Clustering of Multiple Healthy Lifestyle Habits and Health-Related Quality of Life Among U.S. Adults With Diabetes

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OBJECTIVE — We sought to examine the association between clustering of multiple healthy lifestyle habits (HLHs) and health-related quality of life (HRQOL) among adults with diabetes.

RESEARCH DESIGN AND METHODS — We analyzed the representative sample of the civilian, noninstitutionalized U.S. population aged ≥18 years with diabetes using data from the 2005 Behavioral Risk Factor Surveillance System (n = 16,428). Four HRQOL measures were general health rating, physically unhealthy days, mentally unhealthy days, and impaired activity days. Three HLHs included not smoking, engaging in adequate leisure time physical activity, and consuming five or more servings of fruits and vegetables per day.

RESULTS — The proportion of having 0, 1, 2, and 3 HLHs was 10.5, 44.7, 32.9, and 11.9%, respectively. The age-adjusted prevalence rates of poor or fair health, ≥14 physically unhealthy days, ≥14 mentally unhealthy days, and ≥14 impaired activity days were 43.07, 27.61, 17.22, and 18.87%, respectively. After adjustment for potential confounders and comparison with none of the three HLHs, people with all three HLHs were less likely to report poor or fair health (adjusted odds ratio 0.49 [95% CI 0.33–0.71]), ≥14 physically unhealthy days (0.56 [0.39–0.80]), ≥14 mentally unhealthy days (0.35 [0.23–0.55]), or ≥14 impaired activity days (0.35 [0.23–0.56]).

CONCLUSIONS — Accumulation of multiple HLHs was significantly associated with better HRQOL among people with diabetes.

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Diabetes is a common chronic disease, affecting ~20.6 million or 9.6% of adults aged ≥20 years in the U.S. in 2005 (1). People with diabetes have a particularly high risk of mortality and morbidity from coronary heart disease and stroke (2,3). Moreover, diabetes has been the seventh leading cause of death, and the age-standardized mortality rate for diabetes has increased by 45% from 1987 to 2002 in the U.S. (4). Health-related quality of life (HRQOL) is one of the key indicators for national health in Healthy People 2010 (5). It also is a global measure of perceived health and health burden among people with and without diseases or disabilities (6). Studies have shown that HRQOL is impaired among people with diabetes (7). Thus, improving HRQOL is a critical component of clinical management and public health services for people with diabetes.

Diabetes complications, diabetes-related comorbid conditions, severity, and unhealthy lifestyle habits have significant impact on patients' quality of life (8–14). Effective control of diabetes complications and comorbid conditions through pharmacologic management and lifestyle modification may improve HRQOL among people with diabetes. The role of lifestyle modification in improving patients' quality of life, however, is poorly understood. Not smoking (NSMK), getting adequate leisure time physical activity (LTPA), and consuming five or more servings of fruits and vegetables daily (FVC5) have been recognized as three major healthy lifestyle habits (HLHs) because of their effective roles in primary prevention of cancer, cardiovascular disease, stroke, and diabetes (15–18). Studies have suggested that NSMK (19) and adequate levels of LTPA as recommended by the Centers for Disease Control and Prevention (CDC) and the American College of Sports Medicine (20) were strongly associated with increased quality of life in the general population (21). Few studies have provided direct evidence on the association between HLHs and HRQOL in a diabetic population. Limited data have shown that NSMK (12), LTPA (21), and fitness (12) were associated with a better quality of life among people with diabetes. Little is known about whether clustering of multiple HLHs may be associated with better HRQOL among people with diabetes.

The proportion of people who met the recommended levels of all three HLHs was only 5% among those without coronary heart disease and 7% among those with coronary heart disease in the U.S. (22). It is expected that the prevalence of having all three HLHs may be higher among adults with diabetes than in the general population because these healthy habits are important components of disease management (23). The goal of this study was to assess the association between clustering of multiple HLHs and HRQOL among U.S. adults with diabetes in the 2005 Behavioral Risk Factor Surveillance System (BRFSS).

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Abbreviations: BRFSS, Behavioral Risk Factor Surveillance System; CDC, Centers for Disease Control and Prevention; FVC5, consuming five or more fruits or vegetables daily; HLH, healthy lifestyle habit; HRQOL, health-related quality of life; LTPA, leisure time physical activity; NSMK, not smoking; SF-36, 36-item short-form survey.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

RESEARCH DESIGN AND METHODS — The BRFSS, an ongoing state-based and national surveillance system of behavioral risk factors and chronic disease conditions, is a standardized telephone survey conducted by state health departments with assistance from the CDC (24). Trained interviewers collect data on a monthly basis from an independent household probability sample in the noninstitutionalized U.S. adult population (aged ≥18 years). A detailed description of the survey design and random-sampling procedures is available elsewhere (24). According to the formula of the cooperation rate (the proportion of all respondents interviewed of all eligible units in which a respondent was selected and actually contacted), the median response rate for the 2005 BRFSS was 75.1% (25). BRFSS data have consistently been found to provide valid and reliable estimates when compared with national household surveys in the U.S. (26–28).

