

# Activation, Physical Activity, and Outcomes Among Individuals With T2D

Radhika Nair, PhD; Eric Meadows, PhD; Richard Sheer, BA; Ilya Lipkovich, PhD; Jiat-Ling Poon, PhD; Zhenxiang Zhao, PhD; Brian Benneyworth, MD; and Margaret Pasquale, PhD

**M**anagement of type 2 diabetes (T2D), a chronic condition, requires a multipronged approach of diet and exercise along with pharmacological therapies. Studies have reported benefits of physical activity on health-related quality of life (HRQOL),<sup>1</sup> especially in T2D.<sup>2</sup> A review of technology-based interventions, both internet- and smartphone-based programs, has reported improvement in hemoglobin A<sub>1c</sub> (HbA<sub>1c</sub>) levels, diabetes self-management behaviors, and self-efficacy.<sup>3</sup> Similar results in improved HbA<sub>1c</sub> levels were reported in a systematic review and meta-analysis of T2D digital applications.<sup>4</sup> Although these studies have garnered interest, very little is understood about diabetes technology use by older adults and whether increased use of technology improves clinical outcomes and HRQOL.

Patient activation, defined as “the knowledge, skills, ability, and confidence of patients to engage and manage their health,”<sup>5</sup> can play a major role in diabetes management.<sup>6</sup> The underlying premise of patient activation is that individuals are responsible for their health and can therefore have a positive influence on behaviors and outcomes. Studies indicate that patients with higher activation are more likely to adhere to treatment regimens, engage in healthy behaviors, and seek out information to effectively self-manage their chronic conditions.<sup>7-10</sup> Additionally, activated patients can achieve intermediate outcomes such as lowering blood pressure, cholesterol, and HbA<sub>1c</sub> levels to normal ranges.<sup>6,11</sup>

There is no published study evaluating patient activation and physical activity in patients with T2D and the association of these factors with glycemic control and HRQOL. The study explores these associations using data from different sources (claims, survey, fitness tracking) among older adults.

## METHODS

This was an observational, longitudinal cohort study wherein we identified individuals having at least 2 medical claims with a diagnosis of T2D (*International Classification of Diseases, Tenth Revision, Clinical Modification* code E11.x) and at least 1 pharmacy claim for a glucose-lowering medication between January and May 2018.

## ABSTRACT

**OBJECTIVES:** To explore the associations among activation, physical activity, hemoglobin A<sub>1c</sub> (HbA<sub>1c</sub>), and healthy days in older adults with type 2 diabetes (T2D) who participated in wellness programs.

**STUDY DESIGN:** Observational, longitudinal cohort study utilizing survey, claims, and wellness program data.

**METHODS:** From January to May 2018, individuals enrolled in a commercial or Medicare Advantage and prescription drug plan with T2D (aged 55-89 years) and SilverSneakers or step count data were eligible. Three waves of surveys were mailed (n=5000) to collect information on activation (Consumer Health Activation Index; Influence, Motivation, and Patient Activation for Diabetes) and health-related quality of life (Healthy Days). Generalized linear models and predictive models evaluated the associations of unhealthy days and HbA<sub>1c</sub> with physical activity and activation factors. Additional models tested the relationship between physical activity and future acute care visits, accounting for potential confounders via inverse probability of treatment weighting.

**RESULTS:** Respondents to all 3 waves (n = 1147) had higher comorbidity indices but lower HbA<sub>1c</sub> than individuals with T2D without physical activity data ( $P < .0001$ ). Individuals with moderate and high activation levels had 67.4% to 74.0% and 71.6% to 85.6% fewer unhealthy days, respectively, than those with lower activation ( $P < .01$ ). Individuals with high (>8000/day) step counts at baseline were predicted to have 2.04 fewer unhealthy days/month at follow-up ( $P < .05$ ) and 0.19% ( $P < .02$ ) lower HbA<sub>1c</sub> units, respectively, compared with those with less than 4000 steps per day. High SilverSneakers activity (>2 activities per week) reduced subsequent acute care visits by 49%.

**CONCLUSIONS:** Increasing patient activation levels encourages physical activity, which can help improve glycemic control and health-related quality of life, especially among older adults.

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Individuals aged 55 to 89 years were enrolled in a commercial or Medicare Advantage and prescription drug (MAPD) plan as well as a wellness program with fitness tracking. Fitness tracking involved either a daily step count or number of SilverSneakers activities. For step count information, participants who activated a fitness device or used the website to upload step counts were included. SilverSneakers is a fitness program for individuals 65 years and older and is a benefit available through many MA plans.<sup>12</sup> Individuals who were enrolled in the SilverSneakers program and visited the gym or participated in an activity at least 1 time during the identification period were included.

