



# Health-Related Quality of Life Trajectories Among Older Adults With Diabetes Mellitus: A Group-Based Modeling Approach

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## ABSTRACT

**Background:** Health-related quality of life (HR-QoL) is an important issue among older adults with diabetes mellitus. However, information on longitudinal changes in HR-QoL over time using the illness trajectory model is limited.

**Purpose:** The purpose of this study was to identify patterns of temporal change in HR-QoL and their predictors using longitudinal data and a group-based modeling approach.

**Methods:** European Quality of Life–5 Dimensions data for 440 older adults with diabetes mellitus were drawn from the nationwide Korea Health Panel Survey conducted from 2009 to 2013. Latent class growth analysis and multinomial logistic regression models were used to identify the predictors of HR-QoL trajectories.

**Results:** Four distinct classes of HR-QoL trajectory were identified: high decrease ( $n = 46$ , 10.5%), high stable ( $n = 232$ , 52.7%), medium stable ( $n = 157$ , 35.7%), and low increase ( $n = 5$ , 1.1%). Participants in “high decrease” and “high-stable” classes tended to be men who were highly educated, physically active, and adherent to their medication regimen. High economic status, few chronic diseases, independence in activities of daily living, and high self-rated health status were also identified as indicators of being in the “high-decrease” and “high-stable” class group.

**Conclusions/Implications for Practice:** A salient finding of this study is that HR-QoL trajectories in older adults with diabetes mellitus are not homogeneous but instead diverge into four distinct classes. Most participants showed no major changes in HR-QoL across the 5-year period, regardless of HR-QoL level. To prevent patients with diabetes from experiencing chronically low levels of HR-QoL, comprehensive assessment and individualized care based on HR-QoL are necessary.

## KEY WORDS:

diabetes mellitus, health-related quality of life, latent class growth analysis, longitudinal data, older adults.

overall quality of life compared to their peers (Lee & Kim, 2017; Speight et al., 2020). In these individuals, HR-QoL is associated with complications related to glycemic control and comorbidities associated with their disease. Several studies have reported that lifestyle factors, including nutrition, physical activity, smoking, and stress, may influence HR-QoL. Other influences include sociopsychological factors such as depression, anxiety, fatigue, social support, self-esteem, and economic status (Lim & Oh, 2013; Scollan-Koliopoulos et al., 2013; Shiu et al., 2014). The lives of older adults with diabetes mellitus are generally more complicated than those of younger individuals with this condition. Older individuals are at relatively higher risk of contracting geriatric syndromes, pharmacotherapy-related hypoglycemia, and diabetes mellitus-related complications, while also experiencing complications associated with the psychological and physiological changes induced by aging (American Diabetes Association, 2020; Rwegerera et al., 2018). In addition, older adults with diabetes mellitus have largely been considered as a single group with identical characteristics, with no study of unique characteristics between individuals. Furthermore, most studies have sought to identify the relationship between individual variables, with few taking an overall perspective based on a theoretical framework.

Individual HR-QoL may vary over time based on health status and how health conditions are managed. Indeed, it is well known that HR-QoL involves the comprehensive and dynamic perception of mental, physical, and social functioning. Therefore, for older adults with chronic diseases, HR-QoL is likely to change over time (American Diabetes Association, 2020; Kojima et al., 2016; Zaninotto et al., 2009).

Varying patterns of HR-QoL over time have been identified in previous studies for several chronic diseases, including heart failure, chronic obstructive pulmonary disease, stroke,

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## Introduction

Health-related quality of life (HR-QoL) in older adults with chronic diseases has emerged as an important issue in recent years. In numerous previous studies, people with diabetes mellitus have been shown to be more likely to have poorer

colon cancer, coronary artery bypass graft surgery, and substance abuse using a group-based approach (Olson et al., 2014; Pancani et al., 2018; Yoo et al., 2016). Group-based approaches that classify participants into subgroups based on mutually exclusive characteristics and individual responses or patterns have become common (Nagin, 2014). In these prior studies, mean HR-QoL trajectories were presumed to differ between individuals, and the potential of differences developing over time was considered, with potential trajectory trends including the following: remain consistently good, worsen steadily from mild to moderate, move from moderate to severe symptomatology, steadily improve from moderate to mild symptomatology, and remain consistently poor.

Based on the results of previous studies, temporal changes in HR-QoL may differ between individuals depending on the progress of their condition, how it is managed, and aging (Kojima et al., 2016; Yoo et al., 2016; Zaninotto et al., 2009). However, limited information is available on longitudinal changes in HR-QoL over time among older adults with diabetes mellitus. There is also a lack of research on the factors that affect individualized HR-QoL trajectories.

Considering these gaps in the literature, the primary aim of this study was to identify distinctive patterns in temporal changes in HR-QoL using longitudinal data and a group-based modeling approach. Moreover, the predictors of HR-QoL trajectory patterns were identified from the pool of demographic, health-related, and environmental variables included in the revised Wilson and Cleary (1995) model (Ferrans et al., 2005), which provides a theoretical basis for variable selection. The HR-QoL domains in older adults with diabetes mellitus may include physical status, symptoms, functional status, general health perceptions, and overall quality of life (see Figure 1).

