Quality of Life Research (2019) 28:481–490
https://doi.org/10.1007/s11136-018-2013-2

Determinants for quality of life trajectory patterns in patients with type 2 diabetes

Ruey-Hsia Wang[1,2] · Kuan-Chia Lin[3,4] · Hui-Chun Hsu[5] · Yau-Jiunn Lee[5] · Shyi-Jang Shin[6]

Accepted: 24 September 2018 / Published online: 1 October 2018

Abstract

Purpose The purpose of the study was to identify quality of life (QoL) trajectory patterns and the determinants in patients with Type 2 diabetes (T2DM).

Methods A longitudinal design was employed. Totally, 466 patients with T2DM recruited from five diabetic clinics in Taiwan were participants of this study. Demographic and disease characteristics, biomedical factors (HbA1c levels and body mass index), psychosocial factors (self-care behaviors, social support, resilience, diabetes distress), and QoL were collected at baseline. QoL was further measured every 6 months for four waves after baseline. Latent class growth analysis was used to identify QoL trajectory patterns. The multinomial logistic regression was further applied to explore the important determinants of different QoL trajectory patterns.

Results The "steadily poor" ($n=27$, 5.8%), "consistently moderate" ($n=174$, 37.3%), and "consistently good" ($n=265$, 56.9%) trajectory patterns were identified. The HbA1c levels (*OR* 2.16) and diabetes distress (*OR* 1.18) were important for determining participants in the "steadily poor" QoL trajectory pattern. HbA1c levels (*OR* 1.25) and diabetes distress (*OR* 1.14) were important for determining participants in the "consistently moderate" QoL trajectory pattern.

Conclusions To prevent development of relatively worse QoL trajectory patterns in patients with T2DM in a timelier manner, healthcare providers could regularly assess the QoL and provide intervention, especially for those with high HbA1c levels and high diabetes distress. Meanwhile, early intervention for decreasing HbA1c levels and diabetes distress may improve the trajectory development of QoL in patients with T2DM.

Keywords Type 2 diabetes · Quality of life · Trajectory pattern · Self-care behaviors · Diabetes distress · Glycemic control

✉ Ruey-Hsia Wang
wrhsia@kmu.edu.tw

Kuan-Chia Lin
kuanchia@ym.edu.tw

Hui-Chun Hsu
huichun.hsu@leesclinic.org

Yau-Jiunn Lee
lee@leesclinic.org

Shyi-Jang Shin
sjshin@kmu.edu.tw

[1] College of Nursing, Kaohsiung Medical University, 100, Shih-Chuan 1st Road, Kaohsiung City 807, Taiwan, ROC

[2] Department of Medical Research, Kaohsiung Medical University Hospital, 100, Shih-Chuan 1st Road, Kaohsiung City 807, Taiwan, ROC

[3] Institute of Hospital and Health Care Administration, National Yang-Ming University, 155, Sec. 2, Linong st., Beitou District, Taipei City 11221, Taiwan, ROC

[4] Preventive Medicine Research Center, National Yang-Ming University, 155, Sec. 2, Linong st., Beitou District, Taipei City 11221, Taiwan, ROC

[5] Lee's Endocrinology Clinic, 396, Guangdong Rd., Pingtung City 900, Pingtung County, Taiwan, ROC

[6] Division of Endocrinology and Metabolism, Department of Internal Medicine, Kaohsiung Medical University Hospital, 100, Shih-Chuan 1st Road, Kaohsiung City 807, Taiwan, ROC

Introduction

Type 2 diabetes (T2DM) is a global healthcare issue because of its increasing incidence and prevalence in the world population, including Taiwan [1]. Traditionally, diabetes care has been more focused on improving glycemic control and preventing the occurrence of complications. However, with health being increasingly highlighted as necessarily including aspects of well-being, enhancing quality of life (QoL) has become increasingly important for diabetes control [2]. For patients with chronic disease, QoL is the subjective evaluation of the positive and negative aspects of daily life and represents the perceptions of the impacts of disease treatment on the life. Diagnosis with T2DM has been found to negatively impact QoL [3]. Patients with T2DM have a poor QoL than those without T2DM [4]. With increasing life expectancy, enhancing QoL of patients with T2DM is an important responsibility of healthcare providers [2].

Many previous cross-sectional studies have identified determents of QoL in patients with T2DM. Nevertheless, many of them have explored the determinants of a specific time point of QoL. Health status is a dynamic process and may change over time, which is referred to as health trajectory [5]. Patients with T2DM encountering different events may experience distinct QoL trajectory patterns along with the progress of diabetes control. Understanding the QoL trajectory patterns and the determinants may help in providing customized interventions for patients with T2DM undertaking different QoL trajectory patterns and further provide relevant knowledge for evidence-based patient care [6].

Demographic and disease characteristics, biomedical factors and psychosocial factors might determine the QoL trajectory patterns in patients with T2DM according to the findings of cross-sectional and longitudinal studies [7–9]. In terms of psychosocial factors, self-care behavior is crucial for achieving optimal glycemic control in patients with T2DM. Patients with better self-care behaviors are found to have better glycemic control [7, 8]. Therefore, patients might possess relative positive experience regarding the impacts of diabetes control on their life. Many studies have supported that self-care behaviors are positively associated with QoL in patients with T2DM [8, 9]. Therefore, self-care behaviors might be one of the important determinants of QoL trajectory patterns in patients with T2DM.

