Relating Activity and Participation Levels to Glycemic Control, Emergency Department Use, and Hospitalizations in Individuals With Type 2 Diabetes

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IN BRIEF Participation in domestic, leisure, work, and community-based activities may relate to glycemic control, emergency department use, and hospitalizations in individuals with type 2 diabetes and low socioeconomic status. This study sought to determine how such role-related activity levels relate to A1C, emergency department use, and hospitalizations.

The prevalence of diabetes continues to rise, affecting 30.3 million individuals, or nearly 1 in 10 Americans (1). In adults, type 2 diabetes accounts for 90–95% of all diagnosed cases of diabetes (1). Approximately 37% of individuals with diabetes do not follow the recommended guidelines (e.g., daily self-monitoring of blood glucose) to manage their disease (1), which can lead to serious health complications. Poorly managed type 2 diabetes is often defined by elevated A1C, which reflects average blood glucose over ~3 months and has a strong predictive value for diabetes complications (2). As an indicator of diabetes management, A1C ≤7% is the preeminent benchmark of successful treatment to reduce the risk of diabetes-related complications (2). In addition to increasing the risk for disease progression, comorbidity development, and death, a sustained abnormal A1C value (>7%) is associated with increased risk for greater health care utilization (HCU) (3). Elevated A1C has been associated with poor adherence to known healthy self-care behaviors, including diet (4), exercise (5), medication management (6), and monitoring of blood glucose (7). Furthermore, poor type 2 diabetes management results in 32% of hospitalizations for individuals with diabetes (8) and accounts for more than $16 billion in preventable health care costs (9).

Factors affecting adherence to healthy diet, exercise, medication management, and glucose monitoring must be better understood. Much of the work to identify variables related to or predictive of self-management of type 2 diabetes has focused on demographic characteristics. For example, individuals who are minorities, poor, or less educated are more likely to have lower adherence to healthy self-care behaviors required for successful diabetes management (10). Importantly, this research has concluded that individuals with these characteristics experience disparities in health care and social supports in ways that negatively affect their ability to appropriately manage diabetes. Furthermore, these disparities appear to contribute to higher HCU for reasons potentially preventable with proper self-management of type 2 diabetes. In particular, individuals with low socioeconomic status (SES) and/or who are minorities tend to have higher rates of emergency department (ED) visits and hospital admissions for non-urgent or preventable health conditions (11,12).

Although the link between demographic characteristics and dia-

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betes management and related HCU is important, we must not rely on race, ethnicity, and SES as the only explanatory variables for whether an individual will adhere to healthy self-care behaviors for type 2 diabetes. Additionally, authors of a recent review of diabetes self-management research indicated that longstanding focus on diet, exercise, and medication management does not facilitate sustainable lifestyle changes to normalize A1C and reduce HCU (13). Based on this review, the new science of diabetes self-management must expand to evaluate participation levels in daily domestic, leisure, work, and community-based activities that may thwart or promote disease progression within this population (13). Here, we refer to these activities as "role-related daily activities," because participation in them is necessary for the fulfillment of life roles. Role-related daily activities may compete for time and resources required for healthy diabetes self-management behaviors. For example, an individual who experiences challenges in balancing activities associated with work and domestic roles may be at increased risk for poor adherence to diet and blood glucose monitoring tasks that are important to diabetes management.

A large body of research demonstrates that disability after acute injuries, such as traumatic brain injury, stroke, or spinal cord injury, is associated with deficits in daily domestic, leisure, work, and community-based activities and that continued inactivity in these areas promotes further disability in life roles (14–16). A similar process likely exists in chronic diseases such as type 2 diabetes; however, substantial data about role-related activity limitations and participation restrictions are lacking within the type 2 diabetes population. In short, the field needs objective data on how individuals with type 2 diabetes are carrying out their life roles and how aspects of daily domestic, leisure, work, and community-based activities may relate to A1C management and aspects of costly HCU (i.e., ED use and hospitalizations). In the absence of such information, existing self-management approaches may miss a crucial component of daily living: the role-related activities that activate, motivate, and organize the individual.

The purpose of this study was to examine relationships between activity/participation levels and dependent variables of A1C, ED use, and hospitalizations in individuals with type 2 diabetes and low SES. We also sought to examine how demographic variables, number of doctor visits, and number of medications relate to these dependent variables. The following research questions (RQs) guided this study: In individuals with type 2 diabetes who have low SES, how do activity/participation levels in role-related daily activities, number of doctor visits and medications, and demographics relate to *1*) blood glucose levels as measured by A1C (RQ1) and *2*) ED visits (RQ2a) and hospital overnight stays (RQ2b) over the preceding 6 months?

Materials and Methods

Participants

This study applied a cross-sectional design with a convenience sample. Participants included patients seen at a large family medicine center. The family medicine center provides primary care services to a safety net population (i.e., underserved individuals who have lower SES and limited health resources). Recruitment of participants occurred through referral from primary care health providers at the family medicine center and through the use of flyers. To be included in the study, participants were required to have been previously diagnosed with type 2 diabetes, be ≥18 years of age, and be a patient at the family medicine center. Exclusion criteria were a reading level below sixth grade and an inability to understand written or verbal instructions regarding questionnaires. All participants provided written informed consent, and all study procedures were approved by the local institutional review board.