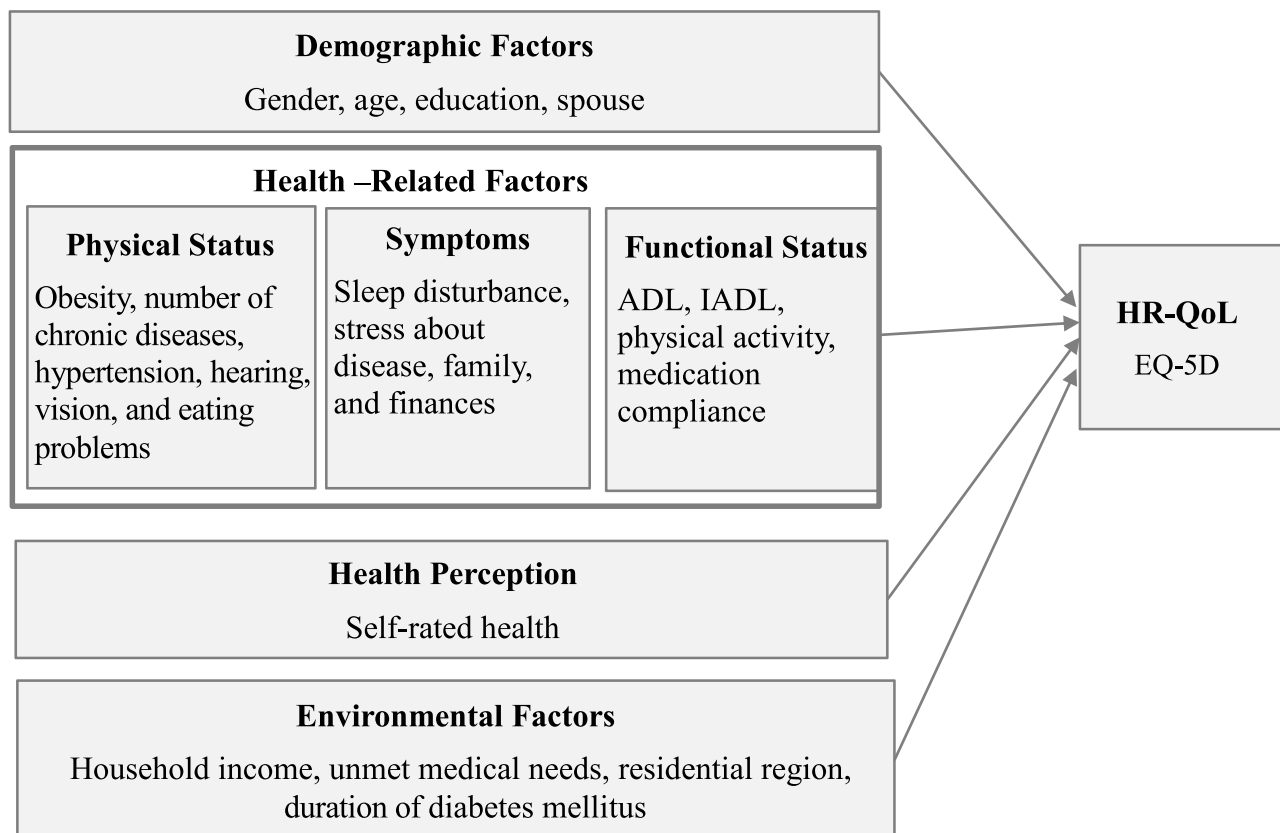
## Methods

### Study Design

This was an analytic, descriptive, and longitudinal analysis of population-based data sourced from the nationwide Korea Health Panel Survey (KHPS).

**Figure 1**

*Conceptual Framework of the Study*



*Note.* ADL = activity of daily living; IADL = instrumental activities of daily living; HR-QoL = health-related quality of life; EQ-5D = European Quality of Life–5 Dimensions.

## Study Population and Data Collection

Longitudinal data were drawn from the KHPS, which was implemented using face-to-face interviews conducted by trained professional interviewers from a nationally representative sample of the Korean population. This survey focused on topics such as the demographic characteristics, service utilization behavior, medical expenditure, and health behaviors of targeted households and all members within the selected households. The KHPS has been conducted annually since 2008. The most recent data set for this survey, the 2015 (the 10th wave) edition, was released in June 2018. HR-QoL scores have been included in the KHPS for 5 years only (2009–2013) and are readily available (Korea Institute for Health and Social Affairs, 2019).

This study comprised 528 older adults with diabetes mellitus who had participated in the KHPS for five consecutive years. Inclusion criteria were being 65 years of age or older and having an official diagnosis of diabetes mellitus. The study excluded those who had responded to survey items concerning HR-QoL on fewer than two occasions. Of the 528 older adults with diabetes mellitus, 440 adults were included as the study population (see Figure 2).

The baseline data consisted of demographic factors, environmental factors, and health-related factors, such as physical status, symptoms, functional status, and health perceptions, based on the revised Wilson and Cleary (1995) model for HR-QoL. The design of this study was considered exempt from ethical review by the institutional review board of Yonsei University Severance Hospital (IRB Approval No. 4-2017-0901), as the collected data were deidentified.

## Measures

### Health-related quality of life

The self-reported European Quality of Life–5 Dimensions (EQ-5D) was used to evaluate HR-QoL. This scale is composed of five dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. Each item is scored using a Likert scale, ranging from 1 to 3, with 1 denoting *no difficulty* and 3 denoting *extreme difficulty*. The total score is the summed score for all five dimensions, which is then converted to a single index score based on the Korean valuation set developed by the Korea Centers for Disease Control and Prevention (Nam et al., 2007). In this study, the single index score for HR-QoL was used, which ranges from  $-0.171$  to 1, with negative values indicating poor health status and values closer to 1 indicating no concern for any of the five dimensions.