Resilience is defined as the ability to recover from challenging life events and help achieve optimal physical or emotional health [10]. People with chronic disease who are high in resilience demonstrate good psychological adjustment; this, finally, might lead to good QoL [11, 12]. The role of resilience on psychosocial adjustment in patients with T2DM has been increasingly emphasized in recent years. A cross-sectional study found that resilience positively associated with QoL in patients with T2DM [13]; accordingly, the influence of resilience on the trajectory patterns of QoL deserves further study.

Diabetes distress is a specific psychological problem in patients with T2DM and refers to a negative emotional response to the stress resulting from diabetes control in daily life [14]. Around 18% of patients with T2DM experience high levels of diabetes distress [14]. Many cross-sectional studies have indicated that diabetes distress is negatively associated with QoL in patients with T2DM [15, 16]. Further research is required to find out whether diabetes distress determines the QoL trajectory patterns in patients with T2DM.

Social support refers to the self-appraisal of social networks from family, friends, and organizations as well as receiving financial, emotional, and informational assistance when needed [17]. Patients with chronic disease need interpersonal resources to help them buffer the negative effect of stress on health [18]. Many cross-sectional studies have supported that higher social support is associated with better QoL in patients with T2DM [19, 20]. Accordingly, social support may determine the QoL trajectory patterns in patients with T2DM.

Besides psychosocial factors, demographic and disease characteristics were found to be associated with QoL. QoL in females, older adults, with long-term duration of diabetes, insulin users, and with more complications are all predictors of poor QoL [21, 22]. Furthermore, biomedical factors such as high hemoglobin A1c (HbA1c) levels and obesity are associated with poor QoL for patients with T2DM [23, 24]. Demographic and disease characteristics as well as biomedical factors should be considered when examining the determinants of QoL trajectory patterns.

Longitudinal designs can trace the trajectory patterns over time. Identifying baseline determinants of trajectory patterns of outcome over time, defined as a baseline tracking model, is helpful to develop timely interventions to improve the development of health outcomes later [5]. The aim of this study was to identify QoL trajectory patterns and the baseline determinants in patients with T2DM based on demographic and disease characteristics, biomedical factors (HbA1c levels and body mass index), and psychosocial factors (self-care behaviors, social support, resilience, diabetes distress) by longitudinal design.

Methods

Design, sampling, and data collection procedure

Data of this study were derived from a longitudinal study that intended to construct an influencing model of diabetes control. Two published papers were derived from this longitudinal study according to different research purposes [12, 25]. In this study, patients with T2DM who were diagnosed

with T2DM for more than 6 months, aged between 20 and 80 years and able to read Chinese language questionnaires were recruited from five diabetic clinics in Southern Taiwan by convenience sampling. Demographic and disease characteristics, biomedical factors, psychosocial factors and QoL were collected at baseline. QoL was further measured every 6 months across four waves after baseline. Because at least three follow-up observations were required to assess trajectory patterns, participants who completed more than three follow-up observations were considered participants of this study. Among 594 participants recruited at baseline, 52 (8.8%) had one observation, 76 (12.8%) had two observations, while 466 (78.5%) participants completed at least three repeated observations and became participants in this study.

Measurements

Biomedical factors including body mass index (weight/height^2) and HbA1c levels were collected from medical records. A self-reported questionnaire was used to collect demographic and disease characteristics, psychosocial factors and QoL. In terms of psychosocial factors, scales used to measure self-care behaviors, social support, resilience, and diabetes distress have been described in detail in previously published papers [12, 25]. QoL measured by a Quality of Life scale was firstly described here. The contents of questionnaires in this study were as follows:

Quality of life scale

A 16-item Diabetes-Specific Quality-of-Life Scale (D-QoL) [26] was used to assess the subjective appraisal of current health-related life affected by emotional suffering, social functioning, adherence to the treatment regimen, and diabetic-specific symptoms. Each item was rated from "Very much" (0 point) to "Not at all" (4 points). This scale was translated into Chinese and the conceptual equivalence was examined by members of the research team. One item "feel depression because of diabetes" was deleted because the measured concept overlapped with diabetes distress, which was also measured in this study. Finally, 15 items were used to measure QoL. The total score ranged from 0 to 60. A higher score indicated better QoL.

Self-care behaviors scale

A 17-item Chinese version of a diabetes self-care scale was used to assess behaviors of medication, diet, exercise, blood sugar monitoring, and adversity prevention [25]. Each item was rated on a 5-point scale ranging from "Never (0 point)" to "Always (4 points)." The range of total score was between 0 and 68. A higher total score indicated more positive self-care behavior.

Social support scale

A 11-item Chinese version of social support scale was used to assess perceived tangible support, informational and emotional support, positive social interaction and affective support of participants [12]. Each item was rated from "Never" (0 point) to "Always" (4 points). The total score ranged from 0 to 44. A higher total score indicated better perceived support.

Resilience scale

A 10-item Chinese version of Connor-Davidson Resilience Scale was used to measure the resilience of participants [27]. The scale is a 5-point Likert scale. Each item was rated from "Never" (0 point) to "Always" (4 points). The total score ranged from 0 to 40. A higher total score indicated higher resilience of participants.