Procedure

Participants completed the following activity/participation questionnaires administered at the family medicine center by an occupational therapist: Frenchay Activities Index (FAI), Community Integration Questionnaire (CIQ), International Physical Activity Questionnaire (IPAQ), and the Michigan Diabetes Knowledge Test (DKT). Demographic (age, sex, race/ethnicity, and comorbidities) and numbers of ED visits, hospital overnight stays, doctor visits, and medications were also collected. Each patient's most recent A1C value was obtained from the electronic medical record.

Measures

Instrumental activities of daily living were assessed using the FAI. The FAI assesses 15 activities in three domains: domestic (e.g., preparing meals, laundry, or cleaning house), leisure/work (e.g., pursuing a hobby, participating in social occasions, or working at a job), and outdoor (e.g., local shopping, driving, or gardening). Individuals are asked to rate how often they perform activities. The FAI has good test-retest reliability (r = 0.96) in the general population aged ≥16 years (17).

Social integration within the home and community was assessed using the CIQ. The CIQ assesses frequency of participation in three domains: home integration (e.g., who cares for children in the home?), social integration (e.g., how often do you visit friends?), and productive activity (e.g., work). Also, the CIQ has good reliability and validity (18). Because the majority of our sample was unemployed, we did not assess the productivity domain.

The International Physical Activity Questionnaire–Short Form (IPAQ-SF) was used to assess physical activity and sedentary behavior. The IPAQ-SF has good reliability and validity (19).

We included the Michigan DKT because knowledge about diet, blood glucose, and comorbidities is important to practicing healthy activities and routines. The Michigan DKT contains questions pertaining to healthy diet, blood glucose monitoring, exercise, and health complications associated with diabetes and is a reliable and valid measure (20).

Statistical Analyses

For each RQ, two primary analyses were conducted: means comparisons and multivariate hierarchical regression. For RQ1, to assess how activity/participation levels in role-related daily activities; number of ED visits, hospitalizations, doctor visits, and medications; and demographics differ between patients who met the American Diabetes Association (ADA) goal of A1C <7% versus those who did not (i.e., A1C >7%), means comparisons were conducted using separate independent samples *t* tests. When the dependent variable was categorical, the Pearson χ^2 test was used with effect size (Cramérs *V*: 0.1 = small, 0.3 = medium, and 0.5 = large effect size). If the assumption of equal variances was not met, the non-parametric equivalent, Mann-Whitney *U* test, was applied with effect size Eta^2 (η^2: 0.01 = small, 0.06 = medium, and 0.14 = large effect size). This occurred in two cases: hospital overnight stays and ED visits.

Additionally, we examined how activity/participation levels in role-related daily activities, number of doctor visits and medications, and demographics relate to ED visits (RQ2a) and hospital visits (RQ2b) over the preceding 6 months. Mean comparisons were conducted using separate independent sample *t* tests to examine differences on each demographic variable, doctor visits and medications, and activity/participation variable between ED users and non-users (RQ2a) and hospital visitors and non-visitors (RQ2b). Effect size was calculated using Cohen's *d* (0.2 = small, 0.5 = medium, and 0.8 = large effect size). The χ^2 statistic was used when the dependent variable was categorical.

Separate three-stage hierarchical linear regressions were conducted for each continuous dependent variable: A1C raw score (RQ1), number of ED visits in the preceding 6 months (RQ2a), and number of hospital overnight stays in the preceding 6 months (RQ2b). Demographic variables (age, sex, minority status, and number of comorbidities) were entered at stage 1. Number of medications, number of ED visits, doctor visits, and hospital overnight stays in the preceding 6 months were entered at stage 2. Activity/participation and diabetes knowledge variables (FAI, IPAQ, Michigan DKT, and CIQ) were entered at stage 3.

Results

A total of 93 subjects participated in the study (48 women, 45 men; average age 58.6 ± 11.4 years; 68% white non-Hispanic, 31% Hispanic; 69% with annual income <$20,000). Demographic data according to A1C classification, ED visitors versus non-visitors, and hospital visitors versus non-visitors are provided in the tables specified in the sections below.

RQ1 Results: Relation of Activity/Participation; Number of ED Visits, Hospitalizations, Doctor Visits, and Medications; and Demographics to A1C

A1C values were available for 79 individuals in the sample (85%), and the remaining 14 (15%) did not have a recent A1C in the medical record. The average A1C value was 7.21%, with 43% (*n* = 34) of the sample not meeting the ADA goal of A1C <7%. Table 1 displays demographics; number of ED visits, hospitalizations, doctor visits, and medications; and activity/participation comparing individuals who met the ADA goal versus those who did not. Overall, demographic makeup; number of ED visits, hospitalizations, doctor visits, and medications; and activity/participation levels did not significantly differ between these groups, with three exceptions. First, the proportion of minorities (21 of 35, 60.0%) with A1C values >7% was significantly higher (χ^2_3 = 7.386, *P* = 0.007; *V* = 0.31) than non-minorities (22 of 55, 38.6%). Second, individuals with A1C values >7% visited the ED significantly more than individuals with A1C values <7% (mean = 1.9 vs. 0.8, respectively; *U* = 566.0, *P* = 0.026, η^2= 0.06). Third, the number of hospital overnight stays in the preceding 6 months was significantly greater (*U* = 617.0, *P* = 0.041, η^2= 0.05) for individuals who did not meet the A1C goal ($\bar{x}$ = 5.3 nights) than for individuals who did meet the goal ($\bar{x}$ = 0.5 nights). A binary logistic regression analysis was conducted to predict whether the A1C goal of <7% was met based on demographic variables; number of ED visits, hospitalizations, doctor visits, and medications; and activity/participation levels. A test of the full model was significant, indicating the predictors, as a set, reliably distinguished between A1C goal met versus goal not met (χ^2_{14}= 26.86, *P* = 0.02). The model explained 39.2% (Nagelkerke R^2) of the variance in whether or not the A1C goal was met and correctly classified 73.1% of cases. Minority status significantly predicted A1C goal status, with minorities being 0.21 times less likely than non-minorities to have an A1C value <7% (*B* = –1.57, *P* = 0.02). FAI domestic score also significantly predicted A1C goal status, with individuals having a higher FAI domestic score being 1.5 times more likely to have an A1C value >7% (*B* = 0.42, *P* = 0.02).