The survey included the Consumer Health Activation Index (CHAI)<sup>13</sup> and the Influence, Motivation, and Patient Activation for Diabetes (IMPACT-D)<sup>14</sup> instruments to assess activation. CHAI is a validated instrument with 10 questions assessing 5 domains (knowledge, self-efficacy, motivation/beliefs, action, and locus of control) to measure an individual's degree of activation with regard to their personal health and health care. The IMPACT-D includes 6 questions about activation specifically designed for diabetes. The raw scores from both CHAI and IMPACT-D were transformed to a scale of 0 to 100, with higher scores indicating greater activation. The CDC's Healthy Days Module<sup>15</sup> was also included in the survey to assess patient-reported HRQOL measured as number of days in the last 30 that their physical or mental health was not good (ie, days they were unhealthy).

The study was designed to have an initial first wave of survey data collection, followed by 2 additional waves of surveys at 3-month intervals to capture short-term, longitudinal information. Respondents of each survey were administered the subsequent survey. The date of response to the first wave of the survey was set as the index date; if missing, we used the postal mailing date of the first survey as the index date. Respondents were enrolled in the health plan for at least 6 months pre- and post index date.

Based on desired sample size ( $n > 300$ ) and response rate of 25% for the first wave and 50% for the subsequent waves, we estimated we would need to mail the survey to 5000 individuals. Among the 251,793 patients with T2D, 18,930 had physical activity information ( $\geq 1$  SilverSneakers activity or uploaded step counts) (Figure). All individuals with step counts recorded from fitness tracking devices ( $n = 931$ ) were included. From the remaining 17,999 patients enrolled in the SilverSneakers program and having at least 1 activity recorded, we randomly selected 4069 individuals, and thereby surveys were mailed to 5000 individuals total. There were 363 of the 931 from the step count group who also qualified with SilverSneakers activity.

### Variables

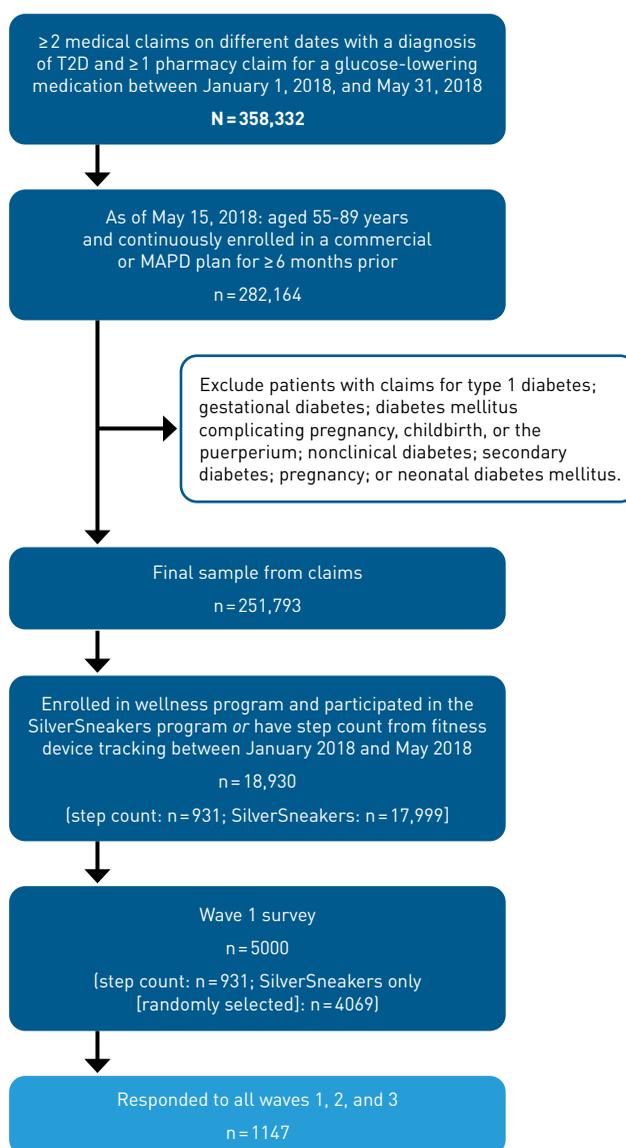
Baseline demographics and comorbidities were evaluated for the 6 months preindex using administrative claims data. Demographic

## TAKEAWAY POINTS

The study combined physical activity data (SilverSneakers and step counts), patient activation (2 instruments), health-related quality of life (HRQOL), and administrative claims data for older adults with type 2 diabetes who participated in a wellness program. This integrated data source confirmed multiple known relationships.

- ▶ Higher activation levels predicted better HRQOL, as measured by fewer unhealthy days.
- ▶ As expected, increased physical activity levels were associated with lower hemoglobin A<sub>1c</sub> levels and predicted fewer unhealthy days and fewer hospitalization and/or emergency department visits.
- ▶ Patient activation levels might be an important consideration in the design and implementation of wellness programs that encourage physical activity and glycemic control.

FIGURE. Sample Selection



MAPD, Medicare Advantage and prescription drug; T2D, type 2 diabetes.

