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ORIGINAL ARTICLE

Joint trajectories of multiple health-related behaviors among the elderly

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Abstract
Objectives The main goal of this study was to identify the multiple trajectories of the following four health behaviors among the elderly by gender: smoking, drinking alcohol, getting regular exercise, and having a health checkup
Methods Data were from a longitudinal survey conducted among the elderly from 1996 to 2007 in Taiwan. In total, 5,880 respondents were included in the analysis
Results The trajectories of health-related behaviors differed between males and females. Five groups of male elderly were identified: smoking, inactive, healthy lifestyle, smoking and drinking, and quitting. Three groups of female elderly were identified: smoking and drinking, inactive, and healthy lifestyle. Age, education, self-rated health, depressive symptoms, and economic satisfaction at baseline were associated with the health behavior trajectories
Conclusion The nature of healthy behaviors and risky behaviors may differ. Thus, multiple trajectories can exhibit patterns that differ from those of single behavior trajectories. Strategies designed to promote health need to consider both gender and behavior patterns which may change over time.

Keywords Health-related behaviors · Group-based trajectories · Lifestyle · Gender difference

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Introduction

Multiple kinds of health behaviors exist in a person's life to form one's lifestyle. Older adults in particular may exhibit dramatic changes in health behaviors as they encounter health threats and risks. Despite such temporal changes, most health behavior research has been cross-sectional. Moreover, existing longitudinal studies of the elderly usually focused on only a single health behavior (Barnett et al. 2008; Bobo et al. 2010; Caetano et al. 2010; Cerda et al. 2008; Frosch et al. 2009; Ilomäki et al. 2009; Platt et al. 2010; Qian et al. 2010; Scott-Sheldon et al. 2010; Shaw and Spokane 2008; Shaw et al. 2010). Only a few previous studies explored the trajectories of behaviors among middle-aged or older adults (Barnett et al. 2008; Bobo et al. 2010; Cerda et al. 2008; Frosch et al. 2009; Scott-Sheldon et al. 2010). There are a few studies considered a combination of health behaviors or a clustering of risk behaviors, but most of them were cross-sectional (Patterson et al. 1994; Schneider et al. 2009). Little is known about longitudinal clustering and multiple trajectories of health-related behaviors.

Health-related behavior trajectories

Smoking, drinking alcohol, regular exercise, and health checkup behaviors among the elders are discussed in this study. The prevalence of smoking across nations has been declining, both for the general population and for the elderly (Qian et al. 2010). Only a few studies have analyzed the smoking behavior trajectories of different subgroups in the population (Frosch et al. 2009; Scott-Sheldon et al. 2010; Conklin et al. 2005). The alcohol consumption usually decreases over time (Karlamangla et al. 2006; Platt et al. 2010), but differences by ethnicity exist (Caetano et al. 2010; Eigenbrodt et al. 2001; Ilomäki et al. 2009). Cerda et al. (2008) and Bobo et al. (2010) identified alcohol use trajectories. The amounts and degree of physical activity generally increase over time for younger adults (Shaw et al. 2010) but usually decrease over time for the elderly (McAuley et al. 2009; Shaw and Spokane 2008; Shaw et al. 2010; Shimada et al. 2007; Slingerland et al. 2007). Only a few studies have studied different trajectories of physical activity over time (Barnett et al. 2008). Studies about general health checkups were most cross-sectional (Chang et al. 2010; Hammond et al. 2010). Research shows that the rate of having a health checkup within the past 2 years for older adults increased (Mokdad et al. 2004).

Clustering of health-related behaviors

Most past studies of clustering of health behaviors have been cross-sectional (Patterson et al. 1994; Schneider et al. 2009). Some behaviors are closely related or co-occur, such as smoking and alcohol use (Patterson et al. 1994; Schneider et al. 2009; Cohen-Mansfield and Kivity 2011). However, some people showed a mixed type of healthy and unhealthy lifestyle, and the relationships between health-related behaviors are even more complicated. Low-to-moderate drinking was related to smoking cessation (Breitling et al. 2010). Heavy drinkers had a low rate of smoking quitting, and lighter smokers and non-daily smokers were more likely to reduce drinking (Kahler et al. 2010). The amount of physical activity is related to moderate alcohol consumption in older adults (Ashe et al. 2009), and others found that smoking cigarettes is related to a decline of physical activity or to inactivity (Zimmermann et al. 2008).

Gender difference

Most studies show that the prevalence of smoking is higher in men than in women in Asian populations (Kaholokula et al. 2006; Tsai et al. 2008). A gender difference in drinking behavior also exists in the general population (Ammon et al. 2008) and in the elderly population (Culberson 2006; Neumark et al. 2007). Men usually have a higher prevalence of drinking alcohol (Cerda et al. 2008; Hajat et al. 2004), but there is no gender difference in the behavior changes over time (Ammon et al. 2008). Males usually engage in greater amounts of physical activity than females, and females are more likely to be inactive (Barnett et al. 2008; Shaw et al. 2010; Shimada et al. 2007). Findings about gender differences in preventive care are inconsistent (Benjamins 2007; Chang et al. 2010; Fenton et al. 2010).

Other factors related to different trajectories of health-related behaviors include age (Barnett et al. 2008; Scott-Sheldon et al. 2010; Hammond et al. 2010), health problems (Frosch et al. 2009; Chang et al. 2010), substance use treatment or drug addiction (Scott-Sheldon et al. 2010), income (Barnett et al. 2008; Cerda et al. 2008), other health-related behaviors (Chang et al. 2010), regular source of care and gender role norms (Hammond et al. 2010).

Purpose of this study

In this study, we used multiple group-based trajectory modeling to identify the multiple trajectories of four health-related behaviors among the Taiwanese elderly by gender using nation-representative longitudinal data. Two risky behaviors (smoking and drinking alcohol) and two healthy behaviors (regular exercise and having general health checkups) were examined. The goals of this study were to describe the longitudinal trajectories of multiple health behaviors and identify factors related to the different trajectory groups. The findings should be useful for designing policies to promote health among the elderly.

