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The effects of diabetes, hypertension and subsequent health control behavior on the survival of a Taiwan cohort aged over 50 years

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ABSTRACT

Purpose: This study used the Taiwan Longitudinal Study in Aging from 1996 to 2011 to investigate the effects of diabetes, hypertension, and healthy living behaviors of those aged over 50 years on the survival status in Taiwan.
Methods: Among the 5,131 participants aged 50 years and above in the 1996 survey were included in this study. Cox's proportional hazards model was used to examine the incidence of diabetes, hypertension, and related mortality risk in those aged over 50 years.
Results: After adjusting for age, gender, education level, diabetes, hypertension, health behavior, and leisure activity, results from the Cox model show that the elderly without diabetes have a lower mortality risk than those with diabetes. Regular exercise was associated with a lower risk of mortality. The hazard ratios of elderly with regular exercise were 0.78 (95 % CI: 0.64–0.96) for two times a week or less, 0.81 (95 % CI: 0.69–0.96) for 3–5 times a week, and 0.84 (95 % CI: 0.77–0.93) for 6 + times a week, respectively. On the other hand, leisure activity positively reduces mortality risk. For example, the hazard ratios of the elderly with watching TV and reading were 0.63 (95 % CI: 0.55–0.72) and 0.80 (95 % CI: 0.72–0.89), respectively. Moreover, smoking can increase mortality risk 23 % whether the elderly are with diabetes or hypertension or not.
Conclusions: Regarding preventing and controlling chronic diseases in the future, continuously encouraging improvement in health behavior and engaging in leisure activities for the middle-aged and over should be considered essential markers.

1. Introduction

The health of those aged over 50 is affected by many factors, including physiological conditions, disabilities, socioeconomic factors, and social function, of which chronic diseases are the primary factors determining the health of this cohort in Taiwan. Chronic diseases such as cancer, heart disease, cerebrovascular diseases, diabetes, and hypertension are significant causes of death in those aged over 50 in Taiwan. The "Taiwan Longitudinal Study in Aging" (TLSA) conducted by the Taiwan Health Promotion Administration, Ministry of Health and Welfare, revealed that more than 80 % of domestic middle-aged and elderly aged above 58 self-reported at least one chronic disease illness according to a physician's diagnosis, and the incidence of chronic diseases increased with increasing age. Thus, the incidence of chronic diseases would increase with Taiwan's aging society. Besides, chronic disease illness does not simply affect physical and mental conditions but also incurs a heavy burden of medical expenditure for families and communities (Avenell et al., 2004). Therefore, maintaining elderly health is a significant challenge for public health and the Taiwan government.

The middle-aged and elderly are at risk of chronic diseases and their associated complications and death due to decreased metabolic activity and insulin resistance (Sakurai et al., 2010). Indeed, the elderly with

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diabetes are at twice the risk of suffering from cardiovascular and cerebrovascular diseases than those without diabetes (Toto, 2005). The middle-aged and elderly with diabetes or hypertension are also at risk of dangerous complications (Meneilly and Tessier, 2001). Furthermore, the elderly with both diabetes and hypertension would have a reduced quality of life and social function, thereby increasing the mortality rate (Chin et al., 2014).

The Taiwan Health Promotion Administration positively promotes the prevention and control of metabolic syndromes, which are judged by testing indicators of abdominal obesity, hypertension, hypertriglyceridemia, and hyperglycemia, to prevent chronic diseases. Some middle-aged and elderly with hypertension and diabetes could easily ignore the initial symptoms of diabetes or hypertension until they experience acute cardiovascular disease or other complications (Chanson and Salenave, 2010; Goldman et al., 2003). Related topics include the efforts to determine the longevity causes (Nieddu et al., 2020), elderly survival forecasting (Liu, 2021), the rising needs of an aging population and its fulfillment attempts (Yang et al., 2021; Zhang et al., 2020; Ye et al., 2019), activities to increase lifespan through healthy aging (Yang and Meng, 2020), and the practical meaning of the changes in health-related behaviors (Feng et al., 2019).