**TABLE 1.** Generalized Linear Model for Association With HbA<sub>1c</sub><sup>a</sup>

Variable	Parameter estimate	Standard error	Pr >  Z	Increase/decrease in HbA <sub>1c</sub>
<b>SilverSneakers activity (ref: &lt; 1/week)</b>				
> 2/week	-0.1010	0.0520	0.0520	-0.10% units
1-2/week	-0.0015	0.0505	0.9758	Not significant
<b>Step count (ref: &lt; 4000/day)</b>				
> 8000/day	-0.2609	0.0919	0.0045	-0.26% units
4000-8000/day	-0.1887	0.0830	0.0229	-0.19% units

HbA<sub>1c</sub>, hemoglobin A<sub>1c</sub>; ref, reference.

<sup>a</sup>Controlling for baseline demographic (age, gender, race, low-income subsidy/dual eligibility) and clinical (diabetes duration, baseline HbA<sub>1c</sub>, Deyo-Charlson Comorbidity Index score, Diabetes Complications and Severity Index score) characteristics. Generalized linear models were estimated using an identity link with a normal error distribution.

variables included age, gender, geographic region, population density (urban, suburban, rural), and plan type (MAPD or commercial). Among those enrolled in MAPD, race was reported and individuals eligible for a low-income subsidy or eligible for Medicare and Medicaid were flagged. Low-income subsidy eligibility applies to Medicare beneficiaries with income below 150% of the poverty level, limited resources, and eligibility for additional premium and cost-share assistance for prescription drugs under the Medicare Part D program. Comorbidity and complication indices included the Deyo-Charlson Comorbidity Index (DCCI)<sup>16-18</sup> and the Diabetes Complications Severity Index (DCSI).<sup>19-21</sup> Time since initial diagnosis of diabetes (diabetes duration) was based on response to a survey question.

CHAI scores were classified as low (< 80), moderate (80-94), and high (≥ 95) activation.<sup>13</sup> IMPACT-D scores were also categorized as low (0-89), moderate (90-99), and high (100) activation. HRQOL was measured as the number of unhealthy days (physical and mental) during the 30 days prior to each survey wave. Survey data from each wave were linked to administrative claims for the prior 3 months, which included HbA<sub>1c</sub> levels and health care resource use (HCRU). HCRU included hospitalizations and emergency department (ED) visits.

Fitness tracking or physical activity was measured as the daily step count or SilverSneakers activity per week for the 3 months prior to and 6 months following the first survey. Using the observed distribution, step counts per day were categorized as follows: low (< 4000), moderate (4000-8000), and high (> 8000). Similar to prior studies,<sup>22,23</sup> we categorized SilverSneakers activities per week into low (< 1), moderate (1-2), and high (> 2) activity levels.

**Analyses**

Baseline demographic and clinical characteristics of individuals who completed all 3 surveys were compared with those of nonresponders and those who did not have physical activity information. Repeated measures generalized linear models (GLMs) were used to evaluate the association of unhealthy days and HbA<sub>1c</sub> as outcomes with physical activity (step count, SilverSneakers activity) and patient activation

(CHAI, IMPACT-D) as covariates. Separate models were run for each type of physical activity (SilverSneakers activity, step count) and activation instrument (CHAI, IMPACT-D). All models controlled for demographic (age, gender) and clinical (baseline HbA<sub>1c</sub>, DCCI score, DCSI score, diabetes duration) characteristics of patients.

Predictive models evaluated the association of physical activity and patient activation with subsequent unhealthy days. Furthermore, GLMs evaluated the impact of physical activity on HCRU (hospitalization and/or ED visits). For these analyses, we used wave 1 as baseline; waves 2 and 3 were combined for the outcome variables. Information on the dependent variable unhealthy days was extracted from the third survey wave. When evaluating the impact of physical activity on HCRU (hospitalization and/or ED visit), step count and SilverSneakers groups (low, moderate, high) were balanced on potential confounders such as demographic measures (including age, sex, race, and population density) and clinical measures (including diabetes duration, DCCI score, and DCSI score) using inverse probability of treatment weighting. The main analyses were restricted to respondents of 3 waves of the survey. This study was approved by Schulman Institutional Review Board (now Advarra) (protocol No. 896).

**RESULTS**

Of the 5000 mailed surveys, 1147 individuals responded to all 3 waves for an overall response rate of 23.0%. When comparing baseline characteristics of respondents with those of individuals with no physical activity information (**eAppendix Table 1** [eAppendix available at [ajmc.com](http://ajmc.com)]), there were some differences in age, area of residence (population density), qualification for low-income subsidy, dual eligibility for Medicare and Medicaid, comorbidity and complication index scores, and glycemic control (all *P* < .0001). Comparing responders and nonresponders, some differences were observed in the proportions eligible for low-income subsidy, dual eligibles, and with HbA<sub>1c</sub> less than 7.0% (*P* < .05). There were minimal differences in diabetes duration, patient activation, and HRQOL across the 3 survey waves (**eAppendix Table 2**).