Methods

Data

Data were taken from the survey titled "Health and Living Status of the Middle-Aged and Elderly in Taiwan" (later renamed as "Taiwan Longitudinal Survey on Aging", TLSA), which is a longitudinal survey that was first conducted in 1989. Face-to-face interviews were conducted with a random sample of individuals (aged ≥60 years) taken from the entire elderly population of Taiwan. A few of the participants lived in institutions, but most (99.0 %) lived in a community. A three-stage proportional-to-size probability sampling technique was used. In 1989, the initial sample included 4,049 people. In 1996, new supplemental respondents aged 50–66 years ($n = 2{,}462$) were added to the panel, and these people were also included in

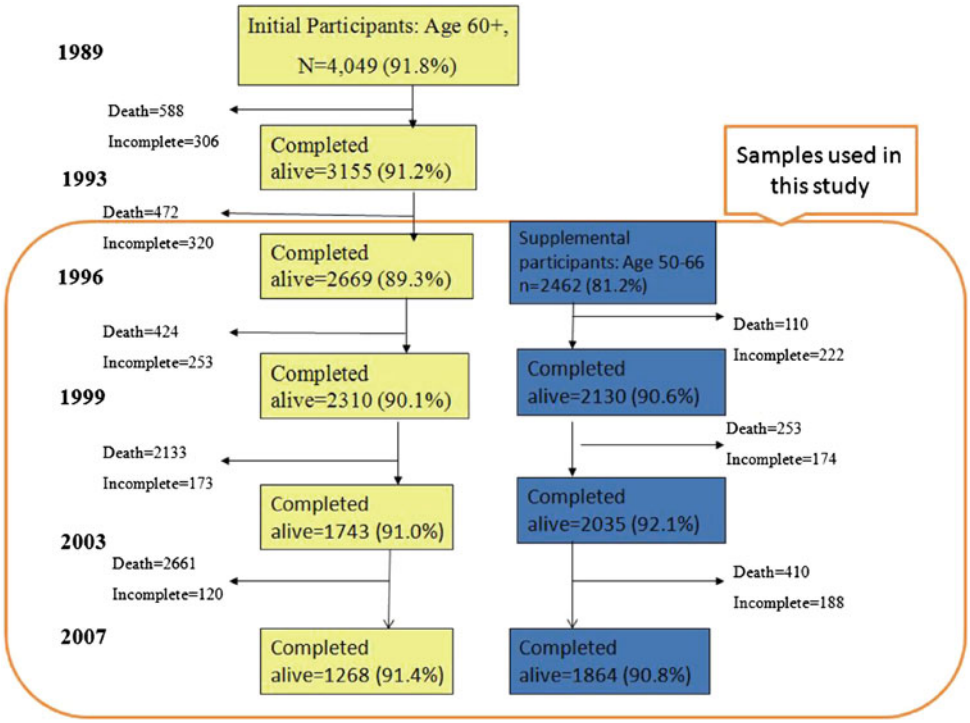


Fig. 1 TLSA surveys and the Taiwanese samples used in this study, 1996–2007

the analysis. The data used in the study reported herein were taken from the interviews conducted in 1996, 1999, 2003, and 2007. The missing and death cases attrited along with the follow-up (see Fig. 1). The institutionalization rate for the older cohort and the younger cohort participants at baseline was 1.5 and 0.1 %, respectively. Only those who completed three or more waves of interviews and who self-reported were included in the analysis. Missing items for the included samples were imputed. In total, 5,880 respondents were included in the analysis.

Measures

Health-related behaviors included smoking, drinking alcohol, getting regular exercise, and having a health checkup. Smoking and drinking alcohol were defined as occurring if the respondent was engaging in the behavior at the interview time. Getting regular exercise was defined as the participant exercising for at least 30 min three times per week, which was based on the recommendations by the Taiwan government. A person was scored as having a health checkup if he/she had a health checkup in the past 3 years. Health checkup indicated a preventive screening program of the whole body. The participants reported either a simple program including only basic biomarkers and physical examination, or an intensive program including aggressive procedures and high technology examinations, were counted. Such simple health checkup program is free of charge for people aged 65 or more every year and aged 45 or more every 3 years since 1995. Each of the four variables was coded as a binary outcome (yes/no).

Predictors of the health behavior trajectories were based on the measures recorded at baseline (1996) and included age (in 1996), number of years of education, marital status (having or not having a spouse), self-rated health, depressive symptoms, social support, social participation, and economic satisfaction. Self-rated health was scored from 1 (very poor) to 5 (excellent). Depressive symptoms were measured using the Centre for Epidemiologic Studies Depression Scale (Kohout et al. 1993), and the score ranged from 0 to 30. Social support included receiving and providing support. Receiving support was measured as the degree to which family/relatives/friends care about you, family/relatives/friends listen to you, you can count on someone from family/relatives/friends when you are ill, and you are satisfied with the care and support that you receive from family/relatives/friends. Providing support included two variables: How often did family or friends come to consult with you for your opinions, and to what degree did you feel that you were being helpful to your family or friends. The score for social support ranged from 1 to 18. Social participation included paid or unpaid work or participation in social groups, such as volunteer groups, community groups, religious groups, occupation associations, political groups or parties, social service groups, clan associations, elderly groups, or elderly colleges. Social participation was coded as yes/no. Economic satisfaction was coded as unsatisfied to satisfied (score ranged from 1 to 5).

Analysis

The group-based trajectory model and the joint trajectory model were used (Nagin 2005) to analyze the data. This method is a person-centered approach that is designed to cluster individuals who follow similar progressions of outcomes or behaviors over time. The group-based trajectory model assumes that the population is composed of a mixture of underlying trajectory groups. It is assumed that $Y_i = \{y_{i1}, y_{i2}, y_{i3}, \ldots y_{iT}\}$, where the longitudinal measurement of an individual i occurs over T periods, and that $P(Yi) = \Sigma\pi_j P^j(Yi)$ where $P(Y_i)$ is the probability of Y_i given membership in group j and π_j is the probability of group j. The form of $P(Y_i)$ is determined by the type of data. In this study, the four behaviors each were defined as a binary variable (yes/no). Thus, a logit model was used (Jones et al. 2001).

