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Use of Wearable Device among Adults in the US with Self-reported Diabetes Mellitus: An Analysis of the 2019 Health Information National Trends Survey

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Abstract **Objective**: To evaluate the prevalence, patterns, and sociodemographic predictors of wearable device use among individuals with self-reported diabetes mellitus. **Methods**: Data for our analysis was drawn from cycle 3 (2019) of the 5th edition of the Health Information National Trends Survey (HINTS 5). Descriptive statistics were used to evaluate the demographic characteristics, prevalence, and frequency of wearable device use among individuals with diabetes mellitus. Multivariable logistic regression was used to identify the sociodemographic predictors of wearable device use. **Results**: We identified 1149 individuals who self-reported diabetes mellitus. Of these, 51.2% were females, 59.3% were white, and 51.6% had less than a college education. The prevalence of wearable device use was 20%. Further, a sizable proportion (86.1%) of the wearable device users were willing to share information from their wearable devices with their healthcare provider, and almost half of them (43.4%) reported daily use of these devices in the past 1-month. Significant sociodemographic predictors of wearable device use include age, income, and level of education. **Conclusion**: Our results highlight the feasibility and acceptability of using wearable devices to deliver evidence-based health care to individuals with diabetes. Future interventions should consider the scalability of these tools and how to reach those subgroups of individuals with diabetes mellitus to whom current technologies may be unavailable.

Keywords: *wearable device, diabetes mellitus, weight loss, physical activity tracking, health behaviors*

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1. Introduction

Diabetes Mellitus (DM) is a global health concern and a leading cause of morbidity and mortality in the United States. According to the Centre for Disease Control, in 2018, there were 34.2 million individuals affected with DM in the United States. [1] In 2017, the total healthcare expenditure on DM was $327 billion dollars. [1,2] DM accounts for 83,564 deaths yearly and contributes significantly to the burden of disease in the US. [2]

Despite significant strides in the management of patients with DM, several problems related to their care continue to persist. First, with the frequent need to use medications for disease control, medication nonadherence is prevalent among patients with DM and is associated with adverse outcomes. [1,2,3] Improving medication management begins with an accurate exchange of information between the health care providers and the patients. [4,5] Therefore, new interventions are needed to move beyond these known barriers and help adherence. [5] Second, prior research has shown that individuals living with DM have low rate of compliance with lifestyle interventions. [6,7] Given that individuals with DM are more likely to have other risk factors, lifestyle intervention remains a crucial component of their care. [8,9,10] Third, individuals with DM who have poor access to adequate healthcare may have suboptimal care and increased rate of long term complications. [11,12,13] Thus, for effective management, strategies to promote positive health behaviors as well as enable continuous monitoring are essential in improving diabetes control. [14]

Wearable technology is increasingly being utilized to care for individuals with chronic diseases especially with increasing demand from limited healthcare resources. [15,16,17] These tools have shown promise in several chronic health conditions, such as obesity, hypertension, cancer, heart disease and more. [18] Non-prescription wearable activity trackers also referred to as "wearable devices" in this study includes Fitbit, Apple watch, Garmin Vivofit, etc. According to a study done by Wulfovich et al, results indicate that wearables have potential to enable better self-management and lead to improved wellbeing but must be further refined to address different individualized aspects of their use. [19] Also, empirical evidence from prior research supports the notion that these devices are beneficial for individuals with diabetes. However, there is further need for close regulation and development of data transmission from the devices into the health record systems. [20,21,22]

Yet, there are limited data on the prevalence of wearable device use among those with diabetes mellitus. Further, it is not known which subgroups are more likely to engage and use these devices. Accordingly, using recent data from the Health Information National Trends Survey (HINTS 5 cycle 3), our study aims to (i) evaluate the prevalence of wearable device use among individuals with self-reported diabetes mellitus (ii) ascertain the patterns of wearable device use and (iii) identify which sociodemographic factors predicts wearable device use.

2. Methods

2.1. Overview of the Health Information National Trends Survey

For this study, data was obtained from the Health Information National Trends Survey (HINTS), a large-scale, household interview survey of US noninstitutionalized adults aged ≥ 18 years. Briefly, HINTS is a national cross-sectional survey of US adults conducted every 1-3 years since 2003 that collects information from the public on a broad range of topics including cancer information, communication, attitudes and behaviors, and use of health information technologies. We utilized data from HINTS 5 Cycle 3 (2019). Data collection for Cycle 3 of HINTS 5 began in January 2019 and concluded in May 2019. In previous iterations of HINTS 5 (cycles 1 and 2), data was gathered using a self-administered mailed questionnaire. However, for cycle 3, two web-based survey options were introduced in addition to the paper mails for data collection.