Individuals with more than 2 SilverSneakers activities per week had 0.10% lower HbA<sub>1c</sub> units compared with those with less than 1 activity per week (*P* = .052) (**Table 1**). Similarly, individuals with moderate step counts (4000-8000 steps per day) and high step counts (> 8000 steps per day) had 0.19% and 0.26% lower HbA<sub>1c</sub> units, respectively, compared with those with fewer than 4000 steps per day (*P* = .02 and *P* < .01, respectively).

Every 1000 additional steps per week were associated with 1.1% fewer unhealthy days (*P* < .01) (**Table 2**). Among individuals with SilverSneakers activity, those with high levels of activation measured using IMPACT-D and CHAI were predicted to have 71.6% and 85.6% fewer unhealthy days, respectively, than patients with low levels of activation (*P* < .01). Similarly, individuals with moderate levels of patient activation measured by IMPACT-D and CHAI were predicted to have 67.4% and 74.0% fewer unhealthy days, respectively, than

those with low levels of activation ( $P < .01$ ). For individuals with step counts, models including the activation variables were not meaningful due to low sample sizes.

In the predictive models for unhealthy days (Table 3), every 1-point increase in an individual's baseline IMPACT-D or CHAI score (0-100 scale) predicted 0.028 and 0.029 fewer unhealthy days, respectively, during the follow-up period. Furthermore, on evaluating physical activity, individuals with high (> 8000/day) and moderate (4000-8000/day) step counts at baseline were predicted to have 2.04 and 1.56 fewer unhealthy days per month at follow-up than individuals with low (< 4000/day) step counts. High SilverSneakers activity (> 2/week) was associated with a 49% lower composite HCRU end point (hospitalization and/or ED visit) (Table 4).

## DISCUSSION

This study successfully demonstrated that data can be integrated from administrative claims, surveys, and a wellness program to assess both clinical and patient-reported outcomes for individuals with T2D, especially among older adults. Although there are challenges in combining different data sources, the additional information can help overcome some of the unmeasured confounders (eg, physical activity, patient activation) inherent in traditional retrospective claims studies.

The associations observed among patient activation, physical activity, HRQOL, and HbA<sub>1c</sub> levels among individuals with T2D provide supportive evidence of the expected relationships in a single, integrated analysis. We observed that physical activity was associated with HRQOL, HbA<sub>1c</sub>, and HCRU. Studies in the literature have reported the benefits of physical activity on HRQOL<sup>1,2</sup> and costs.<sup>22,24</sup> Our results were consistent with the literature and expanded the knowledge base by also controlling for patient activation levels.

In our models controlling for confounding factors including demographics, clinical characteristics, and activation, the association between an increase in physical activity (step count or SilverSneakers) and lower HbA<sub>1c</sub> values (0.10%-0.26%) was small but encouraging. Most clinicians consider 0.5% as a clinically

**TABLE 2.** Repeated Measures Generalized Linear Model for Association With Unhealthy Days<sup>a</sup>

Variable	Parameter estimate	Standard error	Pr >  Z	Exponentiated coefficient (95% CI)	% lower/higher
SilverSneakers Activity per week	-0.0554	0.0429	0.1964	0.95 (0.87-1.03)	-5.4%
Step count (in thousands per week)	-0.0111	0.0038	0.0037	0.99 (0.98-1.00)	-1.1%
<b>Among those with SilverSneakers activity</b>					
IMPACT-D score (ref: low)					
High	-1.2599	0.3246	0.0001	0.28 (0.15-0.54)	-71.6%
Moderate	-1.1195	0.2813	<0.0001	0.33 (0.19-0.57)	-67.4%
CHAI score (ref: low)					
High	-1.9367	0.4577	<0.0001	0.14 (0.06-0.35)	-85.6%
Moderate	-1.3472	0.2567	<0.0001	0.26 (0.16-0.43)	-74.0%

CHAI, Consumer Health Activation Index; HbA<sub>1c</sub>, hemoglobin A<sub>1c</sub>; IMPACT-D, Influence, Motivation, and Patient Activation for Diabetes; ref, reference.

<sup>a</sup>Controlling for baseline demographic (age, gender, race, low-income subsidy/dual eligibility) and clinical (diabetes duration, baseline HbA<sub>1c</sub>, Deyo-Charlson Comorbidity Index score, Diabetes Complications and Severity Index score) characteristics.

Generalized linear models were estimated using a negative binomial error distribution and a log link; the exponentiated parameter estimate is the multiplicative effect of a 1-unit increase in the independent variable on the number of unhealthy days.

**TABLE 3.** Predictive Model for Unhealthy Days (HRQOL)<sup>a</sup>

Variable	Parameter estimate	95% confidence limits	P
IMPACT-D score	-0.0283	-0.06 to -0.00	.0433
CHAI score	-0.0292	-0.05 to -0.01	.0046
Step counts > 8000/day (ref: < 4000/day)	-2.0358	-3.90 to -0.17	.0327
Step counts 4000-8000/day (ref: < 4000/day)	-1.5597	-3.07 to -0.05	.0413
SilverSneakers > 2/week (ref: < 1/week)	-0.0846	-0.75 to 0.58	.8128
SilverSneakers 1-2/week (ref: < 1/week)	-0.0668	-0.71 to 0.58	.8497

CHAI, Consumer Health Activation Index; HRQOL, health-related quality of life; IMPACT-D, Influence, Motivation, and Patient Activation for Diabetes; ref, reference.