Our analysis strategy included three steps. First, we analyzed the trajectory models of each health behavior by the SAS TRAJ procedure. The optimal trajectory group number was determined by comparing the Bayesian information criteria (BIC) and the parsimony principle. Because there were differences among health-related behaviors between men and women, the multi-trajectory analysis was conducted by gender. Next, we used the multiple trajectory model (Jones and Nagin 2007) for analysis. All four health behaviors were joined together in the model. After the health behavior trajectories were determined, we conducted a multinomial logistic regression to compare the differences in characteristics among the health behavior trajectories.

Results

Single behavior trajectories for elderly men and women

Figure 2 shows the single behavior trajectories of elderly. For the men elders, the trajectories of smoking included non-smokers (58.0 %), quitting smokers (10.1 %), and chronic smokers (31.9 %). There were four patterns for drinking alcohol: non-drinkers (68.8 %), starting drinkers (10.0 %), quitting drinkers (10.3 %), and chronic drinkers (10.9 %). Four trajectories for regular exercise were identified: non-exercisers (44.0 %), decreasing exercisers (11.4 %), increasing exercisers (23.3 %), and regular exercisers (21.2 %). Finally, three groups of having a general health checkup were identified: low (33.0 %), increasing (23.5 %), and high (43.5 %).

For elderly women, the variations in health-related behaviors among women were smaller than those among men, particularly for smoking and drinking alcohol. Most elderly women did not smoke (90.3 %); 6.4 % were quitters and 3.3 % were chronic smokers. Most elderly women also did not drink alcohol (96.3 %), and only 3.7 % of them drank. Four trajectories for regular exercise were identified: none or little (49.0 %), decreasing exercisers (17.4 %), increasing exercisers (19.2 %), and regular exercisers (14.4 %). Three groups of health checkup behaviors were identified: declining (10.2 %), high (66.6 %), and low (23.2 %).

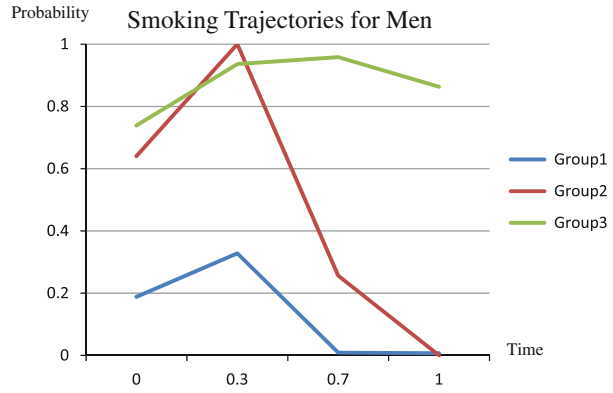
Fig. 2 Group-based trajectories of single health-related behavior for the Taiwanese elderly, 1996–2007. **a** Men—smoking trajectories for men: BIC = −4,289.85 (n = 8,910 observations), BIC = −4,282.98 (n = 2,556 persons). Group 1 (non-smokers): 58.0 %, group 2 (quitting smokers): 10.1 %, group 3 (chronic smokers): 31.9 %. Drinking trajectories for men: BIC = 3,708.37 (n = 8,786 observations), BIC = −3,702.20 (n = 2,556 persons). Group 1 (non-drinkers): 68.8 %, group 2 (starting drinkers): 10.0 %, group 3 (quitting drinkers): 10.3 %, group 4 (chronic drinkers): 10.9 %. Regular exercise trajectories for men: BIC = −5,414.36 (n = 8,447 observations), BIC = −5,408.13 (n = 2,545 persons). Group 1 (non-exercisers): 44.0 %, group 2 (decreasing exercisers): 11.4 %, group 3 (increasing exercisers): 23.3 %, group 4 (regular exercisers): 21.2 %. Health checkup trajectories for men: BIC = −5,423.16 (n = 8,226 observations), BIC = −5,416.53 (n = 2,465 persons). Group 1 (low users): 33.0 %, group 2 (increasing users): 23.5 %, group 3 (high users): 43.5 %. **b** Women—smoking trajectories for women: BIC = −905.56 (n = 8,181 observations), BIC = −899.77 (n = 2,259 persons). Group 1 (none smokers): 90.3 %, group 2 (quitting smokers): 6.44 %, group 3 (chronic smokers): 3.29 %. Drinking trajectories for women: BIC = −894.93 (n = 8,028 observations), BIC = −893.03 (n = 2,259 persons). Group 1 (non-drinkers): 96.3 %, group 2 (drinkers): 3.7 %. Regular exercise trajectories for women: BIC = −4,519.80 (n = 8,154 observations), BIC = −4,513.37 (n = 2,255 persons). Group 1 (non-exercisers): 49.0 %, group 2 (declining exercisers): 17.4 %, group 3 (increasing exercisers): 19.2 %, group 4 (regular exercisers) 14.4 %. Health checkup trajectories for women: BIC = −5,038.10 (n = 7,567 observations), BIC = −5,031.28 (n = 2,190 persons). Group 1 (declining users): 10.2 %, group 2 (high users): 66.6 %, group 3 (low users): 23.2 %

According the grouping of health behavior trajectories, Table 1 shows the characteristics of the samples by trajectory groups and by gender. The five trajectory groups in men and three groups in women were significantly different in health behaviors at each wave. There were also gender differences in health behaviors. Elderly men had a higher probability of smoking, drinking alcohol, getting regular exercise, and having a general health checkup than women. The characteristics of the baseline characteristics across groups were different in age, education, self-rated health, chronic diseases, physical function, depressive symptoms, and social participation in both men and women; there were also gender differences in education, marital status, self-rated health, depressive symptoms, and social support.

