.5] | .4121 |
| **Yes** | 32.4 [29.3-35.5] | 33.4 [29.5-37.3] | 30.7 [25.5-35.8] | |
| **No** | | | | |
| **A1C Test (Past 12 Months)¶** | | | | .1499 |
| **Yes** | 73.6 [70.5-76.6] | 71.9 [68.0-75.9] | 76.4 [71.7-81.1] | |
| **No** | 26.4 [23.4-29.5] | 28.1 [24.1-32.0] | 23.6 [18.9-28.3] | |
| **Foot Examination (Past 12 Months)** | | | | .2947 |
| **Yes** | 74.5 [71.5-77.6] | 75.8 [72.1-79.6] | 72.4 [67.2-77.6] | |
| **No** | 25.5 [22.4-28.5] | 24.2 [20.4-27.9] | 27.6 [22.4-32.8] | |
| **Eye Examination (Past 12 Months)** | | | | **.0055** |
| **Yes** | 94.9 [93.1-96.7] | 97.2 [95.7-98.6] | 90.9 [86.7-95.0] | |
| **No** | 5.12 [3.32-6.93] | 2.81 [1.37-4.26] | 9.12 [5.00-13.3] | |
| **Influenza Vaccine** | | | | |
| **Yes** | 56.2 [52.8-59.7] | 56.2 [51.9-60.6] | 56.3 [50.6-61.9] | .9959 |
| **No** | 43.8 [40.3-47.2] | 43.8 [39.4-48.1] | 43.7 [38.1-49.4]] | |

***Sample consisted of 1,434 respondents who reported having been diagnosed with diabetes.**

**†All estimates consisted of weighted frequency percentages and respective 95% Confidence Intervals**

**‡Bolded Wald chi-square p-values indicate statistical significance at a .05 level**

**Supplemental Table 4. Demographic Characteristics and Health-Related Quality of Health ***

| Demographic | Good HRQL † | Poor HRQL † | P-Value ‡ |
|---|---|---|---|
| **Age** | | | **.0024** |
| **18-24** | 1.47 [0.00-3.51] | 0.37 [0.00-1.09] | |
| **25-34** | 4.19 [1.69-6.70] | 3.24 [0.45-6.02] | |
| **35-44** | 9.96 [6.84-13.1] | 9.15 [4.68-13.6] | |
| **45-54** | 14.2 [11.1-17.2] | 19.0 [14.5-23.6] | |
| **55-64** | 22.7 [19.4-26.0] | 31.8 [26.8-36.8] | |
| **65+** | 47.5 [43.3-51.7] | 36.4 [31.5-41.4] | |
| **Sex** | | | **.0323** |
| **Male** | 56.4 [52.2-60.6] | 48.8 [43.2-54.4] | |
| **Female** | 43.6 [39.4-47.8] | 51.2 [45.6-56.8] | |
| **Education** | | | **<.0001** |
| **Elementary or Less** | 2.28 [0.83-3.73] | 5.75 [2.55-8.94] | |
| **Some High School** | 10.1 [6.92-13.2] | 13.1 [8.24-17.9] | |
| **High School Graduate** | 37.1 [33.1-41.1] | 36.1 [31.0-41.2] | |
| **Some College** | 30.9 [26.8-35.0] | 35.3 [30.0-40.5] | |
| **College Graduate** | 19.6 [16.7-22.5] | 9.79 [7.34-12.2] | |
| **Income** | | | **<.0001** |
| **<$10,000** | 3.45 [1.16-5.73] | 10.9 [6.77-15.0] | |
| **<$15,000** | 6.78 [4.39-9.17] | 10.6 [6.83-14.3] | |
| **<$20,000** | 10.9 [7.66-14.2] | 14.6 [10.5-18.7] | |
| **<$25,000** | 10.6 [7.75-13.4] | 19.3 [14.1-24.6] | |
| **<$35,000** | 12.8 [9.80-15.8] | 10.3 [6.45-14.1] | |
| **<$50,000** | 14.9 [11.5-18.2] | 9.71 [5.55-13.9] | |
| **<$75,000** | 13.7 [10.4-17.0] | 15.1 [10.9-19.4] | |
| **≥$75,000** | 26.9 [22.6-31.2] | 9.54 [5.94-13.1] | |
| **Employment** | | | N/A § |
| **Employed for Wages** | 37.2 [32.8-41.5] | 15.8 [11.5-20.0] | |
| **Self-Employed** | 6.79 [4.62-8.97] | 3.04 [1.27-4.81] | |
| **Out of Work > 1 year** | 1.02 [0.27-1.78] | 4.13 [1.52-6.73] | |
| **Out of Work < 1 Year** | 1.21 [0.18-2.24] | 2.38 [0.37-4.39] | |
| **Homemaker** | 4.55 [2.72-6.38] | 3.03 [1.42-4.63] | |
| **Student** | 0.90 [0.00-2.22] | 0 | |
| **Retired** | 41.0 [37.0-45.1] | 30.4 [25.8-35.0] | |
| **Unable to Work** | 7.33 [4.88-9.78] | 41.2 [35.6-46.9] | |
| **Metropolitan Status** | | | .2076 |
| **Urban** | 95.0 [93.4-96.6] | 93.1 [90.6-95.6] | |
| **Rural** | 5.00 [3.41-6.58] | 6.88 [4.42-9.35] | |
| **Healthcare Coverage** | | | N/A § |
| **Employer Plan** | 35.3 [31.0-39.7] | 21.6 [16.6-26.6] | |
| **Personal Plan** | 7.46 [5.17-9.74] | 8.60 [5.32-11.9] | |
| **Medicare** | 38.8 [34.6-42.9] | 48.9 [43.1-54.6] | |
| **Medicaid** | 11.4 [7.90-14.8] | 14.5 [10.4-18.5] | |
| **TRICARE, VA, Military** | 3.39 [1.83-4.96] | 3.43 [1.33-5.53] | |
| **Tribal Health Services** | 0.39 [0.00-0.94] | 0 | |
| **Other or None** | 3.29 [1.34-5.24] | 3.04 [1.30-4.77] | |
| **History of MI or CAD** | | | **<.0001** |
| **Yes** | 14.4 [11.7 – 17.0] | 31.3 [25.9 – 36.3] | |
| **No** | 85.6 [83.0 – 88.3] | 68.9 [63.7 – 74.1] | |
| **History of Depression** | | | **<.0001** |
| **Yes** | 15.1 [12.1 – 18.2] | 49.6 [44.0 – 55.1] | |
| **No** | 84.9 [81.8 – 87.9] | 50.4 [44.9 – 56.0] | |
| **History of CKD** | | | **<.0001** |
| **Yes** | 7.8 [5.8 – 9.9] | 20.0 [15.7 – 24.3] | |
| **No** | | | |

| | | |
|---|---|---|
| | 92.2 [90.1 – 94.2] | 80.0 [75.7 – 84.3] |

***Sample consisted of 1,434 respondents who reported having been diagnosed with diabetes.**
**†All estimates consisted of weighted frequency percentages and respective 95% Confidence Intervals**
**‡Bolded Wald chi-square p-values indicate statistical significance at a .05 level**
**§At least one category had 0 observations which prevented the calculation of Wald chi-square statistics**
**Abbreviations: MI=myocardial infarction, CAD=coronary artery disease, CKD=chronic kidney disease.**