RQ2a Results: Relation of Activity/Participation; Number of ED Visits, Hospitalizations, Doctor Visits, and Medications; and Demographics to ED Visits

Individuals in our sample visited the ED an average of 1.35 times (SD 2.55; range 0–15) over the preceding 6 months. Table 2 displays demographics; number of ED visits, hospi-

TABLE 1. Demographic, HCU, and Activity/Participation Findings Between A1C Classifications (Total n = 79)

Variable	A1C Classification: A1C <7% (goal met)	A1C Classification: A1C >7% (goal not met)	Statistic[a]	P
Participants, *n* (%)	45 (57.0)	34 (43.0)		
Age, mean (SD), years	58.9 (10.53)	58.9 (11.85)	0.023	0.982
Female, *n* (% of females in study)	24.0 (57.1)	18.0 (42.9)	$0.001\chi^2$	0.972
Male, *n* (% of males in study)	21.0 (56.8)	16.0 (43.2)		
Minority, *n* (% of minorities in study)	11 (57.1)	18 (42.9)	$7.386\chi^2$	0.007
Non-minority, *n* (% of non-minorities in study)	34 (69.4)	15 (30.6)		
Number of comorbidities, mean (SD)	2.9 (1.80)	3.2 (2.28)	–0.53	0.598
Number of doctor visits, mean/past 6 months (SD)	5.3 (4.26)	5.2 (3.89)	0.176	0.861
Number of ED visits, mean/past 6 months (SD)	0.8 (1.57)	1.9 (3.57)	566.0U	0.026
Number of hospital overnight stays, mean/past 6 months (SD)	0.5 (1.39)	5.3 (15.69)	617.0U	0.041
Number of medications, mean (SD)	9.4 (6.07)	7.9 (3.92)	1.332	0.187
IPAQ time in sitting, mean (SD) minutes/week	404.0 (278.84)	355.5 (271.90)	0.774	0.442
IPAQ total METs, mean/week (SD)	3,661.4 (5,540.05)	3,434.3 (5,519.33)	0.181	0.857
FAI domestic score, mean (SD) out of 15	11.2 (3.66)	11.9 (3.06)	–0.813	0.419
FAI leisure/work score, mean (SD) out of 15	7.5 (3.43)	7.3 (3.01)	0.323	0.747
FAI outdoor score, mean (SD) out of 15	9.6 (3.12)	9.4 (3.21)	0.283	0.778
FAI total score, mean (SD) out of 45	28.4 (8.54)	28.6 (7.68)	–0.101	0.92
Diabetes Knowledge Test score, mean (SD) out of 14	9.7 (2.52)	9.8 (2.21)	–0.207	0.837
CIQ-home, mean (SD) out of 10	6.4 (2.92)	6.3 (2.46)	0.174	0.863
CIQ-social, mean (SD) out of 12	8.0 (2.51)	8.0 (2.23)	–0.082	0.935

[a]*t Values from independent samples. t Tests are reported for all variables with three exceptions: minority status and sex used the* χ^2 *test to compare categorical data, and when the assumption for equal variances across A1C categories was not met, the Mann-Whitney U test was used.*

talizations, doctor visits, and medications; and activity/participation data for ED visitors versus non-visitors. Individuals who visited the ED (versus those who did not) had a lower age (mean = 53.3 vs. 62.7 years, t_{91} = 4.314, P<0.001, d = 0.91), had more comorbidities (mean = 3.7 vs. 2.7, t_{91} = –2.656, P = 0.009, d = 0.55), had more doctor visits (mean = 7.2 vs. 4.1 visits, t_{91} = –3.666, P<0.001, d = 0.75), spent more nights in the hospital (mean = 8.0 vs. 0.0, t_{40} = –2.650, P = 0.011, d = 0.59), and had a lower FAI total score (mean = 25.7 vs. 29.7, t_{91} = 2.432, P = 0.017, d = 0.51). Within the FAI domains, leisure/work (mean = 6.5 vs. 7.9, t_{91} = 2.086, P = 0.040, d = 0.44) and outdoor (mean = 8.3 vs. 10.1, t_{91} = 2.724, P = 0.008, d = 0.57) scores were significantly lower for ED visitors than for non-visitors. The between-groups difference in IPAQ sedentary time was nearly significant (t_{91} = –1.974, P = 0.051, d = 0.40), with a trend for ED visitors spending more time sitting than non-ED visitors (mean = 458.8 vs. 342.6 minutes per weekday, respectively).