Multiple trajectories of the four health-related behaviors

Next, the multiple trajectories of the four health-related behaviors were analyzed, and the group numbers of

(A) Men


Probability
Smoking Trajectories for Men
1
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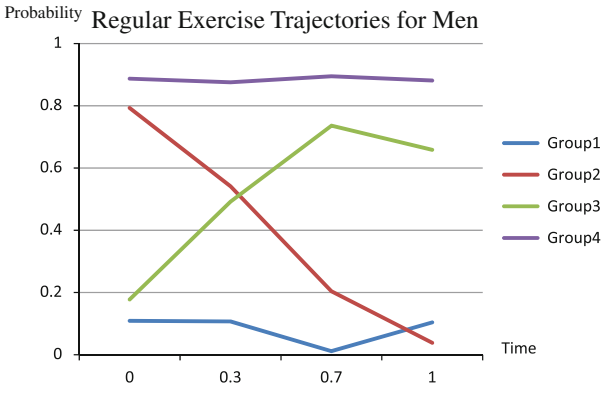
1
Time
Group1
Group2
Group3


Probability
Regular Exercise Trajectories for Men
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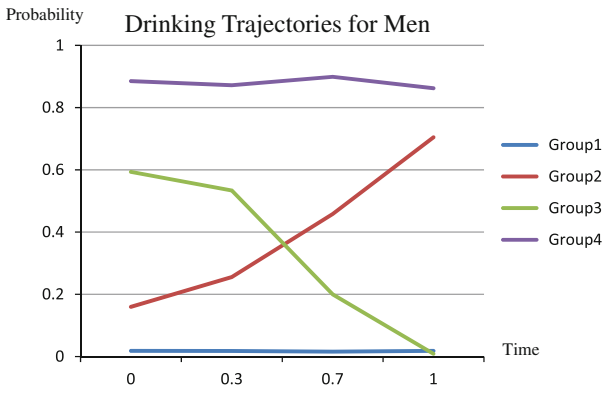
1
Time
Group1
Group2
Group3
Group4


Probability
Drinking Trajectories for Men
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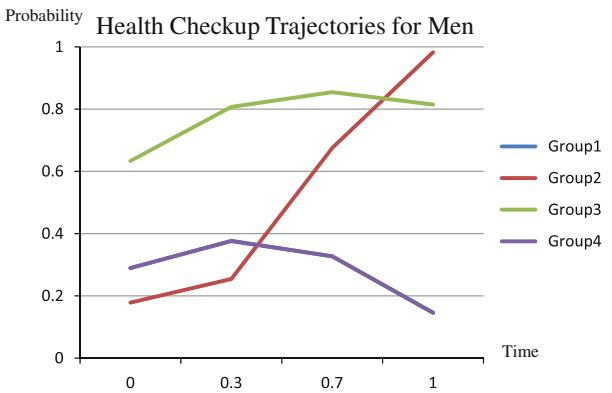
Probability
Health Checkup Trajectories for Men
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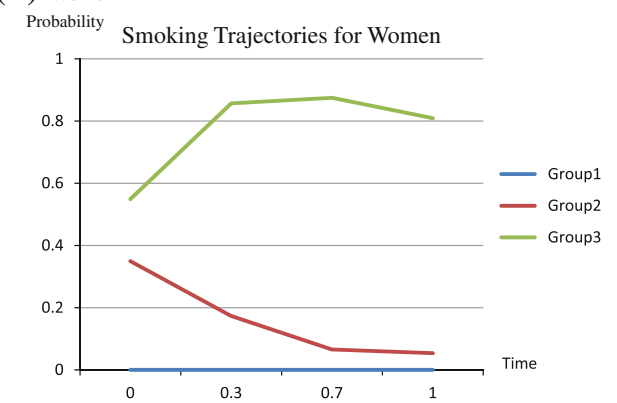
Time
Group1
Group2
Group3
Group4

(B) Women


Probability
Smoking Trajectories for Women
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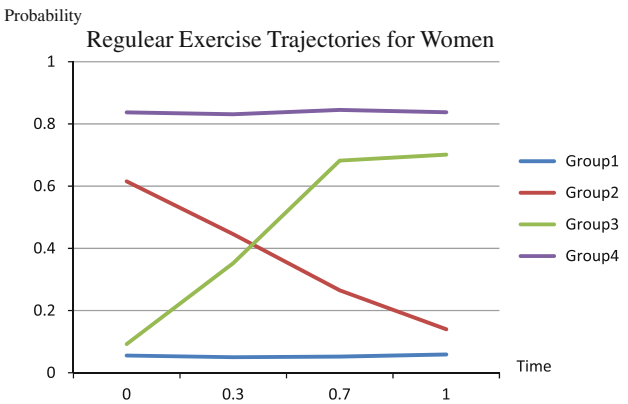
Time
Group1
Group2
Group3


Probability
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Probability
Drinking Trajectories for Women
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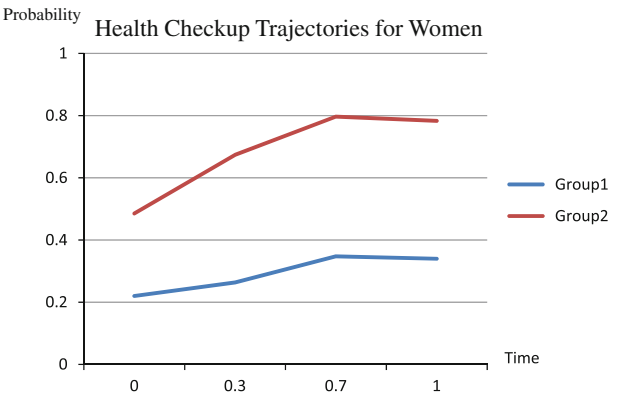
Probability
Health Checkup Trajectories for Women
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0.7
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Time
Group1
Group2

trajectories were determined based on BIC scores. The BIC score leveled off at more than five groups and three groups for males and females, respectively, thus we decided to set five groups for the male elderly and three groups for the female elderly.