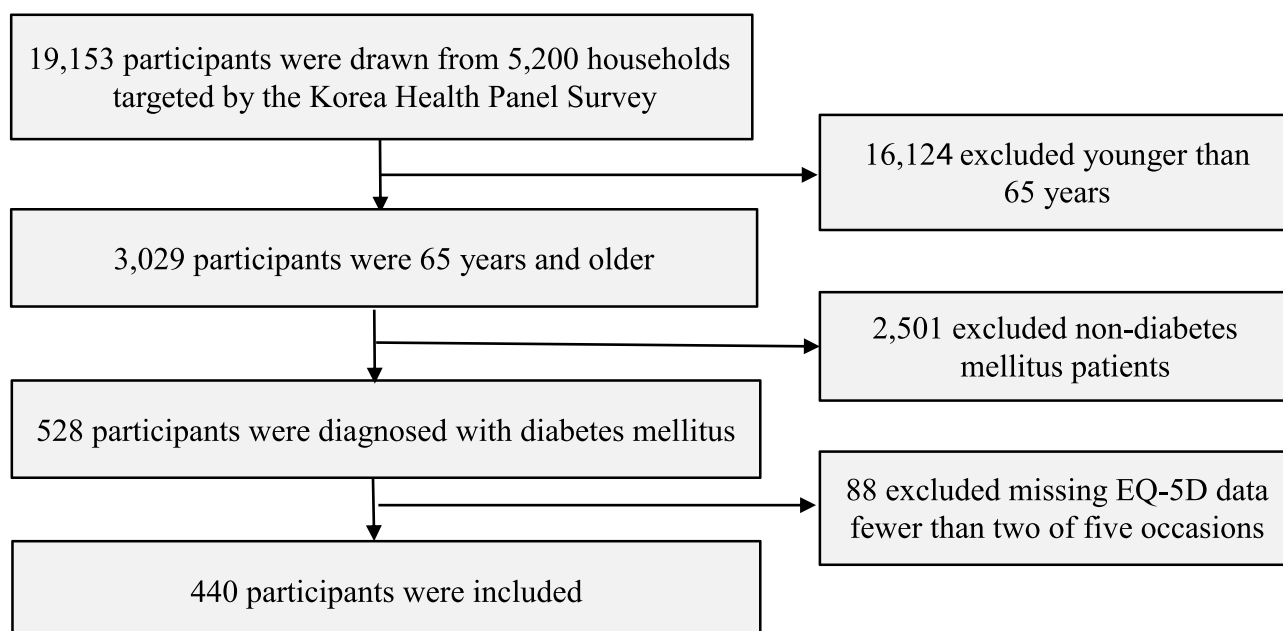
$$\begin{aligned} \text{EQ-5D Index} = & 1 - (0.05 + 0.096 \times M2 + 0.418 \times M3 + 0.046 \times \\ & \text{SC2} + 0.136 \times \text{SC3} + 0.051 \times \text{UA2} + 0.208 \times \text{UA3} + 0.037 \times \\ & \text{PD2} + 0.151 \times \text{PD3} + 0.043 \times \text{AD2} + 0.158 \times \text{AD3} + 0.050 \times \text{N3}) \end{aligned}$$

Note that M = mobility; SC = self-care; UA = usual activities; PD = pain/discomfort; AD = anxiety/depression; 1 = no health problems; 2 = moderate health problems; 3 = extreme health problems; and N3 = number of “3”, extreme health problems.

The reliability of HR-QoL for this measure was very good in this study (Cronbach’s  $\alpha = .92$ ). HR-QoL data were collected at baseline and every year over a 4-year period, spanning 2009–2013.

## Figure 2

Flowchart of the Participant Selection Process



### **Demographic factors**

Demographic characteristics, including gender, age, educational level, and spousal status, were collected. Responses to the question about educational level were sorted into three categories based on the Korean obligatory curriculum: “no schooling,” “elementary or middle school graduate,” and “high school/college graduate or higher.” Educational level was classified as a continuous variable in the analysis, with lower scores indicating lower educational levels.

### **Environmental factors**

Environmental factors included household income, residential region, years of duration of diabetes mellitus (since diagnosis), and whether medical needs were met. Household income was divided into five categories, with higher scores indicating greater financial stability. Residential region was determined using the participant’s current address, which was dichotomized into whether or not the older adults lived in a metropolitan area (i.e., Busan, Daegu, Daejeon, Kwangju, Incheon, Seoul, and Ulsan). Duration of diabetes mellitus was calculated by subtracting the age at which diabetes mellitus was first diagnosed from the participant’s current age. Information on unmet medical needs was obtained using the question: “During the past 12 months, was there ever a time when you felt you needed healthcare but did not receive it?” Availability of healthcare and accessibility problems were classified as either “yes” or “no.”

### **Physical status**

Obesity was assessed by determining body mass index (BMI), which was calculated by dividing weight (kg) by height squared ( $m^2$ ). Using BMI, the participants were categorized into three groups, underweight ( $< 18.5 \text{ kg}/m^2$ ), normal ( $18.5\text{--}22.9 \text{ kg}/m^2$ ), and overweight ( $\geq 23 \text{ kg}/m^2$ ), based on the guidelines published by the World Health Organization for the Asia Pacific Region, the Korean Endocrine Society, and the Korean Society for the Study of Obesity (Korean Endocrine Society, 2010; Nam et al., 2007). The number of chronic diseases participants lived with was measured using a single question: “How many chronic diseases do you have?” Data regarding hypertension and hearing, vision, and eating problems were collected and categorized as either “yes” or “no.”

### **Symptoms**

Wilson and Cleary (1995) defined symptom status as “a patient’s perception of an abnormal physical, emotional, or cognitive state” and classified symptoms into physical symptoms, psychological symptoms, and symptoms that are not clearly physical or psychological in origin (e.g., emotional distress, fear, worry, and frustration). In this study, symptoms were measured using sleep disturbance and stress levels related to the disease, family, and finances. Data were collected and categorized as either “yes” or “no.”

### **Functional status**

Activities of daily living (ADL) were assessed using Katz’s (1983) six-item index, which was designed to examine respondent abilities related to transferring, dressing, using a toilet, bathing, feeding, and continence. Instrumental ADL (IADL) were assessed using the Lawton–Brody Scale, which was designed to assess the ability to use a telephone, go shopping, prepare food, perform housekeeping, do laundry, and handle finances as well as the mode of transportation used and the respondent’s ability to independently manage their own medications (Lawton & Brody, 1969). For statistical analysis, the scores for each item (both ADL and IADL) were calculated and recoded dichotomously as either independent or dependent. If an item was checked as dependent (even one item of ADL or IADL), the item was identified as dependent. Self-reported medication compliance was determined and classified as either “yes” or “no.” Physical activity levels were assessed using the Korean standardized short form of the International Physical Activity Questionnaire (IPAQ; Kim, 2006). This questionnaire contains items related to vigorous physical activity, moderate physical activity, walking, and sitting. Responses were converted into metabolic equivalent tasks in terms of minutes per week following the IPAQ scoring protocol (Chun, 2012). Physical activity levels were categorized into three categories: inactive, minimally active, and active.

### **Health perception**

Self-rated health was assessed using one question: “How do you feel about your health?” This question was scored on a scale of 0 (*poor health*) to 4 (*excellent health*), with higher scores associated with a higher self-rated health score on the 36-item Short-Form Health Survey (Ware, 2005).