HINTS utilizes a probability-based sampling frame in which residential addresses in the United States are sampled, and then 1 adult from each address is randomly selected for participation using the Next Birthday method. The sampling frame consists of a collection of databases used by the Marketing Systems Group to obtain a random sample of addresses. This was then grouped into 2 specific sampling strata: (i) high concentrations of minority populations and (ii) low concentrations of minority populations. Additional information about data collection and methodologies can be found in the corresponding methodology reports for HINTS 5 Cycle 3. [23]

2.2. Sample Population

2.2.1. Study Design and Participants

The total number of households for the H5c3 sample was 23,430 and data was obtained from 5438 respondents who completed at least 50% of the survey. The overall household response rate was 30.3%. The collected data were adjusted to account for the sampling design and nonresponse bias. Sampling weights were assigned to each adult who completed the survey to produce nationally representative estimates for the adult population in the United States.

The 2019 iteration reported herein contained questions about participants usage of wearable devices. For this study, respondents with Diabetes Mellitus was determined by the question, "Has a doctor or other health professional ever told you that you had diabetes or high blood sugar (yes/no)?" Of the complete sample, approximately 1149 participants self-reported a history of diabetes disorder (17% weighted prevalence). Also, 2.61% (142/5438) of observations were with missing data and these were omitted in the final analysis.

2.3. Measures

2.3.1. Use of Wearable Devices among Individuals with Diabetes

The primary goal of this study was to investigate the prevalence and patterns of wearable device use among individuals with self-reported diabetes mellitus. To answer this, we used information obtained from survey items within HINTS 5 Cycle 3, as follows.

First, prevalence of wearable device use was determined by the following question: "*In the past 12 months, have you used an electronic wearable device to monitor or track your health or activity? For example, a Fitbit, Apple Watch, or Garmin Vivofit*" *activity?*" Next, willingness to share health data with their health providers was ascertained by the question: *"Would you be willing to share health data from your wearable device with your health care provider?"*. The response options for both question items were *"yes" and "no"* and so they were treated as binary variables.

Finally, frequency of wearable device use was assessed by the question: *"In the past month, how often did you use a wearable device to track your health?"*. Responses options included; *everyday, almost every day, 1-2 times per week, less than once per week, and none.*

2.3.2. Sociodemographic Predictors of Wearable Device Use

We conducted further analysis to identify which groups of individuals with Diabetes Mellitus are more likely to use wearable devices. To answer this, the following demographic variables were selected and included in the final model; Age was assessed as a categorical variable with age ranges 18-34 (reference), 35-49, 50-64, 65 or more years. Race/ethnicity was categorized into four categories: white (reference), black/African American, Hispanic, and other. Gender was assessed as female (reference) and male. Education was classified into four categories: less than college (reference), some college, college graduate and postgraduate degree. Income was divided into five categories: < $20,000 (reference), $20000-34000, $35000 - 50000, $50000-75000, and $ >75000. Body mass Index was dichotomized into obese (BMI >= 30) and non-obese (BMI < 30).

2.4. Statistical Analyses

Demographic statistics were conducted for the entire study sample and by diabetes status. Both unweighted frequencies and weighted percentages were presented. Then we examined the prevalence and frequency of wearable device use among those with self-reported diabetes using descriptive statistics. Multivariable logistic regressions including sociodemographic variables of age, gender, race, income, and education was conducted to identify predictors of past 12-month usage of wearable device. All analyses were weighted using replicate weights, based on the jack-knife replication method to account for the complex sampling design of HINTS and to obtain nationally representative parameter estimates. Statistical significance was assessed at the $p < 0.05$ level. Data were analyzed using the Stata 14.0 statistical software (svy program).

3. Results

Of the 5,438 respondents for H5c3, a total of 5,296 had provided data on diabetes status. Of those providing usable data, 1,149 (21.7%) self-reported Diabetes, and 4,147 (78.3%) reported no diagnosis of diabetes.

Table 1 shows the demographic distribution of the population. Compared to participants without a self-reported history of diabetes, those with diabetes were significantly more likely to be older, obese, less educated and have a combined household income of less than 20,000 dollars per annum.