HRQOL measures

The four CDC HRQOL measures were derived from the original version of the Medical Outcomes Study 36-item short-form survey (SF-36) instrument (29–31) and have been validated in both healthy and disabled populations with acceptable criterion validity and reliability comparable with multiple-item SF-36 subscales (31–36). The four HRQOL questions were as follows: *1*) "Would you say that in general your health is excellent, very good, good, fair, or poor? 1 = excellent, 2 = very good, 3 = good, 4 = fair, and 5 = poor." 2) "Now thinking about your physical health, which includes physical illness and injury, for how many days during the past 30 days was your physical health not good?" *3*) "Now thinking about your mental health, which includes stress, depression, and problems with emotions, for how many days during the past 30 days was your mental health not good?" *4*) "During the past 30 days, for about how many days did poor physical or mental health keep you from doing your usual activities, such as self-care, work, or recreation?"

HLHs

Smoking status was determined by asking participants, "Have you smoked at least 100 cigarettes in your entire life?" and "Do you now smoke cigarettes every day, some days, or not at all?" NSMK was defined as either having smoked <100 cigarettes during a person's lifetime or having smoked ≥100 cigarettes during a person's lifetime but not currently smoking. Moderate physical activity was assessed by asking participants two questions: "How many days per week do you do moderate activities for at least 10 min at a time?" and "On days when you do moderate activities for at least 10 min at a time, how much total time per day do you spend doing these activities?" Vigorous physical activity was assessed by asking participants two questions: "How many days per week do you do vigorous activities for at least 10 min at a time?" and "On days when you do vigorous activities for at least 10 min at a time, how much total time per day do you spend doing these activities?" LTPA was defined on the basis of CDC recommendations and federal physical activity guidelines (20) (i.e., moderate physical activity for ≥30 min on ≥5 days per week or vigorous physical activity for ≥20 min on ≥3 days per week). FVC5 was defined as consuming five or more servings of fruits and vegetables daily, according to the national objective in Healthy People 2010 (5).

Diabetes, complications, and comorbid conditions

Diabetes was determined by asking participants, "Have you ever been told by a doctor that you have diabetes?" Responses were coded as "yes," "yes, but female told only during pregnancy," or "no." Gestational diabetes was coded as "no" diabetes. Age at onset of diabetes, use of insulin and oral agents, foot ulcer, and retinopathy were determined by participants' self-reports. BMI (kg/m^2) was calculated with the use of self-reported weight and height. According to the World Health Organization guidelines (37), we defined obesity as BMI ≥30 kg/m^2. Hypertension, high cholesterol, physical disability, heart attack, angina or coronary heart disease, stroke, arthritis, and asthma were determined by asking participants whether they had ever been told by a doctor, nurse, or other health professional that they had such conditions.

Statistical analysis

We conducted analyses among men and nonpregnant women aged ≥18 years with diabetes. The prevalence estimates were calculated with use of the entire sample. The subsequent analyses for the association between clustering of multiple HLHs and HRQOL were limited to the subsample, with available data for diabetes modules, which were conducted in 40 states (APPENDIX). Furthermore, we excluded participants with missing data for any of the demographic variables, HRQOL measures, HLHs, diabetes complications, and comorbid conditions. We calculated means for the general health rating and for unhealthy days by the number of multiple HLHs, adjusted for age. We performed direct age adjustment using the U.S. population aged ≥18 years in the year 2000 (weights: 0.129, 0.183, 0.219, 0.299, and 0.170 for age-groups 18–24, 25–34, 35–44, 45–64, and ≥65 years, respectively).

We dichotomized the responses for the self-rated general health question into poor or fair health versus good, very good, or excellent health. The 14-day cutoff point is often used as a marker for clinical depression and anxiety disorders in medical practice and research (38–40); therefore, it was used to dichotomize mentally unhealthy days as frequent mental distress (≥14 days) versus infrequent mental distress (<14 days) in our study. Physically unhealthy days and activity limitation days also were dichotomized at 14 days to be consistent with the cutoff point used for mentally unhealthy days and in line with previous studies (14,19,41). In addition, the 14-day cutoff value corresponds to the upper 10–15% of the distribution for the healthy days measures.

Logistic regression analysis was used to assess whether the clustering of multiple HLHs was independently associated with HRQOL measures. Odds ratios and 95% CIs were estimated unadjusted and adjusted for age, sex, race or ethnicity, education attainment, annual household income, as well as duration, treatment, complications, and comorbid conditions of diabetes. SUDAAN software (release 9.0; Research Triangle Institute, Research Triangle Park, NC) was used to account for the complex sampling design.

RESULTS — The final analytic sample (n = 16,428) consisted of 52.8% men, 67.3% non-Hispanic whites, 13.5% non-Hispanic blacks, 13.2% Hispanic subjects, and 6% were other ethnic groups. The mean age of the diabetic participants was (means ± SE) 58.9 ± 0.11 years (range 18–99). The mean duration of having diabetes was 9.6 ± 0.08 years (range 0–81).