Figure 3 shows the multiple trajectories of the four behaviors. For the men elderly, the five groups were as follows: (1) smoking (23.4 %): the elderly in this group smoked, hardly drank, and had a low probability of engaging in exercise and having a health checkup; (2) inactive (32.3 %): the elderly in this group did not smoke or drink, had the lowest probability of engaging in exercise, and had a medium probability of having a health checkup; (3) healthy lifestyle (19.7 %): the men in this group did not smoke or drink alcohol, and they had a higher probability of getting regular exercise and having a health checkup than members of the other groups; (4) smoking and drinking (11.2 %): the men in this group were chronic smokers and drinkers and had a low probability of engaging in regular exercise, but the trend for having a health checkup was increasing; (5) quitting (13.4 %): the men in this group showed a dramatic decline in smoking and a gradual decline in drinking. Their probability of getting regular exercise was medium, and the probability of having a health checkup gradually increased. Overall, the trends for smoking and drinking alcohol were similar to what we found for the single behavior trajectories, but getting regular exercise and having a health checkup showed different trajectories when analyzed as multiple versus single behavior trajectories.

The three groupings of the four health-related behaviors for the women elderly were: (1) smoking and drinking (5.5 %): a very small percentage of elderly women smoked and drank alcohol. Their probability of engaging in regular exercise was low, and they exhibited a medium and relatively stable probability of having a health checkup; (2) inactive (57.0 %): the largest number of elderly women was in this group. They did not smoke or drink and they had the lowest probability of getting regular exercise, and they showed a low but gradually increasing probability of having a health checkup; (3) healthy lifestyle (37.5 %): the women in this group did not smoke or drink and they had a high and increasing probability of getting regular exercise and a health checkup. As was true for the male elderly, the multiple trajectories of these four behaviors were different from the trajectories for each single behavior, particularly for regular exercise and getting a health checkup.

Factors that affect the multiple health trajectories of health-related behaviors

The differences among the trajectory groups using multinomial logistic regression analysis are shown in Table 2, and the healthy lifestyle group was used as the reference for both in the men and women models. Compared to men in the healthy lifestyle group, those in the smoking (OR = 0.962) and smoking and drinking alcohol groups (OR = 0.937) were more likely to be younger. The elders in all the other four groups had less education (OR ranged from 0.853 to 0.918). The elders in the smoking, inactive, and smoking and drinking groups were more likely to have more depressive symptoms (OR = 1.038 for the smoking group, OR = 1.037 for the inactive group, and OR = 1.053 for the smoking and drinking group) and lower economic satisfaction (OR = 0.772 for the smoking group and OR = 0.764 for the smoking and drinking group). The inactive group also had lower self-rated health than the healthy lifestyle group (OR = 0.834). Social support, social participation, and marital status were not significant. The characteristics of the quitting group were not significantly different from that of the healthy lifestyle group, except for in number of years of education (OR = 0.918).

For women elders, the baseline characteristics did not differ significantly between the smoking group and the healthy lifestyle group. However, the members of the inactive group were more likely to be older (OR = 1.026) and have less education (OR = 0.921), poorer self-rated health (OR = 0.861), more depressive symptoms (OR = 1.306), less social participation (OR = 1.386), and lower economic satisfaction (OR = 0.874).

Discussion

We used data from a four-wave panel study of the Taiwanese elderly to examine the multiple trajectories of four health-related behaviors. Five groups were identified for the male elderly (smoking, inactive, healthy lifestyle, smoking and drinking, and quitting) and three groups were identified for the female elderly (smoking and drinking, inactive, and healthy lifestyle). In general, age, education, self-rated health, depressive symptoms, and economic satisfaction at baseline were associated with the health behavior trajectories.

Different trajectories for multiple behaviors and single behaviors

In our study, the trajectories for each single behavior were similar to those found in previous studies for smoking (Frosch et al. 2009), drinking alcohol (Bobo et al. 2010), and getting regular exercise (Barnett et al. 2008). However, when we analyzed the joint trajectories of multiple health-related behaviors, the heterogeneity present in the single behavior trajectories for getting regular exercise and having a general health checkup were not identified. Only

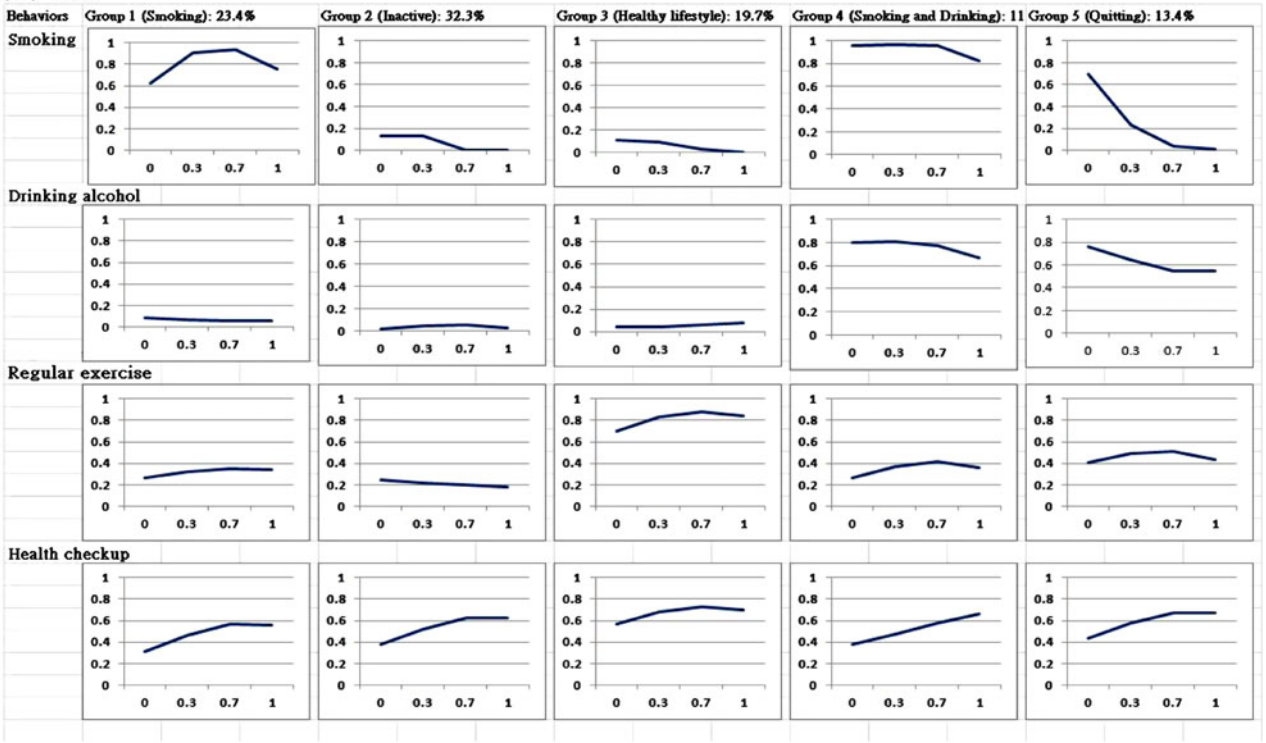
Table 1 Description of multiple trajectories of health-related behaviors (smoking, drinking alcohol, regular exercise, and health checkup) by Taiwanese men and women, 1996–2007 (mean and SD, %)