Results of the hierarchical multiple linear regression are displayed in Table 3. At stage 1, demographic data contributed to a significant regression model ($F_{4,75}$ = 3.500, P = 0.011) and accounted for 15.7% of the variation in the number of ED visits. At stage 2, the entering number of doctor visits, number of hospital overnight stays, and number of medications also resulted in a significant regression model ($F_{7,72}$ = 8.641, P <0.001) and significantly increased the predictive strength of the model from stage 1 ($F_{3,72}$ =

TABLE 2. Demographic, HCU, and Activity/Participation Findings in ED Visitors Versus Non-Visitors (Total *n* = 93)

Variable	ED Visit in Past 6 Months: Yes	ED Visit in Past 6 Months: No	Statistic[a]	*P*
Participants, *n*	41	52		
Age, mean (SD), years	53.3 (10.0)	62.7 (10.9)	4.314	<0.001
Female, *n* (% of females in study)	21 (43.8)	27 (56.3)	$0.005\chi^2$	0.946
Male, *n* (% of males in study)	20 (44.4)	25 (55.6)		
Minority, *n* (% of minorities in study)	18 (54.1)	17 (48.6)	$1.453\chi^2$	0.228
Non-minority, *n* (% of non-minorities in study)	22 (38.6)	35 (61.4)		
Number of comorbidities, mean (SD)	3.7 (2.0)	2.7 (1.9)	–2.656	0.009
A1C, mean (SD), %	7.3 (1.5)	6.9 (1.3)	–1.155	0.252
Number of doctor visits, mean/last 6 months (SD)	7.2 (4.8)	4.1 (3.4)	–3.666	<0.001
Number of hospital overnight stays, mean/last 6 months (SD)	8 (19.3)	0 (0.0)	–2.650[b]	0.011
Number of medications, mean (SD)	9 (5.6)	8.3 (4.6)	–0.689	0.493
IPAQ time in sitting, mean (SD), minutes/week	458.8 (330.2)	342.6 (236.9)	–1.974	0.051
IPAQ total METs, mean/week (SD)	4,039 (5,828.3)	2,604.4 (3,941.5)	–1.326[b]	0.190
FAI Domestic score, mean (SD) out of 15	10.8 (3.9)	11.7 (3.2)	1.204[b]	0.232
FAI Leisure/Work score, mean (SD) out of 15	6.5 (2.7)	7.9 (3.5)	2.086	0.040
FAI Outdoor score, mean (SD) out of 15	8.3 (3.1)	10.1 (2.9)	2.724	0.008
FAI total score, mean (SD) out of 45	25.7 (8.2)	29.7 (7.7)	2.432	0.017
Diabetes Knowledge Test score, mean (SD) out of 14	9.7 (2.3)	9.7 (2.3)	0.009	0.993
CIQ-Home, mean (SD) out of 10	6.1 (2.9)	6.3 (2.6)	0.195	0.846
CIQ-Social, mean (SD) out of 12	7.4 (2.4)	8.1 (2.3)	1.399	0.165

[a]*t Values from independent samples. t Tests are reported for all variables with two exceptions: minority status and sex used the χ^2 test to compare categorical data.* [b]*Used unequal variances t test results.*

13.214, *P* <0.001) to explain 45.7% of the variation in number of ED visits. At stage 3, entering activity/participation variables resulted in a significant regression model ($F_{16,63}$ = 4.661, *P* <0.001), which explained 54.2% of the variability in number of ED visits. The predictive strength, however, did not significantly increase from stage 2 to stage 3 ($F_{9,63}$ = 1.307, *P* = 0.251).

Table 3 also displays the coefficients for significant predictor variables at each stage of the hierarchical regression. For every 1 year younger a patient was, there was a 0.04 increase in number of ED visits, and each additional comorbidity was associated with a 0.20 increase in ED visits (stage 1 model). Each additional doctor visit and hospital visit was associated with a 0.10 and 0.34 increase in number of ED visits, respectively (stage 2 model). Being a minority was associated with a 0.71 increase in ED visits (stage 3 model). Finally, a 1-unit increase in Michigan DKT and CIQ home score was associated with a 0.18 and 0.16 increase in ED visits, respectively (stage 3 model).

RQ2b Results: Relation of Activity/Participation; Number of ED Visits, Hospitalizations, Doctor Visits, and Medications; and Demographics to Hospital Visits

Individuals in our sample had an average of ~3.5 hospital overnight stays (SD 13.4; range 0–90) in the preceding 6 months. Table 4 displays demographics; number of ED visits, hospitalizations, doctor visits, and medications; and activity/participation data for individuals with a hospitalization versus those without a hospitalization. Individuals who had a hospi-

TABLE 3. Regression Results for Predicting Number of ED Visits

		Change Statistics			ANOVA	
Model	R^2	R^2 Change	F Change	Significant F Change	F	P
1[a]	0.150	0.150	3.849	0.006	3.849	0.006
2[b]	0.237	0.087	4.838	0.010	4.405	0.001
3[c]	0.302	0.065	1.041	0.410	2.600	0.005

[a]Predictors: number of comorbidities, sex (female, 1; male, 0), minority status (minority,1; nonminority, 0), age.