Usage of wearables such as Fitbit, Apple Watch, or Garmin Vivofit was less common, as only 27.1% of the total sample population reported using these devices to monitor their health. Those with diabetes were less likely than the general population to use wearable devices in monitoring their health (20.0% vs 28.6%; p = 0.008). However, a substantial proportion (86.1%) of wearable device users among those with diabetes were willing to share information from their wearable devices with their healthcare provider. In addition, almost half of them (43.4%) reported daily use of these devices in the past 12 month, and about 80% reported using these devices at least once in the past month to track or monitor their health.

Table 1. Participants characteristics according to Diabetes Status

	All (N=5296), weighted %	Diabetes (N=1149), weighted percentage, 95% C. I	Non-Diabetes (N=4147), weighted percentage, 95% C. I	p-value
Gender				
Male	49.3	48.8 (43.7 - 53.8)	49.3 (47.7 - 51.0)	.851
Female	50.7	51.2 (46.2 - 56.3)	50.7(49.0 - 52.3)	
Age				
18-34yrs	24.2	7.0 (3.4 - 10.6)	27.7 (25.5 - 29.9)	
35-49yrs	24.8	16.4 (12.1 - 20.6)	26.6 (24.3 - 28.7)	<.001
50-64yrs	31.2	43.2 (38.4 - 48.1)	28.7 (26.6 - 30.9)	
65yrs +	19.8	33.4 (29.7 - 37.0)	17.0 (16.3 - 17.7)	
Education				
Less than College	39.8	51.6 (47.0 - 56.2)	37.4 (36.4 - 38.4)	
Some College	30.5	29.9 (25.6 - 34.2)	30.6 (29.5 - 31.7)	<.001
College Graduate	17.5	10.3 (8.10 - 12.5)	18.9 (17.8 - 20.1)	
Postgraduate	12.2	8.2 (6.20 - 10.1)	13.1 (12.0 - 14.1)	
Household Income				
< $20,000	18.3	29.8 (25.3 - 34.3)	16.0 (13.3 - 18.6)	
$20,000 - $34,999	11.0	14.6 (10.3 - 18.8)	10.3 (9.0 - 11.6)	
$35,000 - $49,999	13.6	13.0 (9.6 - 16.4)	13.7 (11.9 - 15.5)	<.001
$50,000 - $74,999	17.4	14.9 (11.5 - 18.4)	17.8 (15.7 - 20.0)	
$75,000 or more	39.7	27.7 (23.6 - 31.7)	42.2 (39.6 - 44.7)	
Race				
White	63.5	59.3 (54.4 - 64.2)	64.4 (63.1 - 65.6)	
African American	11.2	12.8 (9.8 - 15.8)	10.9 (10.1 - 11.7)	.083
Hispanic	16.8	20.8 (16.9 - 24.8)	16.0 (15.1- 16.9)	
Others	8.5	7.1 (4.3 - 9.8)	8.7 (7.9 - 9.6)	
Body Mass Index				
Obese (BMI >= 30)	33.1	50.5 (45.3 - 55.7)	29.5 (27.0 - 32.0)	<.001
Non-obese (BMI < 30)	66.9	49.5 (44.3 - 54.7)	70.5 (68.0 - 73.0)	