Table 1—*Age-adjusted prevalence of single and combined HLHs among U.S. adults with diabetes aged ≥18 years (2005 BRFSS)*

	Single HLH						Combined HLH							
	NSMK		LTPA		FVC5		0 HLH		1 HLH		2 HLHs		3 HLHs	
	%	SE	%	SE	%	SE	%	SE	%	SE	%	SE	%	SE
Total	78.4	1.5	40.0	1.6	27.9	1.5	10.5	1.2	44.7	1.7	32.9	1.5	11.9	1.0
Sex														
Men	78.4	2.4	23.9	2.6	39.8	2.5	11.0	1.7	45.8	2.6	33.5	2.5	9.8	1.2
Women	78.5	1.8	32.3	1.9	40.1	2.0	9.6	1.3	43.3	2.0	33.6	1.8	13.5	1.4
Race														
Non-Hispanic white	75.8	1.9	41.5	2.0	26.4	1.9	10.8	1.4	45.7	2.0	32.5	1.8	11.0	1.3
Non-Hispanic black	84.3	1.7	36.3	3.4	26.2	3.2	8.2	1.3	47.4	3.6	33.7	3.4	10.7	2.2
Hispanic	80.6	4.6	38.7	4.6	31.9	4.6	10.8	3.1	41.8	4.7	32.8	4.6	14.6	3.3
Other	83.8	2.4	42.7	5.3	34.2	4.3	7.9	1.7	40.4	5.3	34.7	4.4	17.0	3.7
Age (years)														
18–29	71.6	5.8	45.0	6.1	31.6	5.8	8.0	3.6	46.5	6.3	34.7	5.9	10.8	3.1
30–39	75.1	3.9	45.9	3.9	26.8	3.7	14.2	4.0	39.9	3.6	30.0	3.1	16.0	3.5
40–49	72.8	1.9	39.5	2.1	24.0	1.8	14.2	1.5	44.2	2.3	32.5	2.0	9.0	1.1
50–59	81.1	1.1	34.6	1.5	24.2	1.3	11.2	0.9	48.2	1.6	30.2	1.4	10.4	1.0
60–69	86.6	0.9	36.0	1.4	24.5	1.2	8.2	0.7	46.7	1.4	35.1	1.4	10.1	0.9
70–79	93.8	0.7	36.1	2.0	34.1	2.1	3.7	0.6	43.4	1.9	38.0	2.0	14.8	1.7
>80	97.9	0.7	25.1	2.6	40.9	2.9	1.8	0.7	47.6	2.9	35.5	2.7	15.1	2.5
Education														
Less than high school	65.0	3.8	34.9	4.2	21.9	3.3	21.8	4.1	43.4	4.4	26.1	3.2	8.7	2.5
High school	78.8	2.3	38.2	2.8	23.8	2.4	8.9	0.9	50.7	2.8	31.0	2.6	9.4	1.3
Some college	77.1	2.6	42.8	2.8	30.0	2.7	10.4	2.1	43.4	2.7	31.9	2.4	14.2	2.4
College	88.3	2.6	42.3	3.2	34.1	3.3	4.7	0.7	40.1	3.2	40.9	3.2	14.3	1.6
Income ($)*														
<15,000	68.9	3.7	36.0	4.0	27.0	3.7	13.0	1.8	50.8	3.8	27.7	3.2	8.6	2.1
15,000 to <25,000	73.0	3.7	36.0	4.0	27.9	3.7	13.0	2.2	46.0	4.2	32.1	3.9	8.9	1.6
25,000 to <35,000	82.4	2.0	38.9	3.3	27.3	3.5	8.0	1.2	47.5	3.7	32.3	3.3	12.1	2.7
35,000 to <50,000	84.0	3.1	40.4	3.4	30.9	3.8	9.4	2.9	39.4	3.3	37.7	3.8	13.5	2.6
≥50,000	81.9	3.0	45.6	3.1	28.6	2.8	9.2	2.5	41.5	3.0	33.2	2.5	16.1	2.6

*Participants who did not report annual household income were not included.

The age-adjusted prevalence of diabetes ($n = 33,320$) among men and nonpregnant women aged ≥18 years ($n = 356,112$) was 7.8 ± 0.09%, 7.9 ± 0.14%, and 7.8 ± 0.11% in the total sample, among men, and among women, respectively. Non-Hispanic blacks (12.2 ± 0.35%; $P < 0.001$) and Mexican Americans (8.1 ± 0.36%; $P < 0.001$) had a higher prevalence of diabetes than non-Hispanic whites (7.2 ± 0.08%).

Women had a higher prevalence of having all three HLHs ($P < 0.05$) than men (Table 1). No significant differences were found by racial or ethnic subgroups. Prevalence rates were similar in each age-group ($P > 0.05$ for linear trend). People with a higher level of education ($P = 0.02$ for linear trend) or higher annual household income ($P < 0.01$) had a higher prevalence of having all three HLHs.

The age-adjusted means of the general health rating, physically unhealthy days, mentally unhealthy days, and impaired activity days were 3.3, 7.9, 5.3, and 5.2, respectively. The mean rating of general health was 3.67, 3.42, 3.16, and 3.05 among people with 0, 1, 2, and 3 HLHs, respectively. There was approximately a 2-day decrease in physically unhealthy days, mentally unhealthy days, and impaired activity days with a 1-unit increase in HLH (Fig. 1*A*). The age-adjusted prevalence rates of poor or fair health, ≥14 physically unhealthy days, ≥14 mentally unhealthy days, and ≥14 impaired activity days were 43.07, 27.61, 17.22, and 18.87%, respectively. There were statistically significant linear trends between the accumulation of multiple HLHs and the prevalence of HRQOL measures (all $P < 0.001$) (Fig. 1*B*).

NSMK was significantly associated with having poor or fair health ($P < 0.001$), having ≥14 mentally unhealthy days ($P < 0.001$), and having ≥14 impaired activity days ($P < 0.01$) but was marginally associated with having ≥14 physically unhealthy days ($P = 0.07$) (Table 2). LTPA was significantly associated with all four HRQOL measures (all $P < 0.001$). In contrast, FVC5 was not significantly associated with any of the four HRQOL measures (P values ranged from 0.21 to 0.94).