Trajectory groups	Females (n = 2,190)			Males (n = 2,465)					Gender difference significance
	Smoking and drinking (n = 115)	Inactive (n = 1,287)	Healthy lifestyle (n = 788)	Smoking (n = 587)	Inactive (n = 808)	Healthy lifestyle (n = 467)	Smoking and drinking (n = 280)	Quitting (n = 323)	
Time constant variables at baseline, mean (SD) and %									
Age	67.50 (8.92)***	67.77 (10.00)	64.13 (8.67)	65.84 (9.20)***	68.23 (9.52)	67.42 (8.14)	62.94 (8.52)	67.56 (8.83)	
Education	3.10 (3.29)***	2.56 (3.45)	4.18 (4.09)	5.81 (3.88)***	6.33 (4.24)	8.63 (4.39)	6.79 (3.48)	7.13 (4.51)	***
Marital status (having spouse)	56.1 %*	61.9 %	66.9 %	78.7 %	80.3 %	84.8 %	80.1 %	82.2 %	***
Self-rated health	2.92 (1.07)***	2.91 (1.04)	3.30 (1.08)	3.35 (1.07)***	3.20 (1.09)	3.59 (1.03)	3.52 (1.11)	3.66 (1.08)	***
Chronic diseases	1.30 (1.29)**	1.37 (1.41)	1.17 (1.20)	0.95 (1.18)***	1.27 (1.34)	1.03 (1.18)	0.79 (0.98)	0.99 (1.22)	
Physical function	33.87 (4.02)***	32.67 (6.34)	35.22 (2.11)	34.81 (4.00)***	33.80 (5.84)	35.70 (1.20)	35.55 (1.95)	35.59 (1.58)	
Depressive symptoms	7.25 (6.38)***	7.45 (6.83)	4.98 (5.40)	5.13 (5.65)***	5.29 (5.74)	3.64 (4.38)	4.96 (5.62)	3.93 (4.71)	***
Social support	14.35 (2.21)	14.72 (2.18)	14.68 (1.78)	14.26 (1.94)*	14.30 (2.02)	14.44 (1.88)	13.94 (2.04)	14.25 (1.99)	***
Social participation	80.4 %***	71.2 %	83.4 %	75.9 %**	72.6 %	75.8 %	83.7 %	80.9 %	
Economic satisfaction	3.53 (1.78)	3.47 (1.49)	3.55 (1.19)	3.45 (1.44)***	3.71 (1.64)	3.71 (1.24)	3.24 (1.13)	3.52 (1.25)	
Time-varying health behaviors (%)									
Smoking									
1996	53.0***	0.5	2.4	58.8***	14.3	10.1	95.7	72.3	***
1999	60.9***	0.9	0.3	94.0***	10.8	10.5	97.1	22.3	***
2003	58.8***	0.0	0.4	95.2***	0.0	1.2	97.4	2.4	***
2007	57.8***	0.0	0.0	78.7***	0.0	0.6	81.8	1.3	***
Alcohol drinking									
1996	33.0***	0.6	1.3	7.2***	0.7	3.4	80.7	81.6	***
1999	31.3***	0.6	1.9	7.3***	5.8	4.7	82.5	63.8	***
2003	26.5***	1.1	3.3	4.8***	3.3	5.8	79.2	55.6	***
2007	19.0***	1.7	3.6	5.4***	3.4	8.0	68.9	56.1	***
Regular exercise									
1996	14.8***	11.0	55.9	26.8***	25.1	72.6	28.7	39.6	***
1999	24.3***	5.7	68.0	32.0***	20.4	87.8	33.2	49.2	***
2003	21.6***	7.5	73.5	37.0***	18.6	93.3	43.8	48.6	***
2007	12.2***	8.4	68.8	34.7***	16.5	88.3	34.4	43.3	***
Health checkup									
1996	36.4***	31.6	45.9	32.3***	37.8	58.8	37.7	43.9	***
1999	62.7***	40.7	62.2	46.5***	52.1	66.7	47.4	56.9	**
2003	50.5***	54.6	70.0	56.9***	62.6	73.8	58.2	68.6	*
2007	51.9***	52.3	69.2	56.3**	62.6	69.0	65.6	67.0	*