Taiwan has undergone substantial social changes in the last ten years due to medical and socioeconomic improvements and has transitioned from an agricultural to an industrial society. Significant social environment, family, and lifestyle changes have accompanied this social transformation. The World Health Organization also pointed out unhealthy living behaviors, such as smoking, chewing betel nuts, excessive drinking, lack of physical activity, and a high-fat or high-cholesterol diet, as a significant factor in chronic diseases (World Health Organization, 2010). The middle-aged and elderly could reduce the risk of chronic disease illness by increasing physical activity (Juraschek et al., 2014) and effectively control and prevent chronic diseases by increasing social participation (Sex, 2012). Increasing physical activity and decreasing unhealthy smoking and drinking behavior, in addition to medication control, could effectively improve blood sugar and blood pressure control and further reduce the death risk (Juraschek et al., 2014; Spratt, 2009; Reddigan et al., 2012). Furthermore, hypertension and diabetes are considered risk factors disrupting cerebrovascular function to increase senile dementia (Zavoreo et al., 2014; Barbagallo and Dominguez, 2014). Increased physical activity could delay diabetic patients' cognition loss and improve dementia symptoms (Bourdel-Marchasson et al., 2010). Also, increased physical activity could effectively enhance patients' quality of life and self-rated health and increase social activity to enhance social support and willingness to seek medical resources to reduce the harm caused by chronic diseases (Reddigan et al., 2012).

Many recent studies have mentioned the health benefits of leisure activities and regular exercise for the elderly. These include the potential for appropriate leisure activities to improve health conditions (Hakman et al., 2019; Zhao, 2022), maintaining cognitive function, and psychological health (Sala et al., 2019; Jeong and Park, 2020). The relationship between leisure activities and frailty was also explored (Zhou et al., 2023). On the other hand, proper exercise can enhance cardiovascular function in the elderly (Wang et al., 2021). Besides, physical activity positively affects the cognitive health of the elderly (Xiong et al., 2021). Grevendonk et al. (Grevendonk et al., 2021) mentioned that regular exercise can slow down the aging process. Furthermore, exercise can significantly improve both the physical and cognitive functions of the elderly (Garcia-Hermoso et al., 2020). In summary, it is evident that leisure activities and regular exercise are beneficial for the health of the elderly. However, health benefits and the risk of mortality are not the same.

Due to diabetes and hypertension being common and significant chronic diseases in the elderly of Taiwan, this study used the TLSA database (1996 − 2011) of the Health Promotion Administration, Ministry of Health and Welfare, to determine the mortality risk of the middle-aged and elderly aged above 50 suffering from hypertension and diabetes, and whether health control behavior could improve the mortality risk of patients with hypertension and diabetes. Therefore, this study aims to investigate the relationship between these health control behaviors and the survival of the elderly. Besides, the health control behavior in this study included smoking, regular exercise, leisure activity, and currently chewing betel nuts status.

2. Materials and methods

Data from the TLSA conducted by the Taiwan Health Promotion Administration, Ministry of Health and Welfare in 1996, 1999, 2003, 2007, and 2011 were analyzed. The registered population above the age of 60 in 1989 in Taiwan (not including townships in mountain areas) was selected as the sample population. The TLSA contains the following information:

1. Health: Physical function, disabilities, illness status, psychological health, health behavior, and use of medical health services
2. Social support and work economic status: household status, living arrangements, social support, leisure activity, work and economic conditions, living attitude, and career planning before/after retirement.