Accumulation of the three HLHs was significantly associated with a decreased likelihood of all four HRQOL measures (all $P < 0.001$ for linear trends) (Table 2). NSMK only, LTPA only, the combination of NSMK and LTPA, and the combination of all three HLHs were significantly associated with all four HRQOL measures (Fig. 2). After adjustment for potential confounders and comparison with those with none of the three HLHs, participants with all three HLHs were less likely to report poor or fair health (adjusted odds ratio 0.49 [95% CI 0.33–0.71]), ≥14 physically unhealthy days (0.56 [0.39–0.80]), ≥14 mentally unhealthy days

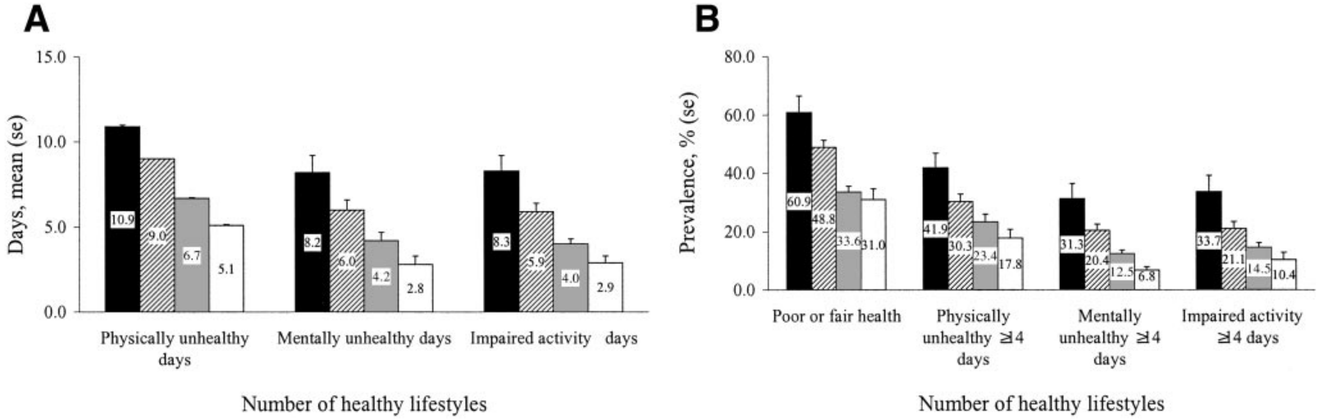

Figure 1—*Age-adjusted means (A) and prevalence (B) of impaired HRQOL measures by the number of multiple HLHs among adults aged ≥18 years (2005 BRFSS). The HLHs included NSMK, adequate vigorous or moderate LPTA, and FVC5.* ■, *0;* ▨, *1;* ▩, *2;* □, *3.*

(0.35 [0.23–0.55]), or ≥14 impaired activity days (0.35 [0.23–0.56]).

CONCLUSIONS— Using a large, nationally representative sample, we demonstrated for the first time that clustering of multiple HLHs was strongly associated with better HRQOL in diabetic adults. This association persisted after adjustment for demographic and socioeconomic characteristics, diabetes complications, diabetes severity, and diabetes-related comorbid conditions. Although NSMK or LTPA alone was associated with a significantly better HRQOL, a combination of NSMK and LTPA, or all three HLHs, appeared to further enhance the association in this diabetic population. We estimated that the prevalence of having all three HLHs (NSMK, LTPA, and FVC5) was ~12% among U.S. adults with diabetes.

The role of NSMK, LTPA, and FVC5 in the primary prevention of cancer, cardiovascular disease, stroke, and diabetes has been widely investigated (15–18). Our results provide evidence that people with diabetes who report achieving recommended levels for these HLHs also report substantially better HRQOL. Among the three individual HLHs, NSMK and LTPA had stronger effects than FVC5 on HRQOL. Abstaining from smoking or en-

Table 2—*Odds ratios and 95% CIs of healthy lifestyle habits on impaired HRQOL among U.S. adults with diabetes aged ≥18 years (2005 BRFSS)*

	Poor or fair health	Physically unhealthy ≥14 days	Mentally unhealthy ≥14 days	Impaired activity ≥14 days
	Odds ratio (95% CI)	Odds ratio (95% CI)	Odds ratio (95% CI)	Odds ratio (95% CI)
NSMK (reference = no)				
Unadjusted	0.62 (0.52–0.73)	0.68 (0.57–0.81)	0.44 (0.37–0.54)	0.55 (0.45–0.66)
Adjusted*	0.71 (0.56–0.89)	0.83 (0.68–1.02)	0.65 (0.52–0.80)	0.69 (0.55–0.87)
LTPA (reference = no)				
Unadjusted	0.51 (0.45–0.59)	0.50 (0.42–0.59)	0.55 (0.46–0.66)	0.42 (0.35–0.52)
Adjusted*	0.66 (0.56–0.77)	0.66 (0.55–0.79)	0.66 (0.54–0.80)	0.56 (0.44–0.7)
FVC5 (reference = no)				
Unadjusted	0.92 (0.79–1.07)	1.06 (0.89–1.26)	0.84 (0.70–1.02)	1.07 (0.86–1.32)
Adjusted*	1.00 (0.85–1.17)	1.09 (0.89–1.33)	0.92 (0.75–1.14)	1.17 (0.92–1.50)
Clustering of HLHs (reference = 0)				
Unadjusted				
1	0.62 (0.49–0.80)	0.66 (0.52–0.84)	0.49 (0.37–0.63)	0.52 (0.40–0.67)
2	0.41 (0.32–0.53)	0.51 (0.39–0.66)	0.36 (0.28–0.48)	0.42 (0.32–0.56)
3	0.36 (0.26–0.49)	0.39 (0.27–0.55)	0.22 (0.15–0.32)	0.24 (0.15–0.37)
P value†	<0.001	<0.001	<0.001	<0.001
Adjusted‡				
1	0.68 (0.49–0.94)	0.75 (0.58–0.97)	0.63 (0.48–0.83)	0.59 (0.44–0.80)
2	0.49 (0.35–0.69)	0.65 (0.50–0.86)	0.52 (0.39–0.70)	0.57 (0.42–0.78)
3	0.49 (0.33–0.71)	0.56 (0.39–0.80)	0.35 (0.23–0.55)	0.35 (0.23–0.56)
P value†	<0.001	<0.001	<0.001	<0.001