[b]Predictors: 1 + doctor visits, hospital nights.

[c]Predictors: 2 + IPAQ sedentary minutes, IPAQ total METs, FAI domestic score, FAI leisure/work score, FAI outdoor score, CIQ-home score, CIQ-social score.

				95% CI for B	
Model	Significant Predictor Variable	B	SE	Lower	Upper
1	Age	–0.082***	0.023	–0.127	–0.037
2	Age	–0.083***	0.022	–0.127	–0.039
	Hospital overnight stays	0.046*	0.019	0.006	0.198
3	Age	–0.071**	0.024	–0.119	–0.023
	Doctor visits	0.131*	0.066	–0.001	0.263
	Hospital overnight stays	0.043*	0.021	0.002	0.084
	CIQ-social score	0.267*	0.130	0.008	0.527

*P ≤0.05; **P ≤0.01; ***P ≤0.001.

talization (versus those who did not) had the following: a lower age (mean = 51.9 vs. 61.0 years, t_{91} = 3.627, P < 0.001, d = 0.89), more comorbidities (mean = 4.4 vs. 2.7, t_{91} = –3.992, P <0.001, d = 0.51), more doctor visits (mean = 8.4 vs. 4.4, $t_{31.4}$ = –3.504, P = 0.001, d = 0.90), more ED visits (mean = 3.8 vs. 0.5, $t_{25.7}$ = –4.439, P <0.001, d = 1.22), more time spent in sedentary activity (IPAQ sit minutes/weekday mean = 570.0 vs. 329.1, $t_{30.6}$ = –3.086, P = 0.004, d = 0.80), and a lower FAI total score (mean = 23.7 vs. 29.5, t_{91} = 3.192, P = 0.002, d = 0.71). Within the FAI domains, domestic (mean = 9.8 vs. 11.9, $t_{33.3}$ = 2.213, P = 0.034, d = 0.56), leisure/work (mean = 6.1 vs. 7.7, t_{91} = 2.145, P = 0.035, d = 0.51), and outdoor (mean = 7.8 vs. 9.9, t_{91} = 3.012, P = 0.003, d = 0.67) scores were significantly lower for individuals with a hospitalization compared to those without.

Results of the hierarchical multiple linear regression are displayed in Table 5. At stage 1, demographic data contributed to a significant regression model ($F_{4,75}$ = 2.869, P = 0.029) and accounted for 13.3% of the variation in the number of hospital overnight stays. At stage 2, entering number of doctor visits, number of ED visits, and number of medications also resulted in a significant regression model ($F_{7,72}$ = 7.082, P <0.001) and significantly increased the predictive strength of the model from stage 1 ($F_{3,72}$ = 11.147, P <0.001) to explain 40.8% of the variation in number of hospital overnight stays. At stage 3, entering activity/participation variables resulted in a significant regression model ($F_{16,63}$ = 4.288, P <0.001), which explained 52.1% of the variability in number of hospital overnight stays. The predictive strength, however, did not significantly increase from stage 2 to stage 3 ($F_{9,63}$ = 1.660, P = 0.118).

Table 5 also displays the coefficients for significant predictor variables at each stage of the hierarchical regression. For every 1 year younger a patient was, there was a 0.05 increase in number of hospital visits, and each additional comorbidity was associated with a 0.28 increase in number of hospital overnight stays (stage 1 model). Each additional ED visit was associated with a 0.84 (stage 2 model) and 0.63 (stage 3 model) increase in number of hospital overnight stays. Finally, a 1-minute increase in IPAQ sitting time was associated with a small but significant increase in the number of hospital overnight stays (stage 3 model).

Discussion

RQ1: How Do Activity/Participation Levels in Role-Related Daily Activities; Number of ED Visits, Hospitalizations, Doctor Visits, and Medications; and Demographics Relate to A1C Level?

Slightly less than half of the patients in our study had a recent A1C val-

TABLE 4. Demographic, HCU, and Activity/Participation Findings in Hospitalized Versus Non-Hospitalized Participants (Total *n* = 93)

	Hospital Visit in Past 6 Months			
Variable	**Yes**	**No**	**Statistic[a]**	***P***
Participants, *n*	24	67		
Age, mean (SD), years	51.9 (9.1)	61.0 (11.3)	3.627	<0.001
Female, *n* (% of females in study)	11 (22.9)	37 (77.1)	0.793	0.373
Male, *n* (% of males in study)	14 (31.1)	31 (68.9)		
Minority, *n* (% of minorities in study)	9 (25.7)	26 (74.3)	0.004	0.949
Non-minority, *n* (% of non-minorities in study)	15 (26.3)	42 (73.7)		
Number of comorbidities, mean (SD)	4.4 (1.8)	2.7 (1.8)	–3.992	<0.001
A1C, mean (SD), %	7.5 (1.5)	6.9 (1.3)	–1.428	0.157
Number of doctor visits, mean/past 6 months (SD)	8.4 (5.3)	4.4 (3.4)	–3.504[b]	0.001
Number of ED visits, mean/past 6 months (SD)	3.8 (3.6)	0.5 (1.1)	–4.439[b]	<0.001
Number of medications, mean (SD)	9.6 (6.1)	8.3 (4.6)	–1.142	0.257
IPAQ time in sitting, mean (SD), minutes/week	570.0 (366.8)	329.1 (220.0)	–3.086[b]	0.004
IPAQ total METs, mean/week (SD)	4,855.3 (7,486.5)	3,335.3 (5,334.9)	–0.932	0.358
FAI domestic score, mean (SD) out of 15	9.8 (4.3)	11.9 (3.0)	2.213[b]	0.034
FAI leisure/work score, mean (SD) out of 15	6.1 (2.9)	7.7 (3.3)	2.145	0.035
FAI outdoor score, mean (SD) out of 15	7.8 (3.4)	9.9 (2.8)	3.012	0.003
FAI total score, mean (SD) out of 45	23.7 (8.8)	29.5 (7.3)	3.192	0.002
Diabetes Knowledge Test score, mean (SD) out of 14	9.6 (2.5)	9.7 (2.2)	0.177	0.860
CIQ-home, mean (SD) out of 10	5.5 (3.1)	6.5 (2.6)	1.49	0.140
CIQ-social, mean (SD) out of 12	7.6 (2.5)	7.8 (2.3)	0.373	0.710