### **Data Analysis**

Data analysis was performed using IBM SPSS Statistics Version 24.0 (IBM, Inc., Armonk, NY, USA) and STATA 14 (StataCorp, College Station, TX, USA). Descriptive statistics (means, standard deviations, and proportions), independent *t* tests, chi-square tests, and analyses of variance tests, including post hoc analysis, were used to determine participant characteristics and compare trajectories.

Latent class growth analysis (LCGA) was used to determine whether there were subgroups or classes within the sample that exhibited different initial levels and different patterns of growth of HR-QoL over time (Yoo et al., 2016). LCGA is a semiparametric statistical technique that is used to analyze longitudinal data under the basic assumption that latent classes of trajectories exist in sample populations. The aim of the LCGA is to select a model with the optimal number of distinct patterns and appropriate polynomial order to best represent the heterogeneity of the trajectories (Yoo et al., 2016). The optimal number of latent classes was determined using the adjusted Bayesian information criterion (BIC), which has been shown to be a robust indicator of class enumeration with categorical outcomes (Muthén & Muthén, 2000). The

adjusted BIC was used to compare several plausible models, with the lowest values indicating the best-fitting model.

Subsequently, multinomial logistic regressions were used to identify factors that affected the different trajectories over time. Results were presented in terms of relative risk ratio (RRR) with 95% confidence intervals.

### Results

A total of 440 older adults with diabetes mellitus participated in the KHPS on more than two occasions during the 5-year period. Their mean age was 72.2 (*SD* = 4.9) years, and 56.6% were women. The mean duration of diabetes mellitus in the study sample was 10.8 (*SD* = 7.9) years; 69.1% of the participants lived with a spouse; and 13.2% had an education level of “no schooling.” At baseline and at the first, second, third, and fourth follow-ups, missing data for the primary outcome variable, HR-QoL, comprised 3.9%, 2.0%, 8.4%, 14.3%, and 19.1% of the responses, respectively. Mean HR-QoL scores increased from baseline to the first

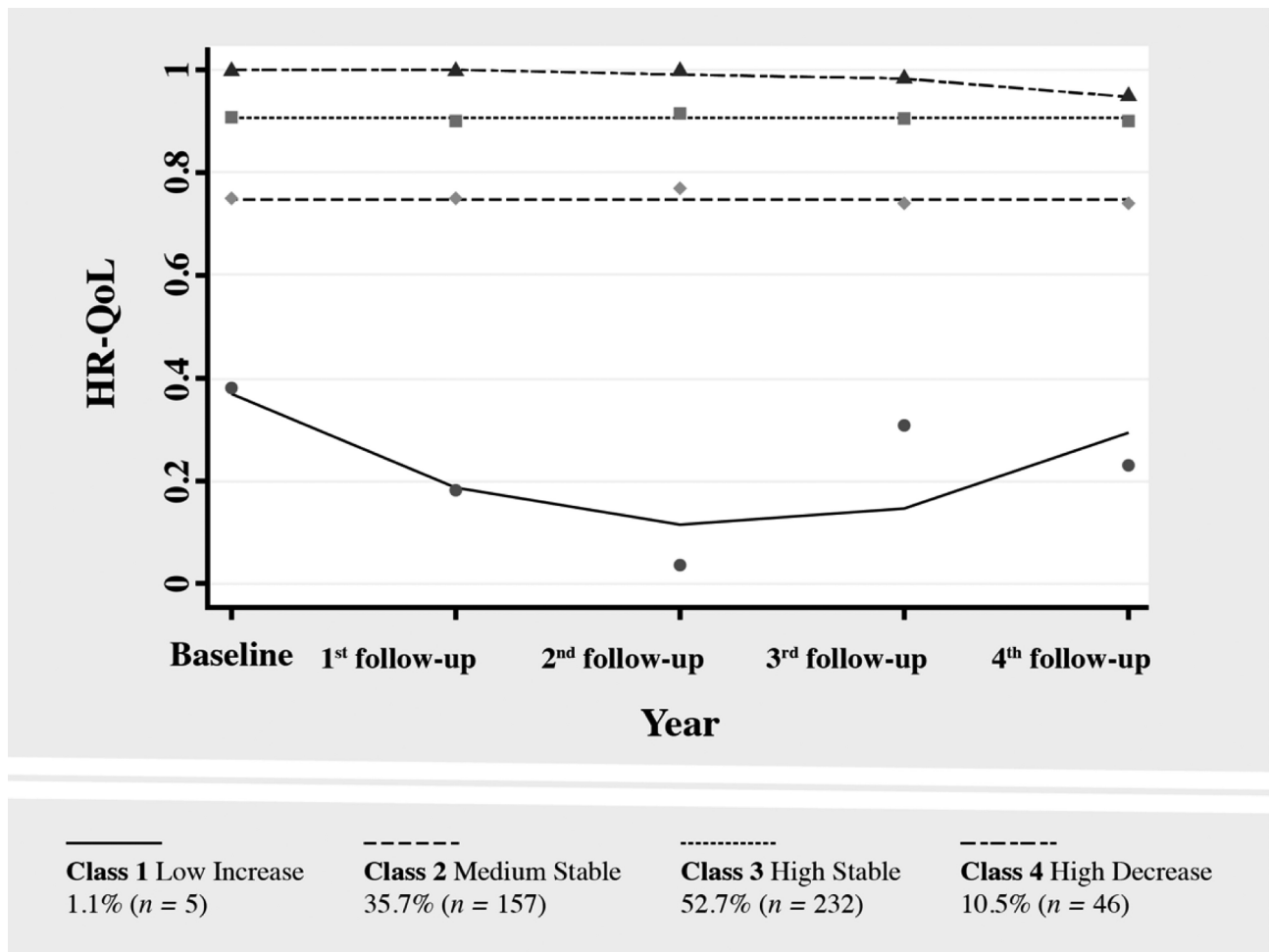
two follow-ups and decreased minimally thereafter, representing significant change ( $F = 4.587, p < .001$ ). The descriptive statistics of the HR-QoL subdomain scores (unweighted score) indicated significant improvement from baseline and through each follow-up point in terms of the mobility, self-care, usual activity, and anxiety/depression subdomain trajectories ( $p < .05$ ). However, the pain/discomfort subdomain trajectory was relatively stable, with a high score at baseline and at the four subsequent follow-up points ( $p < .242$ ).