Diabetes distress scale

An 8-item Chinese version of short form Problem Areas in Diabetes scale was used to assess the diabetes distress of participants [28]. Each item was rated from "Not a problem" (0 point) to "Serious problem" (4 points). The total score ranged from 0 to 32. A higher total score indicated greater diabetes distress.

Demographic and disease characteristics

Data of demographic characteristics included age, sex, and substance use (any habit of smoking, drinking, or betel quid chewing was categorized "yes") in the previous 6 months. Disease characteristics included complications (yes/no), duration of diabetes, and insulin treatment (yes/no).

Validity and reliability of scales

The procedure for testing validity and reliability of self-care, social support, resilience, and diabetes distress scales has been described in previously published papers [12, 25], and the validity and reliability of these scales have been shown to be acceptable [12, 25]. In this study, five experts were invited to examine the appropriateness of each item in quality of life scale from "Not very appropriate" (1 point) to "Very appropriate" (4 points). By calculating the ratio of items scoring 3 or 4 to the total number of items, the content validity index of quality of life scale was 1.0. The Cronbach's α which examined internal consistency was 0.88 for quality of life scale. The reliability and the validity of scales used in this study were acceptable.

Ethical considerations

The study was approved by the Institutional Review Board of Kaohsiung Medical University, Taiwan (approval number: KMUH-IRB-20120347). All of the participants were informed that they would be no penalty for refusal to participate in the study. Participants were allowed to withdraw from the study at any time. Informed consent was obtained from all individual participants included in this study.

Data analysis

Latent class growth analysis (LCGA) was used to identify the different group-based QoL trajectory patterns. The purposes of LCGA are to reveal distinct patterns of homogeneous longitudinal trajectories [29, 30]. A major advantage of LCGA is that it provides an alternative to the ''classify then-analyze'' procedure, in which items are first classified into groups by a given method (e.g., cluster analysis using a distance metric), and then the clusters are compared in terms of various measures. In this study, LCGA is the appropriate method of analyzing inter-QoL trajectory pattern differences in intra-individual QoL changes. Based on the above, the LCGA summarized the heterogeneity (i.e., changes in the development of individual QoL over time according to the data) by using a finite set of unique polynomial functions, each of which corresponds to a discrete trajectory. Missing data were handled using full information maximum likelihood estimation.

The SAS 9.2 software (SAS Institute, Inc., Cary, NC) was used to estimate the model and calculate model performance indexes for alternative models based on Bayesian information criterion (BIC). Low BIC values are interpreted as a good model fit to the data when an additional latent class is included [31]. After QoL trajectory patterns were identified, ANOVA and χ^2 test were used to examine the associations of demographic and disease characteristics, biomedical factors and psychosocial factors with identified trajectory patterns. The multinomial logistic regression was further applied to explore the important determinants of different QoL trajectory patterns.

Results

Distribution of demographic and disease characteristics, psychosocial factors, and QoL

Distribution of baseline demographic and disease characteristics, biomedical factors, psychosocial factors, and QoL of completing one, two observations, and participants of this study (≥ 3 repeated observations) and comparisons among them are shown in Table 1. As shown, participants of this study had significantly lower HbA1c levels and diabetes distress and higher QoL at baseline than those completing one or two observations. The distributions of QoL in all participants at five time points were 52.82 (*SD* = 7.46), 52.54 (*SD* = 7.99), 52.69 (*SD* = 7.63), 53.35 (*SD* = 7.06), and 52.60 (*SD* = 7.81), respectively.

Identifying QoL trajectory patterns

After several solutions, LCGA indicated that three trajectory patterns models (BIC = − 6021.05) had a better fit than one-class (BIC = − 6267.03) and two-class solutions (BIC = − 6077.39). According to the characteristics of distribution, the three QoL trajectory patterns were named as "consistently good" (*n* = 265, 56.9%), "consistently moderate" (*n* = 174, 37.3%), and "steadily poor" (*n* = 27, 5.8%). The means of QoL in three trajectory pattern across five time points are shown in Fig. 1. As shown, means of QoL at five time points for the "consistently good" QoL trajectory pattern were stable and all higher than those of all participants. Means of QoL at five time points for the participants of "consistently moderate" QoL trajectory pattern were stable and slightly smaller than those of all participants. For the "steadily poor" QoL trajectory pattern, QoL substantially declined within the first six months followed by an improvement close to the baseline value. Nevertheless, means of QoL at five time points were all lower than those of all participants.

The association of demographic and disease characteristics, biomedical factors and psychosocial factors with QoL trajectory patterns

Table 2 shows the comparisons of demographic and disease characteristics, biomedical factors and psychosocial factors at baseline on three QoL trajectory patterns. Age of participants in the "consistently good" trajectory pattern was significantly older than those in the "consistently moderate" and the "steadily poor" QoL trajectory patterns. For HbA1c levels, participants in the "steadily poor" QoL trajectory pattern were significantly higher than those in the "consistently good" and the "consistently moderate" QoL trajectory patterns, and those in the "consistently moderate" QoL trajectory pattern were significantly higher than those in the "consistently good" trajectory pattern.