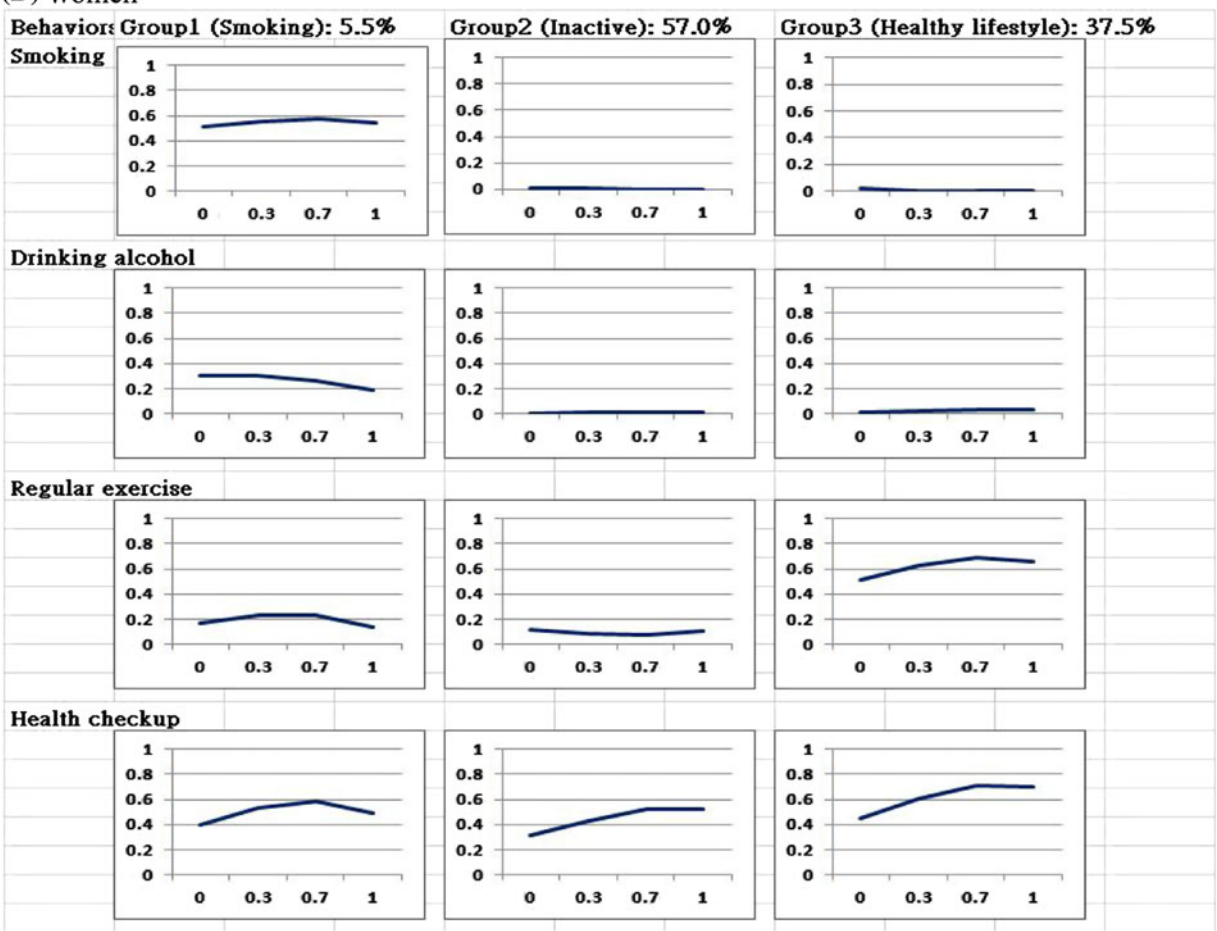
Total n = 5,880. Missing cases were listwise deleted

The significance within gender indicates the difference across groups. The significance by gender at each wave shows in the last column. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

(A) Men


Behaviors
Group 1 (Smoking): 23.4%
Group 2 (Inactive): 32.3%
Group 3 (Healthy lifestyle): 19.7%
Group 4 (Smoking and Drinking): 11
Group 5 (Quitting): 13.4%
Smoking
Drinking alcohol
Regular exercise
Health checkup

(B) Women


Behaviors
Group1 (Smoking): 5.5%
Group2 (Inactive): 57.0%
Group3 (Healthy lifestyle): 37.5%
Smoking
Drinking alcohol
Regular exercise
Health checkup

◀ **Fig. 3** Multiple trajectories of health-related behaviors (smoking, drinking alcohol, regular exercise, and health checkup) for the Taiwanese elderly, 1996–2007. **a** Men: BIC = −18,831.20 (n = 34,023 observations), BIC = −18,747.20 (n = 2,465 persons). **b** Women: BIC = −11,459.99 (n = 31,344 observations), BIC = −1,109.43 (n = 2,190 persons)

the different level of possibility in doing regular exercise and health checkup was identified. The findings suggest that the trajectory of risky behaviors (e.g., smoking and drinking alcohol) and health promoting behaviors (getting regular exercise and health checkup) are not incompatible. Some people may engage in risky behaviors and healthy behaviors at the same time while some people do not do both kinds of behaviors, which complicates the effects of health-related behaviors on health. We suggest that the reciprocal relationship between the risk behavior trajectory and healthy behavior trajectory should be done in the future.

Clustering of health-related behaviors over time

Past research only identified lifestyles or health-related behaviors by a cross-sectional study design. However, our longitudinal study allowed us to analyze the possibility of health-related behaviors clustering over time, and it provided information about the heterogeneity and changes that occur over time in health-related behaviors among the elderly. The group-based multiple trajectory analysis used in this study was able to identify the trajectories of multiple health-related behaviors over time. Some of the trajectory patterns found in this study are similar or consistent with past results (Schneider et al. 2009).