[a]t *Values from independent samples.* t *Tests are reported for all variables with two exceptions: minority status and sex used the* χ^2 *test to compare categorical data.* [b]*Used unequal variances* t *test results.*

ue above the ADA goal, indicating that a substantial number continue to struggle with glycemic control. Self-care behaviors commonly linked to healthy glycemic management are diet (2), exercise (21), and medication management (6). However, many people with type 2 diabetes experience difficulty entering into and maintaining healthy diet, exercise, and medication management routines (22–24). We hypothesize that limitations in daily domestic, leisure, work, and community-based activities affect the ability to adopt or maintain healthy routines. This hypothesis is supported by our finding that many of the participants displayed diminished participation in role-related daily activities and a high amount of sedentary time, as evidenced by FAI and IPAQ scores below published norms (17,25). Although previous studies using the FAI and other measures of daily activity have found type 2 diabetes to be associated with impairment in basic and instrumental activities of daily living, almost all of this work has studied older adults (e.g., see the meta-analysis by Wong et al. [26]). Given the lower mean age of our sample (i.e., not considered older adults) and that functional decline is generally associated with normal aging, our results are some of the first to demonstrate that limitations in daily activity and participation also exist in patients with type 2 diabetes who are not elderly.

Activity/participation indicators were generally not predictive of A1C value in our sample. Previous research in older adults with diabetes demonstrated that the prevalence of physical activity limitations was greater for older adults with diabetes than for adults without diabetes (27). However, a large study of older adults with diabetes showed that controlling for A1C attenuated any relationship between physical disability and dia-

TABLE 5. Regression Results for Predicting Number of Nights Spent in the Hospital

		Change Statistics			ANOVA	
Model	R^2	R^2 Change	*F* Change	Significant *F* Change	*F*	*P*
1[a]	0.133	0.133	2.869	0.029	2.869	0.029
2[b]	0.408	0.275	11.147	<0.001	7.082	<0.001
3[c]	0.521	0.114	1.660	0.118	4.288	<0.001

[a]*Predictors: number of comorbidities, sex (female, 1; male, 0), minority status (minority, 1; non-minority, 0), age.*

[b]*Predictors: 1 + doctor visits, ED visits, number of medications.*

[c]*Predictors: 2 + IPAQ sedentary minutes, IPAQ total METs, FAI domestic score, FAI leisure/work score, FAI outdoor score, CIQ-home score, CIQ-social score, DKT score.*

				95% CI for *B*	
Model	Significant Predictor Variable	*B*	*SE*	Lower	Upper
1	Age	–0.053*	0.024	–0.102	–0.005
	Number of comorbidities	0.276*	0.14	–0.002	0.554
2	ED visits	0.839***	0.158	0.524	1.154
3	ED visits	0.633***	0.178	0.277	0.989
	IPAQ sedentary minutes	0.003**	0.001	0.001	0.006

**P* ≤0.05; ***P* ≤0.01; ****P* ≤0.001.

betes, suggesting that A1C is not well related to disability (28). Although we examined more complex, role-related daily activities (e.g., child care and social integration) than this previous work and did so in a younger sample of individuals, we similarly found that A1C is challenging to predict based on the extent of activity limitations. The exception to this finding pertained to domestic activity participation. We anticipated that greater activity would be predictive of better glycemic control, which was not the case in the realm of basic daily living activities; individuals with higher FAI domestic scores were actually more likely to have an unhealthy A1C (i.e., >7%). The domestic domain of the FAI contains activities such as meal preparation, laundry, and house cleaning. Based on our results, the frequency with which individuals carry out these domestic activities does not appear to positively affect glycemic control. On the contrary, and as has been demonstrated in other research (29,30), demands for frequent engagement in domestic activities may have competed for time required for successful glycemic control.

Two issues may have affected our ability to predict A1C. First, only a small representation of individuals (*n* = 6) had a normal A1C, which reduced the statistical power to parse out the relationship between normal A1C and activity/participation levels. Second, A1C may be problematic as an indicator of type 2 diabetes management (31). Although A1C is a good indicator of average blood glucose over an extended time, it is not an indicator of stability of glycemic control; an individual with tightly controlled blood glucose and an individual with fluctuating blood glucose could have the same A1C (32). For this reason, A1C may be limited as an indicator of stable disease and lifestyle management, and other variables about the person must be considered.