With respect to psychosocial factors, self-care behaviors of participants in the "consistently moderate" QoL trajectory pattern were significantly lower than those in the "consistently good" QoL trajectory pattern. Social support and resilience of participants in the "consistently moderate" and "steadily poor" QoL trajectory patterns were significantly lower than those in the "consistently good" QoL trajectory

Table 1 Distribution and comparison of baseline demographic and disease characteristics, biomedical factors, psychosocial factors, and quality-of-life among participants who complete 1, 2, and ≥3 observations ($N=594$)

Variable	1 observation ($n=52$)	2 observations ($n=76$)	≥3 observations (this study) ($n=466$)	F or χ^2
	Mean ± *SD* [*n* (%)]	Mean ± *SD* [*n* (%)]	Mean ± *SD* [*n* (%)]	
Demographic characteristics				
Age (years)	57.54 ± 10.54	57.29 ± 12.34	58.47 ± 11.33	$F=0.51$
Sex				$\chi^2=0.26$
Male	30 (57.7)	45 (59.2)	208 (44.6)	
Female	22 (42.3)	31 (40.8)	258 (55.4)	
Substance use				$\chi^2=1.00$
No	39 (75.0)	56 (73.7)	359 (77.0)	
Yes	13 (25.0)	20 (26.3)	107 (23.0)	
Disease characteristics				
Complications				$\chi^2=3.22$
No	23 (44.2)	43 (56.6)	225 (48.3)	
Yes	29 (55.8)	33 (43.4)	241 (51.7)	
Duration of diabetes	11.04 ± 7.94	9.51 ± 6.91	9.88 ± 7.12	$F=0.79$
Insulin treatment				$\chi^2=0.02$
No	41 (78.8)	59 (77.6)	352 (75.5)	
Yes	11 (21.2)	17 (22.4)	114 (24.5)	
Biomedical factors				
Body mass index	27.48 ± 5.66	27.05 ± 4.65	26.65 ± 4.59	$F=0.82$
HbA1c	7.73 ± 1.74	7.81 ± 1.62	7.18 ± 1.18	$F=10.54$*** One, two observations > this study
Psychosocial factors				
Self-care behaviors	43.19 ± 11.78	44.39 ± 11.80	44.82 ± 11.22	$F=0.43$
Social support	28.80 ± 12.95	30.65 ± 12.20	32.47 ± 11.55	$F=2.68$
Resilience	32.27 ± 8.11	30.66 ± 8.28	31.21 ± 8.34	$F=0.64$
Diabetes distress	8.00 ± 7.12	10.20 ± 9.07	7.65 ± 6.97	$F=4.13$* Two observations > this study
Baseline QoL	51.13 ± 6.74	50.62 ± 9.67	52.82 ± 7.46	$F=3.55$* Two observations < this study

QoL quality of life

*$p<.05$, ***$p<.001$

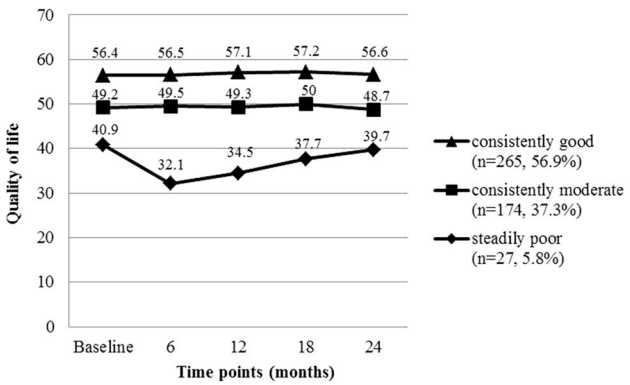

Fig. 1 Three quality of life trajectory patterns across 24 months

pattern. As for diabetes distress, participants in the "steadily poor" QoL trajectory pattern had significantly higher measures than those in the "consistently moderate" and the "consistently good" QoL trajectory patterns, and measures in the "consistently moderate" QoL trajectory pattern were significantly higher than those in the "consistently good" QoL trajectory pattern.

Identifying important determinants of QoL trajectory patterns

Taking "consistently good" QoL trajectory pattern as the reference group, multinomial logistic regression was performed to identify the important determinants of QoL trajectory patterns. As show in Table 3, the HbA1c levels (*OR* 2.16) and diabetes distress (*OR* 1.18) were important

Table 2 Comparison of demographic and disease characteristics, biomedical factors, and psychosocial factors among three quality-of-life trajectory patterns ($N=466$)

Variable	*P* ($n=27$) Mean ± *SD* [*n* (%)]	*M* ($n=174$) Mean ± *SD* [*n* (%)]	*G* ($n=265$) Mean ± *SD* [*n* (%)]	*F* or χ^2
Demographic characteristics				
Age (years)	51.50 ± 16.98	56.87 ± 11.65	60.24 ± 9.95	$F=10.16$*** $P<M, G; M<G$
Sex				$\chi^2=1.26$
Male	10 (4.8)	75 (36.1)	123 (59.1)	
Female	17 (6.6)	99 (38.4)	142 (55.0)	
Substance use				$\chi^2=1.09$
No	19 (5.3)	132 (36.8)	208 (57.9)	
Yes	8 (7.5)	42 (39.2)	57 (53.3)	
Disease characteristics				
Complications				$\chi^2=0.18$
No	14 (6.2)	85 (37.8)	126 (56.0)	
Yes	13 (5.4)	89 (36.9)	139 (57.7)	
Duration of diabetes	8.68 ± 6.49	10.39 ± 7.59	9.66 ± 6.85	$F=0.90$
Insulin treatment				$\chi^2=4.51$
No	17 (4.8)	127 (36.1)	208 (59.1)	
Yes	10 (8.8)	47 (41.2)	57 (50.0)	
Biomedical factors				
Body mass index	26.05 ± 3.45	27.02 ± 4.68	26.47 ± 4.63	$F=0.97$
HbA1c	8.03 ± 1.56	7.36 ± 1.14	6.98 ± 1.11	$F=13.13$*** $P>M, G; M>G$
Psychosocial factors				
Self-care behaviors	42.79 ± 10.16	43.11 ± 10.19	46.19 ± 11.82	$F=4.28$** $M<G$
Social support	26.69 ± 12.34	29.81 ± 10.77	34.51 ± 11.58	$F=9.43$*** $P, M<G$
Resilience	27.46 ± 7.52	29.16 ± 7.61	32.97 ± 8.47	$F=14.16$*** $P, M<G$
Diabetes distress	14.44 ± 9.59	10.72 ± 7.08	4.93 ± 5.05	$F=60.17$*** $P>M, G; M>G$