After completing the baseline survey in 1989, a follow-up visit was performed every 3 − 4 years. As the age of the sampled population increases annually, the middle-aged and elderly aged above 50 in Taiwan in 1996 and 2003 were added as supplementary samples. Data from the surveys in 1996 to 2011 were used for analysis, and the TLSA survey in 1996 was used as the starting year for data analysis. People aged 50 years and above in the 1996 survey were included in this study as participants and 5131 participants completed interviews in total. The maximal observation period was 15 years and three months to determine the occurrence of hypertension or diabetes or the latest health behavior and leisure activity. Moreover, the events of death in the cohort were confirmed by the cause of death data records. In this study, in addition to the basic fixed variables such as age, gender, and educational level, which are based on baseline status (i.e., 1996), other covariates such as diabetes or hypertension, as well as other health behavior variables, are obtained based on the participants' survey status. If a participant died during different survey periods, the covariates are based on the wave before death; if a participant is still alive at the final survey, the covariates are based on the results of the last survey.

The study was approved by the Institutional Review Board (IRB) of Show Chwan Memorial Hospital (SCMH_IRB No: 1090707). For this retrospective study, formal consent is not required. The research involves no more than minimal risk to the subjects. The Institutional Review Board (IRB) of Show Chwan Memorial Hospital has waived informed consent for this study.

3. Measures

The demographic variables, diseases, health behavior, and leisure activity are defined below:

Demographics: age (aged 50 − 59, 60 − 74, 75 +), gender (male, female), and education level (elementary school and under, junior high school, senior high school, college and above).

Diseases: occurrence of hypertension (yes, no) or diabetes (yes, no), which were defined by self-reporting for a case of suffering from diabetes or hypertension, and diagnosis of diabetes or hypertension confirmed by a physician (yes, no).

Health behavior: currently smoking (yes, no), currently chewing betel nuts (yes, no), regular exercise (no, less than twice a week, 3 − 5 times per week, more than six times per week).

Leisure activity: watching TV (yes, no), listening to the radio (yes, no), reading newspapers, magazines, books, or novels (yes, no), chatting

Table 1
Baseline distribution characteristics for the elderly aged 50 + in Taiwan from TLSA 1996–2011.

Covariate	Total (5,131)	Male (2,760)	Female (2,371)
	n (%)	n (%)	n (%)
Age (mean ± std)	66.70 ± 9.37	66.82 ± 9.09	66.57 ± 9.69
50 − 59	1,419(27.66)	718(26.01)	701(29.57)
60 − 74	2,642(51.49)	1,501(54.38)	1,141(48.12)
75+	1,070(20.85)	541(19.60)	529(22.31)
Level of education			
Elementary school or below	4,078(79.48)	1,928(69.86)	2,150(90.68)
Junior high school	427(8.32)	305(11.05)	122(5.15)
Senior high school	474(9.24)	394(14.28)	80(3.37)
College and above	152(2.96)	133(4.82)	19(0.80)
Hypertension	2,818(54.95)	1,406(50.96)	1,412(59.60)
Diabetes	1,303(25.41)	627(22.73)	676(28.54)
Smoking	1,248(24.32)	1,162(42.10)	86(3.63)
Betel nut chewing	311(6.06)	236(8.55)	75(3.16)
Regular Exercise			
No	2,340(45.62)	1,170(42.41)	1,170(49.37)
2 times a week or less	288(5.62)	148(5.36)	140(5.91)
3 − 5 times a week	442(8.62)	227(8.23)	215(9.07)
6+ times a week	2,059(40.14)	1,214(44.00)	845(35.65)
Watching TV.	4,797(93.65)	2,615(94.88)	2,182(92.22)
Listening to radio	1,835(35.95)	1,066(38.91)	769(32.53)
Reading	1,933(37.85)	1,495(54.42)	438(18.56)
Chatting and making tea	3,122(61.12)	1,749(63.69)	1,373(58.13)
Planting	1,486(29.05)	791(28.76)	695(29.37)
Group activities	426(8.31)	208(7.54)	218(9.21)

and making tea with relatives, friends, or neighbors (yes, no), planting flowers, sorting garden, gardening, and plant potting (yes, no), participating in group activities: e.g. singing club, dance, Tai Chi (yes, no).