<sup>a</sup>Generalized linear models were estimated using a negative binomial distribution and a log link. Parameter estimates indicate the change in unhealthy days for each 1-unit increase in the individual covariates.

**TABLE 4.** Generalized Linear Models for Health Care Resource Utilization (hospitalization and/or emergency department visit)<sup>a</sup>

Variable	Parameter estimate	Odds ratio (95% confidence limits)	P
Step counts > 8000/day (ref: < 4000/day)	-0.3202	0.73 (0.30-1.76)	.3960
Step counts 4000-8000/day (ref: < 4000/day)	-0.3595	0.70 (0.31-1.58)	.4890
SilverSneakers > 2/week (ref: < 1/week)	-0.6694	0.51 (0.32-0.82)	.0047
SilverSneakers 1-2/week (ref: < 1/week)	-0.3682	0.69 (0.46-1.05)	.0849

<sup>a</sup>Groups based on step counts and SilverSneakers activity were balanced on baseline demographic (age, gender, race, population density) and clinical (diabetes duration, Deyo-Charlson Comorbidity Index score, Diabetes Complications and Severity Index score) characteristics using inverse probability of treatment weighting. Generalized linear models were estimated using a binomial distribution and a logit link. Exponentiated parameter estimates yield odds ratios, which are interpreted as the odds of a hospitalization and/or emergency department visit occurring for that level of the covariate compared with the reference level specified.

meaningful change.<sup>25</sup> The literature is mixed regarding benefits of physical activity and glycemic levels. Meta-analyses and systematic reviews<sup>26-29</sup> have reported the benefits of physical activity as measured by glycemic level-lowering effects, especially among those with diabetes, whereas other studies<sup>30</sup> have shown no benefit.

Physical activity was inversely associated with unhealthy days, even after controlling for potentially confounding variables. Increased activity predicted fewer unhealthy days, which indicates better QOL. Hamar and colleagues,<sup>1</sup> evaluating the SilverSneakers program, reported its benefits in improving the physical and emotional health of seniors. Their study included all seniors and was not restricted to any disease state. Specifically for diabetes, Çolak et al<sup>2</sup> reported benefits of physical activity on QOL.

Similarly, higher activation levels measured with CHAI and IMPACT-D were associated with fewer unhealthy days than lower activation levels. After controlling for other confounding variables, individuals with low activation levels had 2 to 3 times more unhealthy days than individuals with moderate to high activation levels. Although no studies have specifically evaluated the relationship between patient activation measured with CHAI or IMPACT-D and HRQOL, other studies have evaluated the positive relationship between HRQOL and activation measured with other instruments.<sup>8,31,32</sup>

Finally, greater SilverSneakers activity (> 2/week) was associated with a decrease in hospitalization and/or ED visits. These results are similar to those of previous reports, which stated that increased SilverSneakers activity predicted lower costs,<sup>22,24</sup> which is usually due to decreased HCRU—particularly hospitalization, which often accounts for a majority of the costs. Although not directly comparable because of differences in study population and methods, our results were consistent.

In prior studies evaluating physical activities in the overall population, the mean age was usually younger (approximately 40-50 years).<sup>24,33,34</sup> However, Nguyen et al, who evaluated benefits of SilverSneakers among those with diabetes, noted the mean age of their study's participants to be approximately 72 years,<sup>22</sup> similar to the current study (approximately 71 years). Whereas SilverSneakers-related studies are focused on the older population given the program parameters, most studies related to step counts usually include a younger population.<sup>34</sup> In the current study, because the majority of the respondents were enrolled in MAPD plans (~95%) and participated in the SilverSneakers program, the mean age seems to be in alignment.

The survey respondents had slightly higher DCCI scores, indicating a higher comorbidity burden, but lower HbA<sub>1c</sub> values than individuals with T2D and without fitness tracking. Given that approximately a quarter of the patients had moderate to severe diabetes-related complications, it was encouraging to see participation in physical activities. Similar to other population-based studies,<sup>35,36</sup> at baseline, 57% of the respondents had HbA<sub>1c</sub> less than 7.0%. Lipska and colleagues,<sup>35</sup> who evaluated more than 1 million commercial and MAPD members with diabetes between 2006 and 2013, reported that 54.2% to 56.4% of these patients had

HbA<sub>1c</sub> less than 7.0%. Similarly, Dodd et al,<sup>36</sup> based on data from the National Health and Nutrition Examination Survey from 1999 to 2004, found that approximately 52% of the population with diabetes had HbA<sub>1c</sub> less than 7%.