We also found that smoking and alcohol drinking behaviors can co-occur, consistent with previous studies (Patterson et al. 1994; Schneider et al. 2009; Cohen-Mansfield and Kivity 2011). However, alcohol consumption is not always connected with risky behavior; consuming a moderate amount of alcohol has physical and psychosocial benefits for older adults (Ferreira and Weems 2008). Hajat et al. (2004) found that elderly people who drank had a more active and sociable lifestyle and better self-reported health compared to non-drinkers; moderate drinkers also had better cognitive function than non-drinkers. Moderate drinking is not only related to better health, but it is also related to better lifestyle: low-to-moderate drinkers are more likely to quit smoking (Breitling et al. 2010; Kahler et al. 2010) or to engage in physical activity (Ashe et al. 2009). In our study, the men who quit smoking drank, but they also had a medium probability of getting regular exercise and having a health checkup. In terms of predictors, there was no significant difference between these quitters and the healthy lifestyle men, except that the former were less educated. The men who quit smoking were still in their fair health, so they may not have quit for health reasons. It is possible that they recognized the risk of smoking and tried to correct their lifestyle to be healthier, or they may have quit due to policy interventions or for financial reasons (Qian et al. 2010). The reasons for their change in lifestyle and the subsequent effects on their health should be explored in the future studies.

In this study, we also identified an inactive group for both elderly men and elderly women: they did not smoke or drink, but they also did not engage in positive healthy behaviors such as getting regular exercise and having a health checkup. The inactive trajectory group is the most noticeable group among the Taiwanese elderly. This group was similar to the physically inactive group or the passive lifestyle group described in previous studies

Table 2 Odds ratios of multiple trajectories of health-related behaviors (smoking, drinking alcohol, regular exercise, and health checkup) for Taiwanese men and women elders by multinomial logistic regressions, 1996–2007

Baseline factors	Men				Women	
	Smoking	Inactive	Smoking and drinking alcohol	Quitting	Smoking	Inactive
Age	0.962***	0.989	0.937***	0.998	1.027	1.026***
Education	0.853***	0.891***	0.898***	0.918***	0.969	0.921***
Marital status (no spouse)	1.331	1.068	1.590	1.143	1.272	0.860
Self-rated health	0.992	0.834**	1.111	1.163	0.845	0.861**
Depressive symptoms	1.038*	1.037*	1.053*	1.019	1.029	1.306***
Social support	0.992	0.971	0.934	0.929	0.907	0.983
Social participation (no)	0.891	1.051	0.685	0.821	0.910	1.386*
Economic satisfaction	0.772**	0.907	0.764**	0.889	0.881	0.874*
	−2 Log likelihood = 5,923.437; Chi-square = 266.911, df = 32				−2 Log likelihood = 2,847.898; Chi-square = 177,871, df = 16	

The reference group was the healthy lifestyle group for men and women, respectively. Intercept is omitted in the table

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

(Patterson et al. 1994; Schneider et al. 2009). The inactive elderly men in our study were more likely to be less educated and to have poorer self-rated health and more depressive symptoms than the healthy lifestyle group. The inactive elderly women were more likely to be older, less educated, and have poorer self-rated health, more depressive symptoms, less social participation, and lower economic satisfaction than the healthy lifestyle group. These results indicate that members of the inactive group may have poorer physical, mental, and social health and also have lower socio-economic status. Lower socio-economic status may mean that these people have fewer resources with which to live a healthy lifestyle and that they may consume addictive substances. They may not recognize the significance of a healthy lifestyle and thus may be more inactive or less concerned about their health. This group constitutes the largest group among the elderly, yet these people have been ignored in health promotion programs. Their health and lifestyles should be studied and monitored.

Similarities and differences between genders in trajectories of health-related behaviors

In this study, we detected gender differences in the trajectories of health-related behaviors. The prevalence of smoking and drinking alcohol for elderly Taiwanese women was much lower than that for elderly men, and the multiple trajectories for men and women showed different patterns. The health-related behaviors seemed to be more heterogeneous in men than in women. For example, our trajectories for drinking alcohol for elderly men were similar to those reported by Bobo et al. (2010) for middle-aged women (i.e., consistent, increasing, decreasing, and non-drinkers). In contrast, there were only two categories (yes or no drinking behavior) for elderly Taiwanese women. Conklin et al. (2005) categorized women smokers in four different levels of users and returners. However, only three trajectory groups were identified for elderly Taiwanese women: non-smokers, quitters, and chronic smokers. Possibly most Taiwanese elderly women did not smoke, and the variation in their smoking behavior was smaller than in general population.

Limitations

There are some limitations in this study. First, deaths and loss of follow-up occurred in the survey, and only those who survived during three or more waves were included in the analysis. Thus, selection bias could have occurred because the samples may be healthier than the whole samples. Second, in our study the prevalence of heavy drinking was low (about 5 % or lower), and thus we used the presence/absence of drinking alcohol as the outcome measure rather than the amount consumed. Therefore, our definition of alcohol drinking behavior did not differentiate between problematic drinking and moderate drinking. Third, the time-varying covariates for health-related behaviors were not examined. The effects of time-varying covariates on health-related behaviors should be examined in the future so that the reasons for changing lifestyle patterns can be traced. Fourth, other health-related behaviors could not be included in this study, because the consistent measures or variables were unavailable in this data, such as cognitive function measures. Fifth, the findings were based on the data among the Taiwanese elderly. The joint trajectories of health-related behaviors in this study may not be generalized in other populations.

Conclusions

Lifestyle consists of a set of health-related behaviors and a way of life, so the study of lifestyle should consider multiple health-related behaviors at the same time. Moreover, a long-term study of behavior patterns would help explain the heterogeneity of the trajectories and the factors related to them. We examined multiple trajectories of healthy and risky behaviors over a period of 11 years to show the clustering and changing of patterns across time among the Taiwanese elderly. The data revealed complicated relationships among health-related behaviors and gender differences in the behavior trajectories. A large proportion of the Taiwanese elderly were categorized as being inactive; they showed few risk behaviors but also did not perform many healthy behaviors. The current strategies used to promote health are more helpful for males than females, and the large inactive group has not been targeted for health promotion programs. We suggest that health promotion policies should include different strategies for different groups and that different lifestyles should be monitored over the long term.

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