3.1. Statistical analysis

All data were analyzed using SAS 9.4. The analysis comprised descriptive statistics (including age, gender, education level, hypertension, diabetes, health behavior, and leisure activity of research objects) and a cohort study on the incidence of hypertension and diabetes. The Cox's proportional hazards model was used to determine the correlation between hypertension and diabetes and death status, and demographic variables (age, gender, education level), health behavior (smoking, chewing betel nuts, with/without regular exercise), and leisure activities were included for adjustment. In addition to analyzing the mortality risk of the illness, the effects of diabetes and health behavior or leisure activity on mortality were also investigated.

4. Results

Table 1 shows the characteristics of the study cohort of 5,131 adults aged over 50. It includes 2,760 males (53.79 %) and 2,371 females (46.21 %) with an average age of 67. Most subjects (2,642; 51.49 %) were aged 60 − 74 years, with 4,078 respondents (79.48 %) educated to junior high school and below. The longitudinal survey in 1996 − 2011 revealed that 2,818 subjects (54.95 %) suffered from hypertension, and 1,303 subjects (25.41 %) suffered from diabetes.

Regarding health behavior, 1,248 subjects (24.32 %) smoked, and 311 subjects (24.32 %) chewed betel nuts, with most respondents ((2,340; 45.62 %) not exercising or exercising more than six times a week (2,059; 40.14 %).

In terms of leisure activity, 4,797 subjects (93.65 %) watched TV and listened to the radio (35.95 %), 1,933 respondents (37.85 %) read newspapers, magazines, books, or novels, 3,122 respondents (61.12 %) chatted and made tea with relatives, friends, or neighbors, 1,486 respondents (29.05 %) enjoyed gardening, and 426 respondents (8.31 %) participated in group activities.

Based on the cohort aged 50 + in 1996, this study used the numbers of completed interviews of each wave of the survey from 1996 to 2011 to calculate the proportions of hypertension and diabetes (excluding the number of deaths or loss to follow-up). Fig. 1 shows the increasing prevalence of these diseases from 1996 to 2011. These results suggest that the proportions of hypertension and diabetes increase with increasing age, and the increase in hypertension is higher than for diabetes.

After adjusting for age, gender, education level, hypertension, diabetes, health behavior, and leisure activity, the hazard ratios of Model 3 (Table 2) show that older subjects have an increased mortality risk, with the male death risk 1.52 times that of females (95 % CI: 1.38 − 1.67), respondents with a lower education level have a higher death risk, subjects with hypertension reduce 37 % death risk than those without hypertension (95 % CI: 0.58–0.68), the death risk of diabetic respondents is 1.42 times of those without diabetes (95 % CI: 1.30 − 1.56), smokers are 1.23 times more at risk of death than non-smokers (95 % CI: 1.11 − 1.36), and those who engage in exercise or leisure activities except for listening to the radio, have a lower death risk than those who do not exercise or participate in leisure activities (as seen in Table 2).

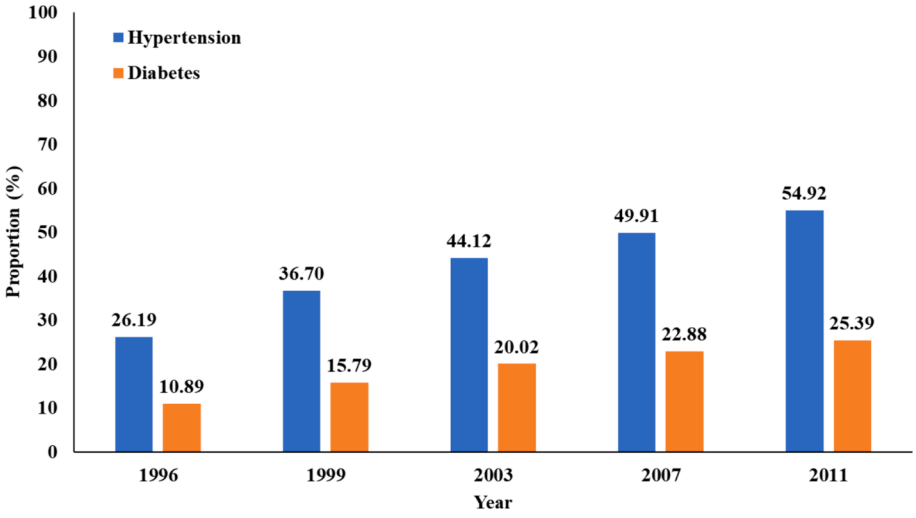

Fig. 1. The proportions of hypertension and diabetes for the elderly aged 50+ in Taiwan from TLSA 1996–2011.