P "steadily poor" trajectory pattern, *M* "consistently moderate" trajectory pattern, *G* "consistently good" trajectory pattern

**$p<.01$, ***$p<.001$

for determining participants in the "steadily poor" compared with "consistently good" QoL trajectory pattern. HbA1c levels (*OR* 1.25) and diabetes distress (*OR* 1.14) were important for determining participants in the "consistently moderate" compared with "consistently good" QoL trajectory pattern.

Discussion

This study identified three QoL trajectory patterns across five time points by longitudinal data, and revealed HbA1c levels and diabetes distress were important baseline determinants of different QoL trajectory patterns in patients with T2DM. Compared with total score, mean QoL measures of all participants across five time points were relatively high, which is consistent with a previous study in Taiwan [32]. More than half of the participants experienced "consistently good" QoL trajectory pattern, in which the mean QoL measures at five time points were stable and higher than those of all participants. This finding may result from the fact that diabetes care is accessible and covered by the National Health Insurance system in Taiwan. Therefore, most participants experience a relatively good QoL trajectory pattern. For participants of "consistently moderate" QoL trajectory pattern, mean QoLs at five time points were slightly smaller than those of all participants but also stable. Considering around 94% of participants were grouped into "consistently good" and "consistently moderate" QoL trajectory patterns, we might conclude that most patients with T2DM adapt to diabetes in habitual and constant ways. Nevertheless, there was a group of participants experiencing relatively low mean

Table 3 Important determinants of quality of life trajectory patterns

Variable	Steadily poor versus consistently good *OR* (95% CI)	Consistently moderate versus consistently good *OR* (95% CI)
Demographic characteristics		
Age	0.98 (0.93–1.02)	0.99 (0.96–1.01)
Sex	0.61 (0.19–1.98)	0.93 (0.55–1.57)
Substance use	0.99 (0.28–3.50)	1.04 (0.55–1.96)
Disease characteristics		
Complications	0.42 (0.14–1.28)	0.77 (0.47–1.28)
Duration of diabetes	0.97 (0.88–1.06)	1.03 (0.99–1.07)
Insulin treatment	0.89 (0.28–2.78)	0.98 (0.55–1.74)
Biomedical factors		
Body mass index	0.90 (0.79–1.03)	1.01 (0.95–1.06)
HbA1c	2.16*** (1.43–3.26)	1.25* (1.00–1.57)
Psychosocial factors		
Self-care behaviors	0.98 (0.94–1.03)	0.98 (0.96–1.00)
Social support	1.01 (0.96–1.06)	1.00 (0.98–1.02)
Resilience	0.97 (0.90–1.04)	0.97 (0.94–1.00)
Diabetes distress	1.18*** (1.09–1.27)	1.14*** (1.09–1.18)

OR odd ratio, *CI* confidence interval

*$p < .05$, ***$p < .001$

QoLs than mean QoL of all participants across five time points, which was defined as "steadily poor" QoL trajectory pattern. Participants of "steadily poor" trajectory pattern had the lowest baseline QoL among three trajectory patterns, and had a substantial decline within the first 6 months. Although QoL gradually improved after 6 months, the QoL still were relatively poor. It might indicate that these patients encountered specific stressors and struggled to adapt to these in their lives, but with little success. Nevertheless, more studies are needed to confirm this suggestion, and healthcare providers need to identify patients with relatively low QoL at baseline and identify possible causes which might worsen QoL and provide early intervention.

In this study, baseline HbA1c levels significantly increased along with the QoL trajectory from "consistently good," "consistently moderate" to "steadily poor" trajectory patterns. The baseline HbA1c levels seem to have a "dose–response" relationship with worsening QoL trajectory patterns. Furthermore, baseline HbA1c levels independently determined the participants in "steadily poor" and "consistently moderate" QoL trajectory patterns after controlling demographic and disease characteristics as well as psychosocial factors. One percent of increase in baseline HbA1c level increased the risk of being in the "steadily poor" QoL trajectory pattern 2.16-fold and that of being in the "consistently moderate" QoL trajectory pattern 1.25-fold. Findings of this study support that high baseline HbA1c levels are a crucial risk determinant of developing relatively worse QoL trajectory patterns. Patients with T2DM but with poor glycemic control may be required by healthcare providers to strictly perform life modification; nevertheless, it might not necessarily reflect on good glycemic control [33]. The stringent yet futile efforts to control blood glucose may cause patients to feel as if they are losing control of their lives and thus increase the risk of developing "steadily poor" and "consistently moderate" QoL trajectory patterns. Nevertheless, more studies are needed to confirm the suggestion.