Table 2. Participants characteristics according to Wearable device status

	All (N=5380), weighted %	Have Wearable (N=1300), weighted percentage, 95% C. I	No Wearable (N=4080), weighted percentage, 95% C. I	p-value
Gender				
Male	49.3	44.5 (40.4 - 48.5)	51.1(49.4 - 52.9)	.014
Female	50.7	55.6 (51.5 - 59.6)	48.9(47.1 - 50.6.8)	
Age				
18-34yrs	24.4	33.6 (29.4 - 37.8)	20.9 (18.3 - 23.5)	
35-49yrs	24.6	30.4 (26.8 - 34.2)	22.4 (19.9 - 24.8)	<.001
50-64yrs	31.6	26.4 (22.6 - 30.2)	32.8 (30.6 - 35.0)	
65yrs +	19.9	9.5 (7.9 - 11.1)	23.9 (23.1 - 24.7)	
Education				
Less than College	39.8	23.7 (19.6 - 27.7)	45.7 (44.2 - 47.2)	
Some College	30.7	33.8 (29.9 - 37.7)	29.5 (28.0 - 31.0)	<.001
College Graduate	17.3	24.4 (21.5 - 27.3)	14.7 (13.7 - 15.7)	
Postgraduate	12.2	18.1 (15.3 - 21.0)	10.0 (8.9 - 11.1)	
Household Income				
< $20,000	18.4	7.9 (4.8 - 11.1)	22.4 (19.4 - 25.4)	
$20,000 - $34,999	11.1	4.8 (3.3 - 6.3)	13.4 (11.6 - 15.2)	
$35,000 - $49,999	13.4	13.0 (9.2 - 16.9)	13.6 (11.9 - 15.2)	<.001
$50,000 - $74,999	17.5	16.4 (13.1-19.7)	17.9 (15.7 - 20.1)	
$75,000 or more	39.6	57.8 (53.8 -61.8)	32.7 (29.7 - 20.1)	
Race				
White	63.5	64.7 (61.0-68.4)	63.1(61.5 - 64.6)	
African American	11.3	8.9 (6.5 - 11.2)	12.3(11.3 - 13.2)	.31
Hispanic	16.7	17.7 (14.4-20.9)	16.4(14.9 - 17.8)	
Others	8.4	8.8 (6.4 - 11.2)	8.3(7.2 - 9.3)	
Body Mass Index				
Obese (BMI >= 30)	32.8	29.6(25.3 - 33.9)	33.9 (30.8 - 37.0)	.15
Non-obese (BMI < 30)	67.3	70.4(66.1 - 74.7)	66.1 (63.0 - 69.2)	

3.1. Predictors of Wearable Device Use among those who Self-reported Diabetes

Education, income levels, and age were significant independent predictors of wearable device use in the Diabetes group and in the general population. The odds of wearable device usage decreased significantly with advancing age. For example, those 65 years or older were less likely to use wearable devices (OR 0.06, 95% CI 0.02 - 0.21; p <0.001) when compared to individuals aged 18-34 years. Also, education level significantly predicts wearable device use. Specifically, individuals with a postgraduate degree had more than twice the odds of using wearable tools (OR 2.86, 95% CI 1.24 - 6.59; p = 0.02) when compared to those with less than a college degree. Lastly, compared to individuals with incomes of less than $20,000 per annum, those with income range of at least $75,000 were significantly more likely to use wearable devices (OR 3.90, 95% CI 1.39 - 10.96; p = 0.01). Sex and race were not independent predictors of wearable device use. Table 2 shows demographic distribution of all survey participants by their wearable device status

4. Discussion

This study sought to evaluate the current prevalence, patterns and predictors of wearable device use to manage health, drawing on data from a nationally representative population of individuals with diabetes mellitus. We observed that 1 in 5 persons with diabetes had used wearable device to monitor their health in the past year preceding the survey. A further 80.7% of the wearable device users expressed willingness to share information from their wearable device with their healthcare provider. A little less than half (43.4%) of the wearable users reported daily use of the device in the past. Lastly, among those with diabetes, age, income, and educational level were significant predictors of wearable device use. These findings are discussed in detail in the following paragraphs.

Overall, our results indicate that those with diabetes are already using these devices to manage their care. We found that 20% of individuals with diabetes mellitus had used wearables to track their health which is higher than rates previously reported in the general population. For example, in 2013, one survey showed 1 in 10 Americans used a wearable device. [18,24] A 2016 cross sectional study by Omar et al reported a prevalence of 12.5% in the general population, in this study approximately 1 in 8 of the respondents used a wearable device monitor in 2015. [25] However, another cross-sectional study by Rongzi et al reported a prevalence of 32% among those with or at risk of CVD. [26] One possible explanation for the higher rates reported in their study could be their sample population which included those with CVD or at risk of

CVD. Our study is novel in that it is the first to report the prevalence of wearable device use among diabetics. We found a higher prevalence among diabetes than previously reported in the general population but this might be as a result of an increasing popularity in wearable device use. [27,28,29,30]

A major finding from our study was that patient with diabetes were significantly less likely than non-diabetics to use wearable device in monitoring their health (p=0.008). This finding differs from a cross sectional study done by Rongzi et al which found that those with or at risk of CVD were more likely to use wearable device compare to those with no risk of CVD with a statistically significant difference. [26] It is possible that people without a self-reported history of diabetes have other conditions like CVD or hypertension for which they used wearable devices. This may also suggest that there are some barriers to wearable device use among diabetics which may include comorbidities, disability, depression, cognitive impairment, and poor quality of life. Studies have shown that diabetic patients have higher rate of disability than non-diabetic. [31] It is also possible that some respondents with diabetes were not using wearable device due to limited literacy, attitude to technologic device and challenges with self-regulation and self-control. [32,33,34] Regardless, wearable device may still be a hopeful tool for those subsets of population that likes to engage technology-based strategy for managing their health. [35]