### Health-Related Quality of Life Trajectories

Using group-based modeling, four distinct classes of HR-QoL trajectories were determined based on the BIC. The BIC decreased continuously from the one-class model to the six-class model ( $BIC_1 = -410.69, BIC_2 = -267.39, BIC_3 = -199.77, BIC_4 = -189.03, BIC_5 = -178.55, BIC_6 = -187.58$ ). The five-class model showed the maximum point of the BIC curves, which comprised the class with less than 1% of cases. The four-class model was reviewed and selected as it contained

**Figure 3**

*Health-Related Quality of Life (HR-QoL) Trajectories for the Four Latent Classes of Older Adults With Diabetes*



the most prominent and substantively meaningful number of classes. The four-class model contained a group with a low HR-QoL pattern of 1.3%, and each group was examined in terms of their conceptual and clinical explanatory feasibility.

The smallest group ( $n = 5$ , 1.1%), Class 1, was labeled “low increase” (LI). This group exhibited steadily worsening HR-QoL (from medium to severe) and had increased 4 years after estimation. Class 2 ( $n = 157$ , 35.7%) was labeled “medium stable” (MS) because, although this group exhibited a slight decrease in HR-QoL over time, the average HR-QoL level was “medium” for the 5-year period. The largest group ( $n = 232$ , 52.7%), Class 3, was labeled “high stable” (HS) because the individuals in this group demonstrated a consistently high HR-QoL level across the 5-year period. Finally, Class 4 ( $n = 46$ , 10.5%) was labeled “high decrease” (HD) because its members maintained a stable HR-QoL score that, although initially the highest among the four trajectory groups, began to decrease at the third follow-up point (see Figure 3 and Table 1).

A summary of the comparison of the sample proportion is provided in Table 2.

### Baseline Characteristics of the Four Trajectory Classes

Information about the demographic, environmental, and health-related factors of the four latent classes is presented in Table 2. Differences in the demographic variables of gender, age, educational level, and spousal status were found among the four trajectory groups. The HD group was younger, the MS group included more women, and the HD group had more men. Whereas environmental factors, residential region, and duration of diabetes mellitus were largely similar among the four groups, group differences in physical status in terms of the number of chronic diseases, hearing problems, and vision problems were found. However, BMI and eating problems were homogeneous among the groups. Intergroup differences in terms of stress were observed for disease, family, and finance. Participants in all groups reported experiencing sleep disturbance issues. Functional status variables such as ADL, IADL, and physical activity differed across the groups, and all four groups complied with medica-

tion well. In addition, health perception differed across the four groups, and the HD group reported better self-rated health at baseline.

### Predictors of Health-Related Quality of Life Trajectories

Multinomial logistic regression was used to identify the predictors of trajectory class group assignment (Table 3). The HD class was used as the reference group for the model, and its characteristics were compared with those of the MS and HS classes at baseline. The LI class was excluded from this analysis because its small number of members could not generate valid statistical difference results.

The HD class and the MS class differed significantly at baseline in terms of gender (RRR = 0.02,  $p < .001$ ), age (RRR = 1.26,  $p = .002$ ), education (RRR = 0.29,  $p = .020$ ), spousal status (RRR = 16.36,  $p = .002$ ), whether medical needs were met (RRR = 12.22,  $p = .038$ ), number of chronic diseases (RRR = 1.38,  $p = .027$ ), vision problems (RRR = 5.84,  $p = .011$ ), ADL (RRR = 0.14,  $p = .009$ ), IADL (RRR = 0.00,  $p < .001$ ), self-rated health (RRR = 0.29,  $p = .001$ ), and medication compliance (RRR = 0.06,  $p = .032$ ).

Compared to the HD class group, the MS class group had an older mean age, lower educational level, higher percentage of women, and lower percentage living with a spouse. Individuals in the MS class tended to have poor vision and believed their medical needs were not sufficiently met as well as having a higher number of chronic diseases, lower levels of independence with regard to ADL and IADL, and lower levels of self-rated health and medication compliance.

The HD class and the HS class differed significantly at baseline in terms of gender (RRR = 0.03,  $p < .001$ ), age (RRR = 1.23,  $p = .002$ ), spousal status (RRR = 17.20,  $p = .001$ ), vision-related problems (RRR = 4.41,  $p = .021$ ), finances-related stress (RRR = 3.09,  $p = .044$ ), and medication compliance (RRR = 0.04,  $p = .009$ ). More specifically, compared to the HD class group, the HS class group had more women, more individuals without a spouse, more vision-related problems, a higher mean age, higher finances-related stress, lower self-rated health, and poorer medication compliance. No differences between these groups were observed

**Table 1**  
*Intercept and Slope of the Four Latent Trajectory Classes (N = 440)*

| Class   | HR-QoL Classes | Intercept (SE) | Linear (SE)    | Quadratic (SE) | n   | % (SE)       | p      |
|---------|----------------|----------------|----------------|----------------|-----|--------------|--------|
| Class 1 | Low increase   | 0.652 (0.161)  | -0.338 (0.129) | 0.053 (0.022)  | 5   | 1.1 (0.553)  | .024   |
| Class 2 | Medium stable  | 0.753 (0.010)  | —              | —              | 157 | 35.7 (3.979) | < .001 |
| Class 3 | High stable    | 0.944 (0.010)  | —              | —              | 232 | 52.7 (3.917) | < .001 |
| Class 4 | High decrease  | 1.712 (0.206)  | -0.137 (0.043) | —              | 46  | 10.5 (1.802) | < .001 |

Note. HR-QoL = health-related quality of life; SE = standard error.