Baseline diabetes distress was relative low when comparing with total possible score in this study. Nevertheless, baseline diabetes distress also seemed to have a "dose–response" relationship with relatively worse QoL trajectory patterns, and was important to determine participants in "steadily poor" and "consistently moderate" QoL trajectory patterns. This finding was consistent with a study in patients with chronic obstructive pulmonary disease, which found baseline depression was an important predictor of QoL trajectory patterns [34]. Participants with high levels of diabetes distress at baseline might indicate being mired in difficulties in coping with diabetes; therefore, they were more likely to develop "steadily poor" and "consistently moderate" QoL trajectory patterns.

In this study, participants who had poor baseline self-care behaviors, resilience, or social support were more likely to be in the "consistently moderate" or "steadily poor" trajectory patterns in association analysis. Enhancing self-care behaviors, resilience, and social support might help participants develop relatively good QoL trajectory patterns. Nevertheless, self-care behaviors,

resilience, and social support were less important than diabetes distress to determine participants in "steadily poor" or "consistently moderate" trajectory patterns. It might because self-care behaviors, resilience, and social support less captured response to life than did diabetes distress. The findings of the study support the notion that decreasing diabetes distress might be more useful than improving self-care behaviors, resilience, and social support to improve relatively good QoL trajectory patterns in patients with T2DM.

In this study, demographic and disease characteristics were not significantly associated with QoL trajectory patterns in patients with T2DM, except for the age. The older the age of the participants, the more they experienced relatively good QoL trajectory patterns in this study. This finding was not consistent with previous studies which found that older age was a predictor of poor QoL [21, 22]. In Taiwan, the economic burden of taking care of diabetes is not heavy in older patients with T2DM because of coverage by the National Health Insurance System. Older patients with T2DM also have more time to plan their lives; therefore, participants with older age might experience relatively good QoL trajectory pattern in this study. Nevertheless, more studies are needed to provide evidence for this conjecture.

Limitation

Some factors may limit the generalization of this study. Firstly, participants were only selected from five diabetic clinics by convenience sampling and completed at least three repeated observations in southern Taiwan, which may limit the representativeness of samples in patients with T2DM. Furthermore, participants of this study had significantly higher baseline QoL as well as lower baseline HbA1c levels and diabetes distress than those not recruited in this study; consequently, the QoL trajectory patterns and baseline determinants might have bias in this study. Additionally, impact of diabetes on QoL might also possess cultural differences [35]; therefore, recruiting patients with T2DM from diverse diabetic clinics and countries is necessary in the future. Secondary, QoL was only followed up for 24 months. The trajectory patterns of QoL for longer periods could be different, so following the QoL for longer periods is suggested. Thirdly, many biomedical factors such as comorbidities or mental disabilities could also impact QoL. Further studies could consider these biomedical factors to more comprehensively understand the determinants of QoL trajectory patterns in patients with T2DM. Fourthly, biomedical and psychosocial factors explored in this study were only measured at baseline, which only provided information regarding baseline determinants of QoL trajectory patterns. These biomedical and psychosocial factors may also change across time, so further studies could measure these biomedical and psychosocial factors in multiple waves and explore the associations of dynamic change of these biomedical and psychosocial factors with QoL trajectory patterns. Finally, although this study applied longitudinal design and identified baseline determinants of QoL trajectory patterns, experimental studies are needed to assess the effect of one-time intervening in HbA1c levels and diabetes distress on modifying QoL trajectory patterns. Consequently, further useful information could be applied in clinical settings.

Conclusions

As we know, no studies appear to have identified QoL trajectory patterns and the baseline determinants in patients with T2DM, especially in Asian populations. Findings of this study provide healthcare professionals with a preliminary understanding of the QoL trajectory patterns and determinants across 24 months. It also provides knowledge for designing customized interventions to improve QoL trajectory development in patients with T2DM. To prevent development of relatively worse QoL trajectory patterns in a timelier manner, regularly assessing the QoL and providing early intervention should be recommended in clinical practice. For those with high HbA1c levels or high diabetes distress at baseline, healthcare providers should be aware of their possible negative affect on QoL trajectory development and provide early intervention to decrease HbA1c levels or diabetes distress that finally, might improve the QoL trajectory development in patients with T2DM.

Acknowledgements The authors would like to thank Yu-Hsuan Huang for helping in data analysis.

Funding The funding of this study was supported by the National Science Council, Taiwan (NSC-102-2628-B-037-012-MY3).