*Adjusted for sex, race/ethnicity, age, education, annual household income, BMI, hypertension, high cholesterol, myocardial infarction, coronary heart disease, stroke, arthritis, asthma, disability, duration of diabetes, foot ulcer, retinopathy, use of insulin and oral agents, and the other two HLHs. †Linear trend. ‡Adjusted for sex, race/ethnicity, age, education, annual household income, BMI, hypertension, high cholesterol, myocardial infarction, coronary heart disease, stroke, arthritis, asthma, disability, duration of diabetes, foot ulcer, retinopathy, and use of insulin and oral agents.

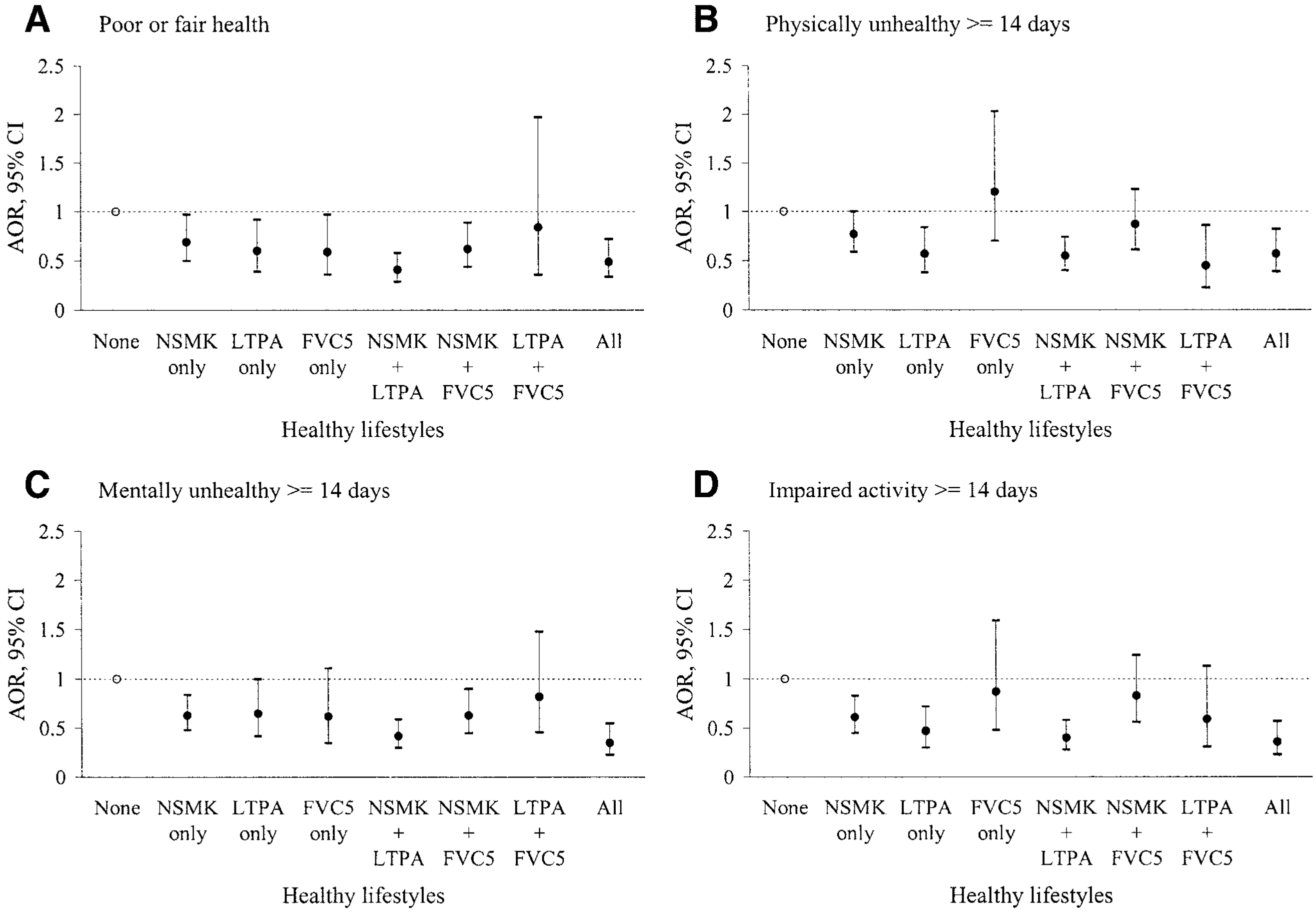

Figure 2—*Odds ratios and 95% CIs of multiple HLHs in relation to impaired HRQOL among adults aged ≥18 years (2005 BRFSS). Data are adjusted odds ratios (AOR) and 95% CIs adjusted for sex, race/ethnicity, age, education, annual household income, BMI, hypertension, high cholesterol, myocardial infarction, coronary heart disease, stroke, arthritis, asthma, disability, duration of diabetes, foot ulcer, retinopathy, and use of insulin and oral agents.*