**Table 2***Differences in the Characteristics of the Four Latent Classes (N = 440)*

| Variable  | LI Class<br>(n = 5)       | MS Class<br>(n = 157)     | HS Class<br>(n = 232)     | HD Class<br>(n = 46)      | $F/\chi^2$ (p)  |
|---|---------------------------|---------------------------|---------------------------|---------------------------|-----------------|
|   | n or M (SD)               | n or M (SD)               | n or M (SD)               | n or M (SD)               |                 |
| <b>Demographic factors</b>  |                           |                           |                           |                           |                 |
| Gender (male/female)  | 2/3                       | 43/114                    | 108/124                   | 38/8                      | 47.577 (< .001) |
| Age (years)   | 71.6 <sup>ab</sup> (6.62) | 73.5 <sup>b</sup> (5.29)  | 71.8 <sup>a</sup> (4.59)  | 69.8 <sup>a</sup> (3.54)  | 8.449 (< .001)  |
| Educational level (none/elementary, middle/high school or higher) | 0/5/0                     | 33/108/16                 | 24/138/70                 | 1/23/22                   | 44.618 (< .001) |
| Spouse (yes/no)   | 4/1                       | 94/63                     | 172/60                    | 34/12                     | 9.454 (.019)    |
| <b>Environmental factors</b>                                      |                           |                           |                           |                           |                 |
| Household income (score, 1–5)                                     | 1.60 <sup>ab</sup> (0.89) | 1.76 <sup>a</sup> (0.99)  | 2.19 <sup>b</sup> (1.18)  | 1.89 <sup>ab</sup> (3.16) | 7.575 (< .001)  |
| Residential region (metro/nonmetro)                               | 0/5                       | 48/109                    | 95/137                    | 15/31                     | 7.135 (.058)    |
| Duration of diabetes mellitus (years)                             | 15.2 (7.98)               | 10.9 (8.16)               | 10.8 (7.85)               | 10.2 (6.84)               | 0.623 (.601)    |
| Whether medical needs were met (yes/no/missing)                   | 1/4                       | 33/122/2                  | 29/194/9                  | 1/39                      | 11.319 (.009)   |
| <b>Health-related factors</b>                                     |                           |                           |                           |                           |                 |
| Physical status   |                           |                           |                           |                           |                 |
| Body mass index   | 22.2 (2.75)               | 23.5 (3.89)               | 24.0 (2.90)               | 24.2 (3.04)               | 1.527 (.207)    |
| Obesity (overweight/normal/underweight/missing)                   | 1/2/2                     | 52/84/19/2                | 73/143/15/1               | 15/26/3                   | 9.028 (.144)    |
| Number of chronic diseases  | 5.00 (1.41)               | 5.52 (2.61)               | 4.28 (2.00)               | 3.57 (1.95)               | 13.900 (< .001) |
| Hypertension (yes/no)   | 4/1                       | 121/36                    | 164/68                    | 32/14                     | 2.373 (.494)    |
| Hearing problem (yes/no)  | 3/2                       | 62/95                     | 65/167                    | 5/41                      | 17.865 (< .001) |
| Vision problem (yes/no)   | 4/1                       | 95/62                     | 97/135                    | 8/38                      | 33.246 (< .001) |
| Eating problem (yes/no/missing)                                   | 1/4                       | 23/134                    | 29/202/1                  | 14/397                    | 1.044 (.775)    |
| Symptoms  |                           |                           |                           |                           |                 |
| Sleep disturbance (yes/no/missing)                                | 2/3                       | 92/65                     | 132/99/1                  | 21/24                     | 2.641 (.468)    |
| Stress regarding disease (yes/no/missing)                         | 2/3                       | 148/7/2                   | 175/48/9                  | 24/16                     | 37.722 (< .001) |
| Stress regarding family (yes/no/missing)                          | 2/3                       | 65/87/5                   | 92/129/11                 | 5/32                      | 12.705 (.004)   |
| Stress regarding finances (yes/no/missing)                        | 4/1                       | 122/33/2                  | 154/69/9                  | 21/19                     | 11.411 (.008)   |
| Functional status   |                           |                           |                           |                           |                 |
| ADL (independent/dependent)                                       | 0/5                       | 82/75                     | 193/39                    | 147/63                    | 59.499 (< .001) |
| IADL (independent/dependent)                                      | 1/4                       | 137/20                    | 231/1                     | 46/0                      | 51.189 (< .001) |
| IPAQ (inactive/minimally active/active/missing)                   | 5/0/0                     | 93/53/11                  | 90/106/35/1               | 14/22/9                   | 26.493 (< .001) |
| Medication compliance (high/low)                                  | 5/0                       | 145/12                    | 205/27                    | 45/1                      | 4.725 (.175)    |
| <b>Health perception</b>  |                           |                           |                           |                           |                 |
| Self-rated health (score, 0–4)                                    | 0.25 <sup>a</sup> (0.50)  | 1.35 <sup>a</sup> (0.930) | 2.04 <sup>b</sup> (0.940) | 2.47 <sup>c</sup> (0.842) | 32.467 (< .001) |

Note. Post hoc was analyzed with the Bonferroni method. LI = low increase; MS = medium stable; HS = high stable; HD = high decrease; ADL = activities of daily living; IADL = instrumental activities of daily living; IPAQ = International Physical Activity Questionnaire.

<sup>a</sup>, <sup>b</sup>, <sup>c</sup> are group names given when the mean difference between groups is significant, and the order is a < b < c.

in terms of household income, residential region, duration of diabetes mellitus, BMI, hypertension, hearing problems, eating problems, sleep disturbances, disease-related stress, and IPAQ.

## Discussion

### Health-Related Quality of Life Trajectories in Older Adults With Diabetes Mellitus

A salient finding of this study is that HR-QoL trajectories in older adults with diabetes mellitus are not homogeneous but rather diverge into four distinct class categories. This finding concurs with the findings of several previous studies that have examined the longitudinal HR-QoL trajectories in

other chronic diseases. For instance, past researchers have identified five distinctive HR-QoL trajectories for patients with chronic obstructive pulmonary disease (Yoo et al., 2016), four distinctive HR-QoL trajectories for patients with colon cancer (Dunn et al., 2013), and two distinctive HR-QoL trajectories for patients who have undergone coronary artery bypass graft surgery (Le Grande et al., 2006), respectively.