Compliance with ethical standards

Conflict of interest The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical approval The studies have been approved by the appropriate institutional and/or national research ethics committee (approval number: KMUH-IRB-20120347). All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

References

1. Lin, C. C., Li, C. I., Hsiao, C. Y., Liu, C. S., Yang, S. Y., Lee, C. C., & Li, T. C. (2013). Time trend analysis of the prevalence and incidence of diagnosed type 2 diabetes among adults in Taiwan from 2000 to 2007: A population-based study. *BMC Public Health, 13*, 318. https://doi.org/10.1186/1471-2458-13-318.
2. American Diabetes Association. (2017). Standards of medical care in diabetes-2017. *Diabetes Care, 40*(Suppl. 1), S1–S142.
3. Feng, X., & Astell-Burt, T. (2017). Impact of a type 2 diabetes diagnosis on mental health, quality of life, and social contacts: A longitudinal study. *BMJ Open Diabetes Research and Care, 5*(1), e000198. https://doi.org/10.1136/bmjdrc-2016-000198.
4. Kiadaliri, A. A., Najafi, B., & Mirmalek-Sani, M. (2013). Quality of life in people with diabetes: A systematic review of studies in Iran. *Journal of Diabetes & Metabolic Disorders, 12*(1), 54. https://doi.org/10.1186/2251-6581-12-54.
5. Lin, K. C., Yan, C. F., Cheng, S. F., & Gau, M. L. (2013). Evaluation of time-varying and cumulative effects in nursing in a longitudinal study. *Nursing Research, 62*(3), 210–215. https://doi.org/10.1097/NNR.0b013e31828804ca.
6. Henly, S. J., Wyman, J. F., & Findorff, M. J. (2011). Health and illness over time: The trajectory perspective in nursing science. *Nursing Reseach, 60*(3 Suppl), 5–14. https://doi.org/10.1097/NNR.0b013e318216dfd3.
7. Laxy, M., Mielck, A., Hunger, M., Schunk, M., Meisinger, C., Rückert, I. M.,… Holle, R. (2014). The association between patient-reported self-management behavior, intermediate clinical outcomes, and mortality in patients with type 2 diabetes: Results from the KORA-A study. *Diabetes Care, 37*(6), 1604–1612. https://doi.org/10.2337/dc13-2533.
8. Lee, E. H., Lee, Y. W., & Moon, S. H. (2016). A structural equation model linking health literacy to self-efficacy, self-care activities, and health-related quality of life in patients with type 2 diabetes. *Asian Nursing Research (Korean Society of Nursing Science), 10*(1), 82–87. https://doi.org/10.1016/j.anr.2016.01.005.
9. Thiel, D. M., Al Sayah, F., Vallance, J. K., Johnson, S. T., & Johnson, J. A. (2017). Association between physical activity and health-related quality of life in adults with type 2 diabetes. *Canadian Journal of Diabetes, 41*(1), 58–63. https://doi.org/10.1016/j.jcjd.2016.07.004.
10. Felten, B. S., & Hall, J. M. (2001). Conceptualizing resilience in women older than 85: Overcoming adversity from illness or loss. *Journal of Gerontological Nursing, 27*(11), 46–53.
11. Tian, X., Gao, Q., Li, G., Zou, G., Liu, C., Kong, L., & Li, P. (2016). Resilience is associated with low psychological distress in renal transplant recipients. *General Hospital Psychiatry, 39*, 86–90. https://doi.org/10.1016/j.genhosppsych.2015.12.004.
12. Wang, R. H., Hsu, H. C., Kao, C. C., Yang, Y. M., Lee, Y. J., & Shin, S. J. (2017). Associations of changes in psychosocial factors and their interactions with diabetes distress in patients with type 2 diabetes: A longitudinal study. *Journal of Advanced Nursing, 73*(5), 1137–1146. https://doi.org/10.1111/jan.13201.
13. Nawaz, A., Malik, J. A., & Batool, A. (2014). Relationship between resilience and quality of life in diabetics. *Journal of the College of Physicians and Surgeons Pakistan, 24*(9), 670–675.
14. Fisher, L., Skaff, M. M., Mullan, J. T., Arean, P., Glasgow, R., & Masharani, U. (2008). A longitudinal study of affective and anxiety disorders, depressive affect and diabetes distress in adults with Type 2 diabetes. *Diabetic Medicine, 25*(9), 1096–1101. https://doi.org/10.1111/j.1464-5491.2008.02533.x.
15. Chew, B. H., Mohd-Sidik, S., & Shariff-Ghazali, S. (2015). Negative effects of diabetes-related distress on health-related quality of life: An evaluation among the adult patients with type 2 diabetes mellitus in three primary healthcare clinics in Malaysia. *Health and Quality of Life Outcomes, 13*, 187. https://doi.org/10.1186/s12955-015-0384-4.
16. Zhu, Y., Fish, A. F., Li, F., Liu, L., & Lou, Q. (2016). Psychosocial factors not metabolic control impact the quality of life among patients with type 2 diabetes in China. *Acta Diabetologica, 53*(4), 535–541. https://doi.org/10.1007/s00592-015-0832-y.
17. Debnam, K., Holt, C. L., Clark, E. M., Roth, D. L., & Southward, P. (2012). Relationship between religious social support and general social support with health behaviors in a national sample of African Americans. *Journal of Behavioral Medicine, 35*(2), 179–189. https://doi.org/10.1007/s10865-011-9338-4.
18. Strom, J. L., & Egede, L. E. (2012). The impact of social support on outcomes in adult patients with type 2 diabetes: A systematic review. *Current Diabetes Reports, 12*(6), 769–781. https://doi.org/10.1007/s11892-012-0317-0.
19. Bourdel-Marchasson, I., Druet, C., Helmer, C., Eschwege, E., Lecomte, P., Le-Goff, M.,… Fagot-Campagna, A. (2013). Correlates of health-related quality of life in French people with type 2 diabetes. *Diabetes Research and Clinical Practice, 101*(2), 226–235. https://doi.org/10.1016/j.diabres.2013.05.011.
20. Bowen, P. G., Clay, O. J., Lee, L. T., Vice, J., Ovalle, F., & Crowe, M. (2015). Associations of social support and self-efficacy with quality of life in older adults with diabetes. *Journal of Gerontological Nursing, 41*(12), 21–29. https://doi.org/10.3928/00989134-20151008-44 (**quiz 30–21**).
21. Wan, E. Y., Fung, C. S., Choi, E. P., Wong, C. K., Chan, A. K., Chan, K. H., & Lam, C. L. (2016). Main predictors in health-related quality of life in Chinese patients with type 2 diabetes mellitus. *Quality of Life Research, 25*(11), 2957–2965. https://doi.org/10.1007/s11136-016-1324-4.
22. Akinci, F., Yildirim, A., Gozu, H., Sargin, H., Orbay, E., & Sargin, M. (2008). Assessment of health-related quality of life (HRQoL) of patients with type 2 diabetes in Turkey. *Diabetes Research and Clinical Practice, 79*(1), 117–123. https://doi.org/10.1016/j.diabres.2007.07.003.
23. Ridderstrale, M., Evans, L. M., Jensen, H. H., Bogelund, M., Jensen, M. M., Ericsson, A., & BJendle, J. (2016). Estimating the impact of changes in HbA1c, body weight and insulin injection regimen on health related quality-of-life: A time trade off study. *Health and Quality of Life Outcomes, 14*, 13. https://doi.org/10.1186/s12955-016-0411-0.
24. Timar, R., Velea, I., Timar, B., Lungeanu, D., Oancea, C., Roman, D., & Mazilu, O. (2016). Factors influencing the quality of life perception in patients with type 2 diabetes mellitus. *Patient Preference and Adherence, 10*, 2471–2477. https://doi.org/10.2147/ppa.s124858.
25. Lee, Y. J., Shin, S. J., Wang, R. H., Lin, K. D., Lee, Y. L., & Wang, Y. H. (2016). Pathways of empowerment perceptions, health literacy, self-efficacy, and self-care behaviors to glycemic control in patients with type 2 diabetes mellitus. *Patient Education and Counseling, 99*(2), 287–294. https://doi.org/10.1016/j.pec.2015.08.021.
26. Lee, E. H., Lee, Y. W., Lee, K. W., Kim, D. J., & Kim, S. K. (2012). Development and psychometric evaluation of a diabetes-specific quality-of-life (D-QOL) scale. *Diabetes Research and Clinical Practice, 95*(1), 76–84. https://doi.org/10.1016/j.diabres.2011.08.022.
27. Campbell-Sills, L., & Stein, M. B. (2007). Psychometric analysis and refinement of the Connor-davidson Resilience Scale (CD-RISC): Validation of a 10-item measure of resilience. *Journal of Traumatic Stress, 20*(6), 1019–1028. https://doi.org/10.1002/jts.20271.
28. Hsu, H. C., Chang, Y. H., Lee, P. J., Chen, S. Y., Hsieh, C. H., Lee, Y. J., & Wang, R. H. (2013). Developing and psychometric testing of a short-form problem areas in diabetes scale in chinese