gaging in adequate physical activity has been consistently related to reductions in all-cause mortality and morbidity and mortality from cancer, cardiovascular diseases, stroke, and type 2 diabetes (15). Our results suggest that people with diabetes who did not smoke or who participated in physical activity reported ~2 fewer days per month in physically unhealthy days, mentally unhealthy days, and impaired activity days. We detected a significant association of FVC5 only with poor or fair health, a marginally significant association with ≥14 mentally unhealthy days in the past month, but no significant association with ≥14 physically unhealthy days or ≥14 impaired activity days. However, a combination of FVC5 with NSMK or LTPA appeared to have a stronger association with general health or physical health compared with the individual factors alone. Nevertheless, our findings do not negate the importance of sufficient fruit and vegetable consumption because of its important role in the primary prevention of cancer, cardiovascular diseases, and stroke (42–44).

Most previous studies focused on the protective effects of HLHs individually. The role of clustering of these HLHs on primary or secondary prevention rarely has been examined. In a cohort study, a greater number of multiple low-risk factors (i.e., favorable diet score, nonsmoking, moderate to vigorous exercise ≥30 min/day, BMI <25 kg/m^2, and alcohol ≥5 g/day) was associated with a lower relative risk of coronary heart disease events (18) or type 2 diabetes (16). The significant linear trend for the relationship between clustering of multiple HLHs and a higher level of HRQOL as shown in our study suggests that accumulation of multiple HLHs also may be related to a better quality of life in secondary prevention in the diabetic population. In fact, the proportion of people who had two or three HLHs was less than half (~45%) among people with diabetes as indicated in our study and only 30% among people with heart disease (22). Therefore, further effort is needed to promote multiple HLHs in both healthy and diseased populations.

Several previous studies considered healthy weight (BMI between 18.5 and 25 kg/m^2) as one of the HLHs in addition to NSMK, LTPA, and FVC5 (45–48). In some of these studies, >50% of the participants had at least two HLHs and >20% of the participants had at least three HLHs (45–48). In our study, we chose not to include healthy weight as an indicator of an HLH because we believe that healthy weight is an outcome of behavior and obesity is an important risk factor or comorbid condition for diabetes, which was accounted for in all of our analyses.

Our study has several limitations. First, all measures in the BRFSS are self-reported and may be subject to information bias. However, the HRQOL measures have been validated in diverse populations and have excellent retest reliability

(35). Smoking status, blood pressure, height, weight, BMI, and demographic characteristics were found to be highly valid and reliable. Physical activity and fruit and vegetable consumption were found to be moderately valid and reliable (27). In addition, misclassification bias for self-reported diabetes, diabetes complications, and diabetes-related comorbid conditions may be minimal in the present study because previous studies have shown a substantial agreement between self-report and medical records for diabetes, hypertension, myocardial infarction, and stroke (49). Because misclassification bias among self-reported measures in the present study appears to be nondifferential, our findings may underestimate the true association between clustering of HLHs and HRQOL. Second, because BRFSS was a cross-sectional survey, we were unable to determine whether the observed linear trend for the relationship between clustering of HLHs and HRQOL measures actually was causal. It is possible that people with a better HRQOL are more likely to adopt HLHs, particularly LTPA. Therefore, if this association could be confirmed in future research using a prospective design or clinical trial, it may have meaningful implications in clinical practice and public health service to promote the recommended levels of the three HLHs and to substantially improve HRQOL in the diabetic population. Third, because impaired activity included self-care, work, or recreation, a slight construct overlap may be possible when examining the association of LTPA with impaired activity days. However, our results may not be influenced because all associations were adjusted for physical disability status, and similar patterns were replicated in the subsample of people free of physical disability.

In conclusion, the first goal of Healthy People 2010 is to help people of all ages increase their life expectancy and improve their quality of life. This goal may be particularly important among people with diabetes because disease severity, complications, and comorbid conditions greatly impair their quality of life. Our findings suggest that having two or more HLHs may be associated with patients' quality of life more substantially than the single factors alone. Because less than half of patients with diabetes have achieved the recommended levels of two or more HLHs, greater efforts are urgently needed to promote the adoption of multiple HLHs among people with diabetes in the U.S.

Acknowledgments— We thank the BRFSS state coordinators for their assistance in data collection.

The findings and conclusions in this article are those of the authors and do not necessarily represent the views of the Centers for Disease Control and Prevention.

APPENDIX— In 2005, the following 40 states had data available for the BRFSS diabetes module: Alabama; Alaska; Arizona; Arkansas; California; Colorado; Connecticut; Delaware; Washington, DC; Florida; Georgia; Idaho; Indiana; Iowa; Kentucky; Louisiana; Maine; Minnesota; Missouri; Montana; Nevada; New Hampshire; New Jersey; New Mexico; New York; North Carolina; North Dakota; Ohio; Pennsyvania; South Carolina; South Dakota; Tennessee; Texas; Utah; Vermont; Virginia; Washington; West Virginia; Wyoming; and the Virgin Islands.