Patient activation scores and number of unhealthy days did not vary across the 3 survey waves. Lack of variability across time for patient activation and unhealthy days may indicate that respondents did not experience any major events during the study period that affected their activation or QOL. Patient activation was measured using 2 instruments, namely CHAI and IMPACT-D. Whereas CHAI has been validated and has established thresholds for determining level of activation, IMPACT-D is a new instrument and does not yet have established thresholds for interpretation. We observed some ceiling effects with IMPACT-D, with the high activation category defined as those with a maximum score.

In contrast to the patient activation scores, the physical activity levels varied by time period. This might be due to the seasonality, with a decrease in physical activities during the November-January months due to cold weather or the holiday season. However, it should be noted that the mean step count per day was 5000 to 6000, which is comparable with the mean step count among young adults.<sup>37-41</sup> Some studies have considered young adults with mean steps of 5000 to 7499 steps per day as having low levels of activity. However, among older adults, the mean steps per day can range between 2000 and 9000 and are dependent on various factors including chronic comorbidities and disabilities.<sup>40</sup> Although our population was predominantly 65 years and older, it might indicate that the study population was more physically active than others of comparable age. Still, only half the population consistently had at least 1 SilverSneakers activity per week and the proportions decreased slightly during the third wave (November-January), similar to step counts. For future studies, at least 1 year of physical activity data could be needed to account for seasonality.

## Limitations

Common limitations observed in administrative claims data, such as potential errors in coding, omissions in claims data, and unmeasured clinical, economic, or behavioral factors, may affect results. This study utilized data with a Medicare-rich population, so the results may not be generalizable, particularly for younger individuals in commercial plans. Although the study data were drawn from a large national health plan with individuals enrolled throughout the United States, the results may not be generalizable to the overall US population, specific subpopulations in certain geographic regions, or different health plans.

No causal inference can be ascertained from the results because this was a nonrandomized study using data observed in a noninterventional setting. Additionally, lack of medical record information not available in claims makes it difficult to understand the impact of this information on diagnosis, treatment, and outcomes. Lifestyle factors including smoking, sleep habits, diet, and body mass index, which are important in the management of T2D, were not available.

The study evaluated individuals with HbA<sub>1c</sub> laboratory values pre- and post index, which were not available for the entire sample. Those who did not have some or all laboratory values may differ from individuals with all laboratory values available in the data.

We obtained some information, such as patient activation, HRQOL, and diabetes history, using a survey. Individuals who responded to all 3 waves may differ from the nonrespondents in ways beyond the variables available from administrative claims and the wellness program. Compared with nonrespondents, the respondents were similar in age, although fewer individuals were dually eligible and/or low-income subsidy eligible. Almost double (~10%) the individuals without physical activity were located in rural areas compared with those reporting physical activity (~5%), potentially indicative of disparities in access to facilities in rural areas compared with urban/suburban locations. Glycemic control was better in respondents compared with nonrespondents.

On comparing respondents with those without physical activity data, we observed that the respondents were slightly younger, with a higher comorbidity burden and better glycemic control. There might be other differences between these groups beyond the data available for evaluation. For example, it is possible that those without physical activity information may actually be more active than the respondents. Because of the modest, but important, differences between our study population and the overall population with T2D, potential selection bias needs to be considered in any future study implementing similar methods. Finally, the short duration of the study (6 months preindex and 6 months post index) may not have been sufficient to see substantial changes or patterns over time. However, to minimize attrition, we intentionally designed the study to be short term, relative to annual enrollment periods.

## CONCLUSIONS

In this study, a prospective survey, wellness program data, and administrative claims were successfully integrated. The associations between variables were consistent with expected relationships and contributed additional evidence from IMPACT-D, a new diabetes-specific measure of patient activation. Although this study was exploratory, its findings set the foundation for future research in understanding the influence of patient activation and physical activity on health outcomes among older adults with T2D. ■

**Author Affiliations:** Humana Healthcare Research Inc (RN, RS, MP), Louisville, KY; Eli Lilly and Company (EM, IL, JLP, ZZ, BB), Indianapolis, IN.

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**Author Disclosures:** Drs Nair and Pasquale were employed by Humana Healthcare Research at the time of the study and own stock in Humana Inc. Mr Sheer is employed by Humana Healthcare Research and owns stock in Humana Inc. Humana Healthcare Research received funding to conduct this study. Drs Meadows and Zhao were previously employed by and owned stock in Eli Lilly and Company, which manufactures medicines for the treatment of diabetes. Drs Lipkovich, Poon, and Benneyworth are employed by and own stock in Eli Lilly and Company.

**Authorship Information:** Concept and design (RN, EM, IL, JLP, ZZ, MP); acquisition of data (RN, EM, RS, ZZ, MP); analysis and interpretation of data (RN, EM, RS, IL, JLP, ZZ, BB, MP); drafting of the manuscript (RN, EM, BB); critical revision of the manuscript for important intellectual content (RN, EM, RS, IL, JLP, ZZ, BB, MP); statistical analysis (RS); provision of patients or study materials (RN, EM, RS, ZZ, MP); obtaining funding (ZZ, MP); administrative, technical, or logistic support (RN); and supervision (RN, MP).