We found that individuals who lacked a recent A1C value in their primary medical home's electronic chart spent more time in the hospital than others with a recorded A1C. A missing A1C value could indicate that the patient is not participating with regular diabetes follow-up and labs to the extent that he or she is at increased risk for hospitalization. Other researchers have demonstrated that individuals with diabetes who do not show up for regular primary care appointments are at 60% greater risk for hospitalization (33). Indeed, compared to individuals with a recent A1C value in our study, those without a recent value visited their doctor significantly less. Of course, these individuals may have had a recent A1C value obtained outside of the health care system in which the family medicine center resides.

A1C level and race/ethnicity appear to be related. Approximately 38% (*n* = 35) of individuals in our sample were of a minority race or ethnicity, which was associated with a greater likelihood for having an A1C value >7%, compared to non-minorities. This finding aligns with results from a Centers for Disease Control and Prevention (CDC) study of data obtained in the National Health and Nutrition Examination Survey (34).

The CDC researchers found that non-Hispanic whites were more likely to have an A1C value <7% (48.6%) than Mexican Americans (35.4%). Of the minorities from whom we had a recent A1C result (n = 29), a slightly larger percentage (38.1%) had an A1C value >7% than was revealed in the CDC study.

RQ2a: How Do Activity/Participation Levels in Role-Related Daily Activities; Number of ED Visits, Hospitalizations, Doctor Visits, and Medications; and Demographics Relate to ED Visits?

Overuse of the ED, especially for non-emergency or preventable reasons, is prevalent in individuals with type 2 diabetes and generally for people with low SES (10). We found that participants averaged ~1.4 ED visits per 6 months, which is seven times higher than the average of the general U.S. population (35). Use of the ED for non-urgent care is a significant contributor to wasteful health care spending in the United States and results in ED overcrowding that negatively affects clinical outcomes (36).

Although previous research has demonstrated that limitations in basic diabetes self-care behaviors (e.g., medication management and blood glucose monitoring) predispose ED use in people with diabetes (37,38), little is known about the relationship between more complex lifestyle activity/participation factors and ED use. We found that, compared to individuals who did not visit the ED, ED visitors were engaged to a lesser extent in leisure/work (e.g., hobbies, socializing, and working) and outdoor (e.g., shopping, driving, and gardening) activity domains. Our findings suggest that participation in role-related daily activities is related to ED use in individuals with type 2 diabetes.

In terms of predicting ED use with number of hospitalizations, doctor visits, and medications, our regression analyses revealed that the number of hospital overnight stays in the preceding 6 months contributed most strongly as a predictor of ED visits. This finding is not surprising because the correlation (r = 0.6, P <0.001) between ED visits and number of hospital overnight stays was moderate to good and because a hospital admission may be an outcome of an ED visit. According to a study of 78,114 ED visits recorded in the National Hospital Medical Care Survey, ED visits with the highest hospitalization rate are those associated with short-term diabetes complications (e.g., hypoglycemia leading to loss of consciousness) (39). Of course, individuals more likely to show up in the ED may be less healthy and therefore prone to greater hospitalizations and, as we also found, in need of more appointments with their doctor.

We found ED visitors with type 2 diabetes to be younger than non-visitors, which aligns with results from a 10-year study of ED use in the general U.S. population (40). Individuals 18–44 and 45–64 years of age have accounted for the greatest increase in ED visits, which has been driven in part by increased Medicaid enrollment rates among the non-elderly (40). Medicaid and otherwise underinsured individuals who do not have a medical home are more likely to seek out services in an ED, especially given that two-thirds of EDs serve as safety-net facilities (40). In contrast, the number of ED visits among the elderly has remained relatively stable (40) and may be the result of improved care and better access to primary care for Medicare beneficiaries (41). Finally, younger individuals tend to have more work and familial responsibilities that compete with the time and energy needed for healthy activity, participation, and exercise routines. Taken together, findings from our and others' research suggest that inadequate health care resources and greater life demands may interact to result in higher ED use in younger individuals with diabetes.

Being of minority status was associated with nearly one additional ED visit per 6 months, compared to non-minorities. This finding is consistent with other research of disparities in chronic ED use, which shows that minorities have an increased risk for more ED visits (39). Furthermore, chronic ED use in minority and lower SES groups has been associated with fewer chronic disease management resources (42).

Interestingly, a higher Michigan DKT score significantly predicted a slightly greater number of ED visits, although individual contributions to the regression model were relatively small. Typically, higher diabetes knowledge is associated with a lower prevalence for ED use (43) and subsequent hospitalization (44). In the present study, perhaps having better knowledge of diabetes aided our participants in making decisions for appropriate ED use. For example, the Michigan DKT contains questions about how the individual can deal with low or high blood glucose—conditions that, left unaddressed, could result in serious health complications. Higher CIQ home scores also predicted greater ED use. Previous work has shown that people with higher CIQ home scores tend to be married (45), and individuals who are married are more likely to use the ED (46). This result may occur because a spouse is available to recognize the person's need for an ED visit. In contrast, individuals who live alone and do not have social resources within their home (e.g., would have a low CIQ home score) may lack the necessary support and assistance to recognize an emergency situation.