patients. *Journal of Nursing Research, 21*(3), 212–218. https://doi.org/10.1097/01.jnr.0000432048.31921.e2.
29. Muthen, B., & Muthen, L. K. (2000). Integrating person-centered and variable-centered analyses: Growth mixture modeling with latent trajectory classes. *Alcoholism: Clinical and Experimental Research, 24*(6), 882–891.
30. Nagin, D. S., & Tremblay, R. E. (2001). Analyzing developmental trajectories of distinct but related behaviors: A group-based method. *Psychological Methods, 6*(1), 18–34.
31. Nagin, D. S. (2005). *Group-based modelling of development*. Cambridge: Harvard University Press.
32. Wang, R. H., Wu, L. C., & Hsu, H. Y. (2011). A path model of health-related quality of life in type 2 diabetic patients: A cross-sectional study in Taiwan. *Journal of Advanced Nursing, 67*(12), 2658–2667. https://doi.org/10.1111/j.1365-2648.2011.05701.x.
33. Cohen, S., Janicki-Deverts, D., & Miller, G. E. (2007). Psychological stress and disease. *JAMA, 298*(14), 1685–1687. https://doi.org/10.1001/jama.298.14.1685.
34. Yoo, J. Y., Kim, Y. S., Kim, S. S., Lee, H. K., Park, C. G., Oh, E. G., & Oh, Y. M. (2016). Factors affecting the trajectory of health-related quality of life in COPD patients. *International Journal of Tuberculosis and Lung Disease (IJTLD), 20*(6), 738–746. https://doi.org/10.5588/ijtld.15.0504.
35. Safita, N., Islam, S. M., Chow, C. K., Niessen, L., Lechner, A., Holle, R., & Laxy, M. (2016). The impact of type 2 diabetes on health related quality of life in Bangladesh: Results from a matched study comparing treated cases with non-diabetic controls. *Health and Quality of Life Outcomes, 14*(1), 129. https://doi.org/10.1186/s12955-016-0530-7.