References

1. Centers for Disease Control and Prevention: *National Diabetes Fact Sheet: General Information and National Estimates on Diabetes in the United States, 2005.* Atlanta, GA, U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, 2005
2. Haffner SM, Lehto S, Ronnemaa T, Pyorala K, Laakso M: Mortality from coronary heart disease in subjects with type 2 diabetes and in nondiabetic subjects with and without prior myocardial infarction. *N Engl J Med* 339:229–234, 1998
3. Idris I, Thomson GA, Sharma JC: Diabetes mellitus and stroke. *Int J Clin Pract* 60:48–56, 2006
4. Jemal A, Ward E, Hao Y, Thun M: Trends in the leading causes of death in the United States, 1970–2002. *JAMA* 294:1255–1259, 2005
5. U.S. Department of Health and Human Services: *Healthy People 2010.* Washington, DC, U.S. Govt. Printing Office, 2000
6. Testa MA, Simonson DC: Assesment of quality-of-life outcomes. *N Engl J Med* 334:835–840, 1996
7. Rubin RR, Peyrot M: Quality of life and diabetes. *Diabetes Metab Res Rev* 15:205–218, 1999
8. U.K. Prospective Diabetes Study Group: Quality of life in type 2 diabetic patients is affected by complications but not by intensive policies to improve blood glucose or blood pressure control (UKPDS 37). *Diabetes Care* 22:1125–1136, 1999
9. Coffey JT, Brandle M, Zhou H, Marriott D, Burke R, Tabaei BP, Engelgau MM, Kaplan RM, Herman WH: Valuing health-related quality of life in diabetes. *Diabetes Care* 25:2238–2243, 2002
10. Lloyd A, Sawyer W, Hopkinson P: Impact of long-term complications on quality of life in patients with type 2 diabetes not using insulin. *Value Health* 4:392–400, 2001
11. Maddigan SL, Feeny DH, Majumdar SR, Farris KB, Johnson JA: Understanding the determinants of health for people with type 2 diabetes. *Am J Public Health* 96:1649–1655, 2006
12. Rejeski WJ, Lang W, Neiberg RH, Van DB, Foster GD, Maciejewski ML, Rubin R, Williamson DF: Correlates of health-related quality of life in overweight and obese adults with type 2 diabetes. *Obesity (Silver Spring)* 14:870–883, 2006
13. Wexler DJ, Grant RW, Wittenberg E, Bosch JL, Cagliero E, Delahanty L, Blais MA, Meigs JB: Correlates of health-related quality of life in type 2 diabetes. *Diabetologia* 49:1489–1497, 2006
14. Brown DW, Balluz LS, Giles WH, Beckles GL, Moriarty DG, Ford ES, Mokdad AH: Diabetes mellitus and health-related quality of life among older adults: findings from the Behavioral Risk Factor Surveillance System (BRFSS). *Diabetes Res Clin Pract* 65:105–115, 2004
15. Eyre H, Kahn R, Robertson RM: Preventing cancer, cardiovascular disease, and diabetes: a common agenda for the American Cancer Society, the American Diabetes Association, and the American Heart Association. *Diabetes Care* 27:1812–1824, 2004
16. Hu FB, Manson JE, Stampfer MJ, Colditz G, Liu S, Solomon CG, Willett WC: Diet, lifestyle, and the risk of type 2 diabetes mellitus in women. *N Engl J Med* 345:790–797, 2001
17. Kurth T, Moore SC, Gaziano JM, Kase CS, Stampfer MJ, Berger K, Buring JE: Healthy lifestyle and the risk of stroke in women. *Arch Intern Med* 166:1403–1409, 2006
18. Stampfer MJ, Hu FB, Manson JE, Rimm EB, Willett WC: Primary prevention of coronary heart disease in women through diet and lifestyle. *N Engl J Med* 343:16–22, 2000
19. Strine TW, Okoro CA, Chapman DP, Balluz LS, Ford ES, Ajani UA, Mokdad AH: Health-related quality of life and health risk behaviors among smokers. *Am J Prev Med* 28:182–187, 2005
20. Pate RR, Pratt M, Blair SN, Haskell WL, Macera CA, Bouchard C, Buchner D, Ettinger W, Heath GW, King AC: Physical activity and public health: a recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. *JAMA* 273:402–407, 1995
21. Brown DW, Balluz LS, Heath GW, Mori-