**Address Correspondence to:** Richard Sheer, BA, Humana Healthcare Research Inc, 500 W Main St, Louisville, KY 40202. Email: rsheer1@humana.com.

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## eAppendix

Given the exploratory nature of the study and based on an initial sample size calculation for a cross-sectional evaluation at the significance level of 0.05, with the null hypothesis correlation of 0.5 and alternative correlation of 0.6, a one-sided test estimated we would need a sample of 302 people yielding a power of 80%. Expecting a 25% response rate to the first wave and 50% for the subsequent 2 waves, we estimated we would need an initial sample of ~5,000 patients.

**eAppendix Table 1: Comparing baseline demographic and clinical characteristics of survey respondents to those with no physical activity information**

Baseline Characteristics	With Type 2 Diabetes Mellitus				
	Survey Respondents (with physical activity information)	Survey Non-Respondents (with physical activity information)	<i>P</i> value <sup>b</sup>	Individuals with no physical activity information	<i>P</i> value <sup>c</sup>
N	1,147			232,761	
<b>Demographic Characteristics</b>					
Age, years; Mean (SD)	70.8 (7.0)	70.2 (7.3)	0.0112	72.0 (7.6)	<0.0001
Median [Q1-Q3]	71 [67 - 76]	70 [65 - 75]		72 [67 - 77]	
Sex; n (%)					
Male	553 (48.2%)	1,723 (52.6%)	0.0017	106,757 (45.9%)	0.7511
Female	594 (51.8%)	1,488 (45.4%)		119,657 (51.4%)	
Unknown	--	64 (2.0%)		6,347 (2.7%)	
Geographic Region; n (%)			<0.0001		<0.0001
Northeast	17 (1.5%)	61 (1.9%)		5,573 (2.4%)	
Midwest	237 (20.7%)	512 (15.6%)		40,127 (17.2%)	
South	814 (71.0%)	2,435 (74.4%)		163,362 (70.2%)	
West	78 (6.8%)	201 (6.1%)		17,255 (7.4%)	
Population Density; n (%)			0.0037		<0.0001
Urban	828 (72.2%)	2,344 (71.6%)		143,413 (61.6%)	
Suburban	222 (19.4%)	601 (18.4%)		55,008 (23.6%)	
Rural	57 (5.0%)	148 (4.5%)		22,656 (9.7%)	
Unknown	40 (3.5%)	182 (5.6%)		11,684 (5.0%)	
Health Plan Type; n (%)			0.9034		<0.0001
MAPD	1,090 (95.0%)	2,973 (90.8%)		227,336 (97.7%)	
Commercial	57 (5.0%)	300 (9.2%)		5,425 (2.3%)	
Plan Characteristics (MAPD only)					
Low-Income Subsidy; n (%) <sup>a</sup>	190 (17.4%)	706 (23.7%)	0.0003	78,343 (34.5%)	<0.0001
Dual Eligible for Medicaid and Medicare; n (%) <sup>a</sup>	143 (13.1%)	520 (17.5%)	0.0054	58,421 (25.7%)	<0.0001

Baseline Characteristics	With Type 2 Diabetes Mellitus				
	Survey Respondents (with physical activity information)	Survey Non-Respondents (with physical activity information)	P value <sup>b</sup>	Individuals with no physical activity information	P value <sup>c</sup>
<b>Clinical Characteristics</b>					
Deyo Charlson Comorbidity Index					
Mean (SD)	3.7 (2.3)	3.8 (2.5)	0.2187	3.0 (2.5)	<0.0001
Median [Q1-Q3]	3 [2 - 5]	3 [2 - 5]		3 [1 - 5]	
Diabetes Complication Severity Index (DCSI);					
Mean (SD)	2.3 (1.8)	2.4 (1.9)	0.4753	1.8 (1.8)	<0.0001
Median [Q1-Q3]	2 [1 - 3]	2 [1 - 4]		1 [0 - 3]	
DCSI Score Category; n (%)			0.1289		
Very Low Severity (DCSI Score 0-1)	429 (37.4%)	1,238 (37.8%)		118,588 (50.9%)	<0.0001
Low Severity (DCSI Score 2-3)	448 (39.1%)	1,184 (36.2%)		73,064 (31.4%)	
Moderate Severity (DCSI Score 4-7)	262 (22.8%)	812 (24.8%)		39,851 (17.1%)	
High Severity (DCSI Score 8-13)	8 (0.7%)	41 (1.3%)		1,258 (0.5%)	
Hemoglobin A1c					
	<i>n=856</i>	<i>n=2,245</i>		<i>n=130,533</i>	
Mean (SD) %	6.9 (1.2)	7.2 (1.3)	<0.0001	7.3 (1.5)	<0.0001
Median [Q1-Q3] %	6.8 [6.1 - 7.5]	6.9 [6.3 - 7.8]		7.0 [6.3 - 8.0]	
< 7.0%; n (%)	492 (57.5%)	1,153 (51.4%)	<0.0001	64,003 (49.0%)	<0.0001
≥ 7.0%; n (%)	364 (42.5%)	1,092 (48.6%)	0.3185	66,530 (51.0%)	0.0184
≥ 8.0%; n (%)	122 (14.3%)	513 (22.9%)	<.0001	32,635 (25.0%)	0.0010
≥ 9.0%; n (%)	43 (5.0%)	222 (9.9%)	0.0002	15,770 (12.1%)	<0.0001