Further, our findings suggest that those with diabetes are approachable and are willing to communicate findings from their wearable tools with their clinicians. Although only 1 in 5 respondents with diabetes used a wearable device, we found that 4 in 5 of wearable users were willing to share information from these tools with their healthcare provider. This is consistent with other studies that indicates that individuals are likely and willing to share data from their wearable device with their health care providers. [36,37] This is very important for continuous monitoring of patient with diabetes. Our findings also show that a little less than half of this patient reported daily use of the device for the past month and about 80% reported using these devices at least once in the past month to track or monitor their health.

The use of wearable device has been shown to promote increase physical activity and help manage weight which reduces diabetes and cardiovascular disease. [26,38,39,40] Some studies have questioned the efficacy of wearable devices and its ability to maintain weight loss. [24,41] Other studies have recognized the potential and feasibility of supporting behavioral and lifestyle changes especially weight loss. [40,42,43,44] Kurti and Dally 2013, conducted a non-randomized trial of wearable device activity intervention among sedentary adults >50yrs and found that steps increased 182% when monetary incentives are offered and 108% when no incentives are offered. [45,46] An exploratory study by Naslund et al of individuals with serious mental illness enrolled in a 6 month lifestyle program that examine the association between daily step count with wearable device and weight loss, found a significant positive association. Higher step count was associated with greater weight loss. [42] This suggests that wearable device may be potentially effective strategy for motivating and supporting weight loss in patient with diabetes mellitus.

Over time, doctors have incorporated more technology into their practice, especially with regards to apps, social media and wearables. [47] A 2017 study by Ipsos digital doctors, showed that 56% of surveyed physician in the US strongly agree that connected health device and tools will provide patient with real time data and knowledge about their health that will enable them to proactively manage their health and prevent disease. [48] Due to lack of standardization of information from wearable device, interpretation of data is a challenge and doctors may not be able to rely on information from the wearable device until it is standardized and streamline into EHR for easy access, but may recommend them based on their potential for supporting behavioral changes.

However, wearable device technologies are not without its problems. Past research has shown that ownership and usage of wearable device is associated with certain sociodemographic factors. Omara et al in the study of wearable device in the general US population, showed that the use of wearable device decreased significantly with advancing age and decreasing level of education and varied with sex. [25] Similar trends were reported by Shan et al with current use of wearable device increasing with decreasing age and increasing level of education ($p<0.001$). [26] Our finding are consistent with the literature regarding the disparity in the use of digital devices such as wearable technologies. We found that older adults and those with low income and lower level of education were less likely to use wearable device technologies. Race and sex were not independent predictors of wearable device use. Unlike the study done by Omara et al which reported wearable device use varied significantly with sex, we did not find any significant difference with sex.

5. Strength and Limitations

The strengths of the study include the use of the HINTS, a nationally representative dataset form a large sample of US adults. To date, no other study has evaluated wearable devices use among individuals with diabetes mellitus drawing from a nationally representative sample. To ensure generalizability of the study, replicate weights were applied to generate estimates. Yet, our findings should be considered with the following limitations in mind. First, there is an intrinsic reporting bias and recall bias because the data were self- reported. Diabetes mellitus was self-reported and not confirmed through a clinical diagnosis. Second, the study did not highlight which of the devices were used, specific uses of the device, type of device used and how it influenced the participant's condition. Third, the questions asked were not specific about the type of DM (T1DM or T2DM). There is a likelihood that those with T1DM would be more prone to use the wearable device. Lastly, given the cross-sectional nature of the study, it is not possible to draw any conclusions on causality.

6. Conclusions

Although using a wearable device to successfully promote health and reduce weight is a complex and multistep process with several considerations, [29] our results highlight the feasibility and acceptability of using wearable devices to monitor and track the health of individuals with diabetes. Future interventions should consider the efficacy, scalability, and sustainability of these tools and how to reach those subgroups of individuals with diabetes mellitus to whom current technologies may be unavailable such as those of older age and lower socioeconomic status.

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