Across the 5 years of the survey, approximately 90% of the study participants (the sum of HS and MS classes) reported no significant changes in HR-QoL. Similar results have been found in previous studies. Schmitz et al. (2013) reported that 72% of adults with diabetes mellitus maintained consistently good self-rated health over 3 years. Furthermore, Schwandt et al. (2017) reported that, as per the

**Table 3**  
Class Comparison (Multinomial Logistic Regression)

| Variable                             | Trajectory Class             |                |        |                              |               |        |
|--------------------------------------|------------------------------|----------------|--------|------------------------------|---------------|--------|
|                                      | MS Class vs. HD Class (Ref.) |                |        | HS Class vs. HD Class (Ref.) |               |        |
|                                      | RRR                          | 95% CI         | p      | RRR                          | 95% CI        | p      |
| <b>Demographic factors</b>           |                              |                |        |                              |               |        |
| Gender (male)                        | 0.02                         | [0.00, 0.89]   | < .001 | 0.03                         | [0.01, 0.17]  | < .001 |
| Age (years)                          | 1.26                         | [1.09, 1.46]   | .002   | 1.23                         | [1.08, 1.40]  | .002   |
| Educational level                    | 0.29                         | [0.10, 0.82]   | .020   | 0.55                         | [0.22, 1.38]  | .201   |
| Spouse (yes)                         | 16.36                        | [2.90, 92.39]  | .002   | 17.20                        | [3.32, 89.03] | .001   |
| <b>Environmental factors</b>         |                              |                |        |                              |               |        |
| Household income                     | 0.97                         | [0.68, 1.39]   | .881   | 1.19                         | [0.90, 1.58]  | .215   |
| Residential region (metro)           | 0.97                         | [0.30, 3.13]   | .957   | 1.62                         | [0.58, 4.50]  | .354   |
| Duration of diabetes mellitus        | 0.99                         | [0.92, 1.08]   | .858   | 0.99                         | [0.92, 1.07]  | .824   |
| Whether medical needs were met (yes) | 12.22                        | [1.15, 129.96] | .038   | 8.14                         | [0.84, 79.17] | .071   |
| <b>Health-related factors</b>        |                              |                |        |                              |               |        |
| Physical status                      |                              |                |        |                              |               |        |
| Body mass index                      | 0.99                         | [0.69, 1.45]   | .983   | 1.07                         | [0.78, 1.49]  | .668   |
| Obesity (underweight)                | 2.75                         | [0.07, 115.44] | .595   | 2.70                         | [0.10, 70.56] | .551   |
| Obesity (normal)                     | 0.51                         | [0.07, 3.58]   | .498   | 1.05                         | [0.19, 5.65]  | .959   |
| Number of chronic diseases           | 1.38                         | [1.04, 1.85]   | .027   | 1.09                         | [0.83, 1.42]  | .542   |
| Hypertension (yes)                   | 0.94                         | [0.27, 3.22]   | .915   | 1.17                         | [0.39, 3.50]  | .783   |
| Hearing problem(s) (yes)             | 1.69                         | [0.38, 7.55]   | .494   | 2.25                         | [0.56, 9.10]  | .254   |
| Vision problem(s) (yes)              | 5.84                         | [1.50, 22.66]  | .011   | 4.41                         | [1.25, 15.55] | .021   |
| Eating problem(s) (yes)              | 0.89                         | [0.17, 4.74]   | .894   | 0.86                         | [0.19, 3.96]  | .850   |
| Symptoms                             |                              |                |        |                              |               |        |
| Sleep disturbance (yes)              | 1.45                         | [0.50, 4.25]   | .495   | 1.50                         | [0.59, 3.85]  | .395   |
| Stress regarding disease (yes)       | 2.61                         | [0.60, 11.47]  | .203   | 0.99                         | [0.34, 2.89]  | .979   |
| Stress regarding family (yes)        | 2.90                         | [0.82, 10.25]  | .098   | 2.78                         | [0.88, 8.82]  | .082   |
| Stress regarding finances (yes)      | 2.88                         | [0.81, 10.30]  | .104   | 3.09                         | [1.03, 9.27]  | .044   |
| Functional status                    |                              |                |        |                              |               |        |
| ADL (independent)                    | 0.14                         | [0.03, 0.61]   | .009   | 0.71                         | [0.18, 2.77]  | .625   |
| IADL (independent)                   | 0.00                         | [0.00, 0.00]   | < .001 | —                            | —             | —      |
| Medication compliance (high)         | 0.06                         | [0.01, 0.79]   | .032   | 0.04                         | [0.00, 0.45]  | .009   |
| IPAQ (inactive)                      | 0.79                         | [0.15, 4.16]   | .783   | 0.69                         | [0.17, 2.79]  | .599   |
| <b>Health perception</b>             |                              |                |        |                              |               |        |
| Self-rated health                    | 0.29                         | [0.14, 0.58]   | .001   | 0.54                         | [0.28, 1.04]  | .063   |

Note. Reference value: gender (female), spouse (no), dwelling area (nonmetro), whether medical needs were met (no), hypertension (no), hearing problem(s) (no), vision problem(s) (no), eating problem(s) (no), stress regarding diseases (no), stress regarding family (no), stress regarding finances (no), ADL (dependent), IADL (dependent), compliance (low), obesity (overweight), IPAQ (active). Continuous variables. Education levels = 1 (no schooling) to 3 (more than high school); Self-rated health: 0 (poor health) to 4 (excellent health). MS = medium stable; HD = high decrease; HS = high stable; RRR = relative risk ratio; CI = confidence interval; ADL = activities of daily living; IADL = instrumental activities of daily living; IPAQ = International Physical Activity Questionnaire.

heterogeneity in the glycolated hemoglobin (HbA1c) levels (i.e., an indicator of blood sugar level) of young adults with diabetes mellitus, approximately 80% of the patients across four distinct trajectories exhibited relatively stable HR-QoL patterns. These results may be explained by the positive relationship between HR-QoL and glycemic control (Lim & Oh, 2013; Scollan-Koliopoulos et al., 2013; Shiu et al., 2014).

In this study, the average length of time that participants had diabetes mellitus was 10.8 years at baseline, after which, over the 5-year period of the study, their HR-QoL showed no major change. In order to prevent diabetic complications such as retinopathy or nephropathy, self-care from the onset

of the disease is essential. However, most diabetic patients neglect self-care within the initial 10-year period from initial onset to the development of complications (Jang et al., 2014; Park & Ryu, 2002; Shin, 2019). The results of this and previous studies provide practical support to the critical importance of self-management during the initial 10-year period. This study, in particular, provides evidence indicating that the health management of diabetes should focus on the initial 10 years after diagnosis in order to promote higher levels of HR-QoL in old age.