Table 2
The hazard ratios (95 % CI) of mortality for the elderly aged 50 + in Taiwan from TLSA 1996–2011 by demographic, diabetes, hypertension, health control behaviors, and leisure activities.

Covariate		Model 1[a] HR	Model 2[b] HR	Model 3[c] HR
Age Group	50 – 59	1.00	1.00	1.00
	60 – 74	3.19 (2.80 – 3.64)	3.32 (2.91 – 3.79)	3.20 (2.80 – 3.65)
	75+	9.06(7.89 – 10.39)	9.56(8.32 – 10.99)	8.78(7.62 – 10.10)
Gender	Female	1.00	1.00	1.00
	Male	1.50(1.38 – 1.63)	1.43(1.31 – 1.57)	1.52(1.38 – 1.67)
Level of education	Elementary school or below	1.00	1.00	1.00
	Junior high school	0.72(0.61 – 0.84)	0.75(0.64 – 0.88)	0.86(0.73 – 1.02)
	Senior high school	0.64(0.54 – 0.75)	0.69(0.58 – 0.81)	0.82(0.69 – 0.97)
	College and above	0.57(0.43 – 0.75)	0.64(0.49 – 0.85)	0.74(0.56 – 0.98)
Hypertension	No	1.00	1.00	1.00
	Yes	0.62(0.57 – 0.67)	0.64(0.59 – 0.70)	0.63(0.58 – 0.68)
Diabetes	No	1.00	1.00	1.00
	Yes	1.37(1.25 – 1.50)	1.40(1.27 – 1.53)	1.42(1.30 – 1.56)
Smoking	No		1.00	1.00
	Yes		1.21(1.10 – 1.34)	1.23(1.11 – 1.36)
Betel nut chewing	No		1.00	1.00
	Yes		1.02(0.86 – 1.21)	1.07(0.90 – 1.27)
Regular Exercise	No		1.00	1.00
	2 times a week or less		0.69(0.57 – 0.85)	0.78(0.64 – 0.96)
	3 – 5 times a week		0.71(0.60 – 0.84)	0.81(0.69 – 0.96)
	6 + times a week		0.72(0.66 – 0.79)	0.84(0.77 – 0.93)
Watching TV.	No			1.00
	Yes			0.63(0.55 – 0.72)
Listening to radio	No			1.00
	Yes			0.94(0.86 – 1.03)
Reading	No			1.00
	Yes			0.80(0.72 – 0.89)
Chatting and making tea	No			1.00
	Yes			0.88(0.81 – 0.95)
Planting	No			1.00
	Yes			0.84(0.76 – 0.92)
Group activities	No			1.00
	Yes			0.80(0.67 – 0.95)

Note: HR = hazard ratio.
[a] Model 1 = Demographic (age group, gender, and level of education) + Diabetes (yes, no) + Hypertension (yes, no).
[b] Model 2 = Model 1 + Health control behaviors (smoking, betel nut chewing, and regular exercise).
[c] Model 3 = Model 2 + Leisure activities (watching TV, listening to radio, reading, chatting and making tea, planting, and group activities).

5. Discussions

5.1. Key findings

An unhealthy lifestyle, a significant cause of chronic diseases, can be effectively controlled and prevented by increasing physical activity and social participation (World Health Organization, 2010; Juraschek et al., 2014; Sex, 2012). This study evaluated the effects of current health behavior and leisure activity of patients with chronic diseases on their mortality risk, revealing that improving health behavior and enhancing leisure activity could significantly reduce the death risk of a Taiwanese cohort aged over 50 years. Therefore, the importance of good health behavior and leisure activity should be continuously promoted to those suffering from chronic illnesses.