<sup>a</sup> Assignment was limited to Medicare Advantage patients. <sup>b</sup> Comparing survey responders and non-responders

<sup>c</sup> Comparing survey responders and individuals with no physical activity information

SD – Standard Deviation; MAPD – Medicare advantage and prescription drug plan; DCSI - Diabetes Complication Severity Index

**eAppendix Table 2: Survey responses and physical activity information for each survey wave**

	<b>Wave 1</b>	<b>Wave 2</b>	<b>Wave 3</b>
<b>Survey Responses, n</b>	<b>1,720</b>	<b>1,455</b>	<b>1,150<sup>‡</sup></b>
<b>Diabetes History</b>	<i>n</i> = 1,672	<i>n</i> = 1,411	<i>n</i> = 1,116
< 5 years	322 (19.3%)	238 (16.9%)	132 (11.8%)
5-10 years	405 (24.2%)	354 (25.1%)	300 (26.9%)
11-15 years	316 (18.9%)	284 (20.1%)	227 (20.3%)
>15 years	629 (37.6%)	535 (37.9%)	457 (40.9%)
<b>Patient Activation or Motivation</b>			
<b>IMPACT-D™</b>	<i>n</i> = 1,597	<i>n</i> = 1,363	<i>n</i> = 1,078
Mean (SD)	91.3 (10.0)	92.3 (9.3)	92.5 (9.4)
Median [IQR]	95 [86 - 100]	95 [86 - 100]	95 [86 - 100]
Low (0-89)	480 (30.1%)	361 (26.5%)	275 (25.5%)
Moderate (90-99)	555 (34.8%)	480 (35.2%)	366 (34.0%)
High (100)	562 (35.2%)	522 (38.3%)	437 (40.5%)
<b>CHAI</b>	<i>n</i> = 1,637	<i>n</i> = 1,387	<i>n</i> = 1,102
Mean (SD)	82.6 (13.3)	83.8 (13.1)	83.8 (12.0)
Median [IQR]	84 [76 - 92]	86 [76 - 94]	84 [78 - 92]
Low (0-79)	546 (33.4%)	424 (30.6%)	333 (30.2%)
Moderate (89-94)	788 (48.1%)	669 (48.2%)	556 (50.5%)
High (95-100)	303 (18.5%)	294 (21.2%)	213 (19.3%)
<b>Health-related Quality of Life - Healthy Days</b>			
<b>Total Unhealthy Days</b>	<i>n</i> = 1,563	<i>n</i> = 1,363	<i>n</i> = 1,073
Mean (SD)	6.8 (10.1)	6.1 (9.7)	6.3 (9.5)
<b>Physically Unhealthy Days</b>	<i>n</i> = 1,600	<i>n</i> = 1,386	<i>n</i> = 1,087
Mean (SD)	4.7 (8.3)	4.3 (8.0)	4.4 (7.8)
<b>Mentally Unhealthy Days</b>	<i>n</i> = 1,621	<i>n</i> = 1,398	<i>n</i> = 1,112
Mean (SD)	3.2 (6.9)	2.8 (6.5)	2.8 (6.5)
<b>Physical Activity</b>			
<b>Step Count (per day)</b>	<i>n</i> = 296	<i>n</i> = 281	<i>n</i> = 235
Mean (SD)	5,612 (4,078)	5,730 (4,127)	5,178 (3,895)
Median [IQR]	4,716 [2,890 – 7,705]	4,886 [2,918 – 7,881]	4,389 [2,104 – 7,583]
<4,000 steps per day	116 (39.2%)	113 (40.2%)	110 (46.8%)
4,000-8,000 steps per day	110 (37.2%)	100 (35.6%)	71 (30.2%)
>8,000 steps per day	70 (23.7%)	68 (24.2%)	54 (23.0%)
<b>SilverSneakers ®(per week)</b>	<i>n</i> = 1,024	<i>n</i> = 970	<i>n</i> = 658
Mean (SD)	1.3 (1.2)	1.4 (1.2)	0.7 (0.6)
Median [IQR]	1 [0 - 2]	1 [0 - 2]	1 [0 - 1]
<1 per week	495 (48.3%)	465 (47.9%)	482 (73.3%)
1-2 per week	265 (25.9%)	245 (25.3%)	143 (21.7%)
>2 per week	264 (25.8%)	260 (26.8%)	33 (5.0%)

IMPACT-D™ - Influence, Motivation, and Patient Activation for Diabetes, CHAI - Consumer Health Activation Index; SD – standard deviation; IQR - Interquartile range  
<sup>‡</sup> - 3 respondents sent survey during third wave only.