RQ2b: In People With Type 2 Diabetes Who Have Low SES, How Do Activity/Participation Levels in Role-Related Daily Activities; Number of ED Visits, Hospitalizations, Doctor Visits, and Medications; and Demographics Relate to Hospital Visits?

Type 2 diabetes increases the risk for serious health conditions resulting from microvascular (e.g., neuropathy) and macrovascular (e.g., cerebrovascular disease) complications that require hospitalization (2) but might be preventable. Although preventable hospitalizations have decreased within the U.S. diabetes population (47), approximately one-third of diabetes-related admissions are still attributable to poorly controlled diabetes (8). Our participants spent an average of 3.5 nights in the hospital over a 6-month period. From an HCU perspective, these hospitalizations are concerning because of the cost and resources associated with them, especially if the hospitalization is related to lifestyle factors. Results from the present study help to shed light on factors contributing to hospitalization.

Our finding that hospitalized individuals spent more time in sedentary activity than individuals not hospitalized aligns with other research but is nonetheless concerning. A recent review of studies from several countries demonstrates that physical inactivity is directly related to the incidence of hospitalization (48). Current guidelines recommend 150 minutes/week of moderately vigorous activity (2), which, if followed, significantly reduces health complications and hospitalizations in people with type 2 diabetes (49). In contrast, individuals who do not engage in the recommended physical activity are prone to develop comorbidities requiring hospitalization. Indeed, we found that hospitalized individuals had an average of approximately four comorbidities, which was significantly greater than nonhospitalized participants. Individuals who required hospitalization also participated less in domestic, leisure/work, and outdoor daily activities than individuals who were not hospitalized. Considering both the IPAQ sedentary and FAI scores, people with hospitalizations were clearly less physically active and had lower participation in daily domestic, leisure, work, and community-based activities important to leading an independent and fulfilling life. Furthermore, these activity patterns and deficits may contribute to poorer health and disease progression to the extent that hospitalization becomes imminent. Conversely, individuals who participate more in domestic, work/leisure, outdoor, and exercise activities appear to have a lower risk for hospitalization.

Limitations

Some limitations should be considered when examining the study results. First, because 15% our sample lacked a recent A1C value, overfitting of the RQ1 regression model may have occurred. For the sample with A1C values (n = 79), our regression had approximately four subjects per independent variable. Austin and Steyerberg (50) recently demonstrated that only two subjects per independent variable would be adequate to estimate regression coefficients, standard errors, and confidence intervals in regression. Although our analysis for RQ1 met this threshold, a more conservative and ubiquitous rule suggests that a minimum of five subjects per independent variable is preferable (51). Furthermore, whether a patient has a recent A1C value may be an influential variable in relation to activity/participation and may indicate that the patient is less engaged in his or her diabetes care (e.g., by not having regular glycemic testing) or is more effectively managing type 2 diabetes (requiring less frequent glycemic testing). Although not part of this study's analyses, we found that patients without recent A1C results did not significantly differ from those with a recent A1C. Second, we relied on A1C values previously collected by the medical staff. Doing so could mean that the recorded A1C was not representative of the patient's current glycemic control at the time other data were collected. Future studies should attempt to either collect A1C at the time of evaluation or at least restrict inclusion of participants to individuals with a sufficiently recent A1C value. Third, distinguishing diabetes-related versus non–diabetes-related hospital and ED visits may be useful in determining the appropriateness of such HCU. We were unable to consistently make such a distinction based on medical record data or patient report. However, the study findings reveal that overall hospital and ED use significantly differs in relation to certain aspects of the patients' activity/participation levels. Finally, we relied on mostly subjective reports about HCU, which could be affected by patient bias. Future studies ideally should use billing claims data or other data resources to gather objective information on HCU.

Conclusion

Although more attention has been given to diet, exercise, medication management, and blood glucose control, the results of this study indicate that participation in lifestyle activities within domestic, work/leisure, and outdoor contexts, which are part of maintaining healthy and fulfilling life roles, are also associated with a lower risk for ED visits and hospitalization. Accordingly, participation in role-related daily activities must be considered as a factor that may either support or thwart adherence to known healthy self-care behaviors for type 2 diabetes. Important demographic factors of age and ethnicity/race indicate that younger individuals and minorities are at an increased risk for ED visits and hospitalization, and racial or age-related disparities in preventable health consequences of type 2 diabetes need to be addressed. Finally, the findings indicate targets for intervention. Beyond more exercise and healthier eating, interventions may need to improve participation in daily activities related to life roles and routines. Achieving greater balance in roles, activities, and routines may be especially important for younger individuals who have more demands on their time. Such a balance could also benefit other healthy lifestyle behaviors important to type 2 diabetes management. For example, building greater efficiency into work or domestic routines could free up more time for exercise, healthy meal planning, and better attention to medication requirements and blood glucose. Interventions that specifically address the development and refinement of role-related daily activities may be helpful. Furthermore, campaigns to educate, establish healthy routines, and engage in preventive health practices in younger and minority individuals with type 2 diabetes are necessary, especially for people with lower SES.

Duality of Interest

No potential conflicts of interest relevant to this article were reported.

Author Contributions

M.P.M. performed statistical analyses and wrote the manuscript. K.E.A. and A.A.S. provided edits throughout the manuscript. K.E.A., T.C.K., and L.A.G. researched data. T.P.M. and D.R.M. contributed to discussion and reviewed the manuscript. M.P.M. is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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