Regarding mortality risk, hypertension is a protective factor, mainly because of the unobvious initial symptoms that are often ignored and result in death caused by complications of acute cardiovascular disease. Patients with hypertension heed healthcare professionals' suggestions of improving dietary habits and lifestyles to reduce the death risk (Chanson and Salenave, 2010; Goldman et al., 2003 Feb). Besides, the previous study also shows that the elderly with hypertension have a higher life expectancy but not a healthy one (Liang et al., 2020). Actually, the protective effect of death may due to the hypertension-controlled behaviors. However, the information related to hypertension control was not obtained in TLSA. It is one of the limitations of this study.

However, improving or enhancing their health behavior (e.g., without smoking or regular exercise) could reduce mortality risk. The results of Model 3 in Table 2 show the effects of regular exercise, smoking, and leisure activity on mortality risk, where regular exercise and leisure activity have positive effects on reducing mortality risk, and smoking has a negative effect. The elderly who engage in regular exercise (health-promoting behavior) experience a lower risk of death. However, the effects between different times of the week might not be significant. Regular exercise and leisure activity can reduce mortality risk by 16 % to 22 % and 6 % to 37 %, respectively. Moreover, smoking can increase mortality risk by 23 %, whether the elderly are with diabetes or hypertension or not.

The elderly population aged above 65 years was about 7.1 % in 1993 in Taiwan but increased to 11.5 % by 2013, so Taiwan has become an increasingly aging society. According to the statistics, the population aging speed in Taiwan is about 24 years, faster than in Europe and America. In this case, the impact and effect of an aging society on health, healthcare, economy, social development, and welfare should be positively encountered. To enhance elderly health, relevant health promotion policies aimed at the middle-aged and elderly should be designed. The active aging proposed by the WHO is regarded as a significant reference structure in various countries. Active aging is defined as elderly people continuously participating in activities with family, peers, and the community to enhance their quality of life and achieve the most appropriate health status and social participation (World Health Organization, 2002).

To maintain independence and autonomy in daily life, healthcare services should be promoted, and the self-health control behavior of patients with chronic diseases to enhance their self-care ability. The present study revealed that diabetic patients could effectively reduce the mortality risk by improving their health behavior (not smoking and increasing physical activity). Moreover, participating in leisure activities could effectively reduce the mortality rate of the middle-aged and

elderly. Previous research indicated that increased leisure activity could increase the opportunities for interacting with communities to assist the middle-aged and elderly in social participation to address psychological health problems of geriatric depression as well as improve the chronic disease status (McAuley and Rudolph, 1995; Kim et al., 2014; Major, 2001).

5.2. Limitations

Regarding the study limitations, the data were collected by a questionnaire. Therefore, recall bias is risky, and the accuracy and existing unknown illnesses might not be verified. Nonetheless, this study was a 15-year longitudinal survey with a 5.6 % follow-up rate loss due to non-death factors; therefore, the adequate effective samples provided reduced deviation.

6. Conclusion

The present study revealed that the risk of hypertension and diabetes increases with increasing age, and the increase in hypertension is higher than for diabetes, thus confirming that chronic diseases are a significant threat to the health of the middle-aged and elderly. Current policies in Taiwan emphasize the prevention of chronic diseases and healthcare of the middle-aged and elderly, so individual self-health behavior control should be promoted in the future to highlight the effect of personal healthcare on health with empirical data.

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CRediT authorship contribution statement

I-Wen Huang: Writing – original draft, Data curation, Conceptualization. **Shih-Chia Liu:** Writing – original draft, Methodology, Formal analysis. **Shao-Jen Weng:** Writing – original draft, Supervision, Project administration. **Cheng-Hsi Liao:** Resources, Formal analysis, Data curation. **Ho-Pang Yang:** Writing – original draft, Validation, Funding acquisition. **Yao-Te Tsai:** Writing – review & editing, Writing – original draft.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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