Consistent with the literature, 11% of the participants (those in the HD and LI class groups) exhibited changes in



their trajectory that changed their HR-QoL status over time (Olson et al., 2014; Pancani et al., 2018; Yoo et al., 2016). This finding suggests both that HR-QoL may change over time and that it is important for individualized care to be based on the level and patterns of HR-QoL in a patient. Furthermore, the findings show that even older adults with lower levels of HR-QoL have the potential to improve their HR-QoL across time.

## Factors Influencing the Health-Related Quality of Life Trajectories of Older Adults With Diabetes Mellitus

The absence of chronic diseases and vision problems was found to be a strong predictor of HD class group assignment among older adults with diabetes mellitus. This result is consistent with previous findings that physical status such as geriatric syndromes and diabetes-related complications (e.g., diabetic retinopathy, neuropathy, and nephropathy) decrease HR-QoL in older adults with diabetes mellitus (Bowen et al., 2015; Kalyani et al., 2010; Speight et al., 2020). These diabetes-related complications and aging-related problems seem to reduce the functional status of older adults with this condition and to limit their activities and self-care management, thereby resulting in a decrease in HR-QoL (Laiterapong et al., 2011).

Functional status was found in this study to be highly predictive of HR-QoL trajectory classification, whereas independent ADL and IADL were identified as predictors of assignment to HD and HS class groups. This result concurs with the findings of previous studies, which found evidence of physical function-related limitations in older adult participants negatively impacting their cognitive and affective self-evaluations (Olson et al., 2014). Stress related to disease, family, and finances was determined to be a factor affecting trajectories, with finances-related stress identified as the most significant factor distinguishing the respective HR-QoL trajectories of the HS and MS class groups. This echoes past findings indicating that psychological distress directly affects HR-QoL in older adults with diabetes mellitus (Shiu et al., 2014).

Unsurprisingly, medication compliance, a form of self-care management, was found to affect HR-QoL in older adults with diabetes mellitus. This result is consistent with past findings indicating that self-care management is affected by autonomous motivation and self-efficacy and that poorer disease-related self-care management lowers HR-QoL in older adults with diabetes mellitus (Lee & Kim, 2017). Achieving good glycemic control by adhering to diabetes self-management behaviors helps patients feel better, which positively affects HR-QoL.

Self-rated health, which is a known contributor to HR-QoL (Ferrans et al., 2005), was found in this study to be a strong predictor of assignment to the HD and HS class groups. Older adults with diabetes mellitus who had better self-rated health were more likely to maintain their HR-QoL pattern relative to other older adults (Schmitz et al., 2013; Shiu et al., 2014; Speight et al., 2020). Meanwhile, self-rated health was deter-

mined to be an important predictor of poor functioning in diabetes, with the trajectory of self-rated health seeming to become even more important over time (Schmitz et al., 2013). These results have practical implications for groups of individuals with similar HR-QoL trajectory patterns because they not only help identify group-specific risk factors but also help healthcare providers make informed decisions about when and how nursing interventions should be implemented.

## Limitations

Several limitations potentially affect the findings of this study. First, ADL and IADL were found to be relatively independent of one another. As the data used in this study were sourced from a nationwide, face-to-face survey, frail older adults may not have been able to participate in this survey. Therefore, it is possible that self-exclusion by these older, more frail individuals led to an overestimation of HR-QoL. The initial variables between missing and analytical cases represent a potential limitation. This study focused on short-term rather than long-term changes in HR-QoL in older adults with diabetes mellitus. Therefore, it is recommended that future researchers use variables such as chronological age and age at diabetes mellitus diagnosis to identify age-related subgroups for targeted study. This may facilitate a better understanding of long-term HR-QoL trajectories in older adults with diabetes mellitus and of the development of targets and time frames for individualized nursing interventions. Only BMI, number of chronic diseases, hypertension, hearing, vision, and eating problems were available for consideration as physical status-related variables in this study. Furthermore, only sleep disturbance and stress related to disease, family, and finances were available for consideration as symptom-related variables. Other physical conditions or symptoms shown to affect the HR-QoL of older adults with diabetes mellitus in earlier studies were not available for consideration in this study. Unavailability of potentially influential/important data is a general limitation of secondary data analysis.

## Conclusions

Despite the noted limitations, this study adds to the existing literature in three ways. First, this study evaluated temporal changes in HR-QoL using longitudinal data obtained from a national sample of older adults with diabetes mellitus rather than using cross-sectional data obtained from the general population.

Second, many previous studies have reported that older adults with diabetes mellitus are more likely to have poorer self-rated health and overall HR-QoL. Although older adults with diabetes mellitus have generally been treated as a homogeneous group in terms of individual characteristics, this study extended the findings of earlier research by distinguishing between latent classes within the population with diabetes mellitus. This improves scholarly understanding of the temporal HR-QoL trajectories of older adults with diabetes mellitus and has important implications for nursing practice

and research. According to the findings, the HR-QoL of older adults with diabetes mellitus may follow four distinct patterns. Therefore, unique nursing interventions may be tailored to each HR-QoL pattern. For those following a high-level HR-QoL trajectory, for example, nursing care should aim to maintain their HR-QoL pattern. For those at a medium level, nursing care may aim to maintain or improve HR-QoL. For those at a low level, nursing interventions may aim to improve HR-QoL. Qualitative research will be necessary to determine the factors that significantly influence each pattern.

Third, this study found that, across HR-QoL class categories, most of the participants exhibited no major changes in HR-QoL during the 5-year period. This implies that HR-QoL history may help predict future HR-QoL level in older adults with diabetes mellitus. These research findings may help healthcare providers understand the need to comprehensively assess and promote HR-QoL in older adults with diabetes mellitus.

## Author Contributions

Study conception and design: SP, TL

Data collection: SP

Data analysis and interpretation: CP

Drafting of the article: SP

Critical revision of the article: SP, TL

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