arty DG, Ford ES, Giles WH, Mokdad AH: Associations between recommended levels of physical activity and health-related quality of life: findings from the 2001 Behavioral Risk Factor Surveillance System (BRFSS) survey. *Prev Med* 37:520–528, 2003
22. Miller RR, Sales AE, Kopjar B, Fihn SD, Bryson CL: Adherence to heart-healthy behaviors in a sample of the U.S. population (Abstract). *Prev Chronic Dis* 2:A18, 2005
23. American Diabetes Association: Standards of medical care in diabetes, 2006. *Diabetes Care* 29 (Suppl. 1):S4–S42, 2006
24. Centers for Disease Control and Prevention: *Behavioral Risk Factor Surveillance System User's Guide*. Atlanta, GA, Centers for Disease Control and Prevention, 2006
25. Centers for Disease Control and Prevention: 2005 Behavioral Risk Factor Surveillance System data quality report handbook [article online], 2006. Available from http://www.cdc.gov/brfss/technical_infodata/surveydata/2005/2005dqrhandbook.rtf. Accessed 14 September 2006
26. Mokdad AH, Stroup DF, Giles WH, the Behavioral Risk Factor Surveillance Team: Public health surveillance for behavioral risk factors in a changing environment: recommendations from the Behavioral Risk Factor Surveillance Team. *MMWR* 52:RR–9, 2003
27. Nelson DE, Holtzman D, Bolen J, Stanwyck CA, Mack KA: Reliability and validity of measures from the Behavioral Risk Factor Surveillance System (BRFSS). *Soz Preventivemed* 46 (Suppl. 1):S3–S42, 2001
28. Nelson DE, Powell-Griner E, Town M, Kovar MG: A comparison of national estimates from the National Health Interview Survey and the Behavioral Risk Factor Surveillance System. *Am J Public Health* 93:1335–1341, 2003
29. Hennessy CH, Moriarty DG, Zack MM, Scherr PA, Brackbill R: Measuring health-related quality of life for public health surveillance. *Public Health Rep* 109:665–672, 1994
30. Ware JE Jr, Sherbourne CD: The MOS 36-item short-form health survey (SF-36): I. Conceptual framework and item selection. *Med Care* 30:473–483, 1992
31. Moriarty DG, Zack MM, Kobau R: The Centers for Disease Control and Prevention's Healthy Days Measures: population tracking of perceived physical and mental health over time. *Health Qual Life Outcomes* 1:37, 2003
32. Andresen EM, Fouts BS, Romeis JC, Brownson CA: Performance of health-related quality-of-life instruments in a spinal cord injured population. *Arch Phys Med Rehabil* 80:877–884, 1999
33. Ounpuu S, Chambers LW, Chan D, Yusuf S: Validity of the US Behavioral Risk Factor Surveillance System's health related quality of life survey tool in a group of older Canadians. *Chronic Dis Can* 22:93–101, 2001
34. Toet J, Raat H, van Ameijden EJ: Validation of the Dutch version of the CDC core healthy days measures in a community sample. *Qual Life Res* 15:179–184, 2006
35. Andresen EM, Catlin TK, Wyrwich KW, Jackson-Thompson J: Retest reliability of surveillance questions on health related quality of life. *J Epidemiol Community Health* 57:339–343, 2003
36. Newschaffer CJ.: *Validation of Behavioral Risk Factor Surveillance System (BRFSS) HRQOL Measures in a Statewide Sample*. Atlanta, GA, U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, 1998
37. World Health Organization: *Physical Status: The Use and Interpretation of Anthropometry: Report of a WHO Expert Committee*. Geneva, World Health Org., 1995 (Tech. rep. ser. no. 854)
38. Centers for Disease Control and Prevention: Self-reported frequent mental distress among adults: United States, 1993–1996. *JAMA* 279:1772–1773, 1998
39. Milazzo-Sayre LJ, Henderson MJ, Manderscheid RW: Serious and severe mental illness and work: what do we know? In *Mental Disorder, Work Disability, and the Law*. Bonnie RJ, Monahan J, Eds. Chicago, University of Chicago Press, 1997
40. Strine TW, Chapman DP, Kobau R, Balluz L, Mokdad AH: Depression, anxiety, and physical impairments and quality of life in the U.S. noninstitutionalized population. *Psychiatr Serv* 55:1408–1413, 2004
41. Ford ES, Moriarty DG, Zack MM, Mokdad AH, Chapman DP: Self-reported body mass index and health-related quality of life: findings from the Behavioral Risk Factor Surveillance System. *Obes Res* 9:21–31, 2001
42. Dauchet L, Amouyel P, Hercberg S, Dallongeville J: Fruit and vegetable consumption and risk of coronary heart disease: a meta-analysis of cohort studies. *J Nutr* 136:2588–2593, 2006
43. He FJ, Nowson CA, MacGregor GA: Fruit and vegetable consumption and stroke: meta-analysis of cohort studies. *Lancet* 367:320–326, 2006
44. Riboli E, Norat T: Epidemiologic evidence of the protective effect of fruit and vegetables on cancer risk. *Am J Clin Nutr* 78 (Suppl. 3):559S–569S, 2003
45. Ashaye MO, Giles WH: Are heart disease patients more likely to have healthy lifestyle behaviors? Results from the 2000 Behavioral Risk Factor Surveillance Survey. *J Cardiovasc Risk* 10:207–212, 2003
46. Ford ES, Ford MA, Will JC, Galuska DA, Ballew C: Achieving a healthy lifestyle among United States adults: a long way to go. *Ethn Dis* 11:224–231, 2001
47. Pronk NP, Anderson LH, Crain AL, Martinson BC, O'Connor PJ, Sherwood NE, Whitebird RR: Meeting recommendations for multiple healthy lifestyle factors: prevalence, clustering, and predictors among adolescent, adult, and senior health plan members. *Am J Prev Med* 27:25–33, 2004
48. Reeves MJ, Rafferty AP: Healthy lifestyle characteristics among adults in the United States, 2000. *Arch Intern Med* 165:854–857, 2005
49. Okura Y, Urban LH, Mahoney DW, Jacobsen SJ, Rodeheffer RJ: Agreement between self-report questionnaires and medical record data was substantial for diabetes, hypertension, myocardial infarction and stroke but not for heart failure. *J Clin Epidemiol* 57:1096–1103, 2004