Ph.D. Dissertation of Nursing

Latent Classes of Frailty Trajectories and Their Predictors among Community-dwelling Middle-aged and Older Adults in Korea

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Abstract

There is no study on the frailty trajectory including both middle-aged and older people, and the understanding of the long-term frailty trajectory is insufficient. This study aimed to identify the frailty trajectory, subgroups of the frailty trajectory, and the predictors that differentiate these subgroups among community-dwelling middle-aged and older adults.

The participants were 9,775 individuals aged 45 years and older who participated in the Korean Longitudinal Study of Aging (2006–2018). Frailty was measured using a frailty instrument comprising three items: grip strength weakness, exhaustion, and social isolation. Latent growth curve modeling and latent class growth modeling were performed to identify the frailty trajectory and latent classes of the trajectory. Multinomial logistic regression was used to confirm the predictors that classified the latent classes.

Over 12 years, the slope of the frailty trajectory among the participants showed a gradual increase. In addition, there was a difference in the latent class of frailty trajectories among middle-aged and older adults. The middle-aged participants were divided into two groups: maintaining robustness and changing from pre-frailty to robustness. The older adults were divided into

three groups: maintaining robustness, maintaining pre-frailty, and changing from the frailty to pre-frailty group. Regular exercise, cognitive dysfunction, and social participation were significant predictors that differentiated each latent class in both middle-aged and older adults; additionally, current smoking and the number of chronic diseases were significant predictors in middle-aged people.

Various subgroups within the frailty trajectory existed among community-dwelling middle-aged and older adults. To reduce frailty, it is necessary to intervene with modifiable factors appropriate for each age group.

Keywords: Frailty, Frailty trajectory, Middle aged, Older adults, Korean Longitudinal Study of Aging, National population cohort study

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This doctoral dissertation includes the contents of the published article mentioned below.

Jang, A. R., Sagong, H., & Yoon, J. Y. (2022). Frailty trajectory among community-dwelling middle-aged and older adults in Korea: evidence from the Korean Longitudinal Study of Aging. *BMC Geriatrics, 22*(1), 524.

This dissertation offered an expansion of the literature review, and the conceptual framework was newly added, following the doctoral dissertation review format of Seoul National University's College of Nursing.

In addition, the study used the Korean Longitudinal Study of Aging data collected by the Korea Employment Information Service. It is clearly stated that neither of the organizations has been involved in the process of the study, nor did they intervene with the study's results.

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I. Introduction

1. Importance of the study

Frailty is a dynamic condition that affects individuals experiencing loss in one or more of the physical, psychological, or social domains (Gobbens, Luijkx, Wijnen-Sponselee, & Schols, 2010), and pre-frailty is an early and reversible risk state before frailty (Sezgin, Liew, O'Donovan, & O'Caoimh, 2020). Frailty is influenced by multiple variables, and increases the risk of negative health outcomes including mortality, falls, hospitalization, and disability in performing activities of daily living (ADL) (Fried et al., 2001; Gobbens et al., 2010; Morley et al., 2013). The definition and prevalence of frailty varies in community-dwelling older adults even though, typically it is approximately 10% (Kojima, Liljas, & Iliffe, 2019). A systematic review which analyzed 21 cohort studies abroad, found that there was a 10.7% prevalence of frailty and a 41.6% prevalence of pre-frailty among community-dwelling older adults (Collard, Boter, Schoevers, & Oude Voshaar, 2012). In Korea, a previous study involving the Korean Frailty and Aging Cohort Study showed that the prevalence of frailty and pre-frailty among adults aged ≥ 70 years was 14.1% and 45.9%, respectively (Jang et al., 2021).

In general, frailty increases with age (Kojima et al., 2019), and it is the leading cause of a variety of negative health outcomes. A study conducted in the United States, with 5,317 persons aged 65 years and older, showed that frailty predicts future adverse outcomes such as falls, worsening mobility, ADL disability, hospitalization, and death (Fried et al., 2001). In particular, the mortality rate of frail older adults is significantly high. The mortality rate between a frail group and a robust group of older adults were compared. It was found that after 3 and 7 years the mortality rate was six times higher and over three-times higher, respectively, in the frail group compared to that in the robust group (Fried et al., 2001). Similar results were found in Korea's longitudinal study targeting 11,844 community-dwelling older adults, showed that the mortality rate after 3 years in the frail group was 2.28 times higher than that in the non-frail group (Lee et al., 2014). In addition, frailty is associated with deteriorating health-related quality of life and mental well-being (Kanauchi, Kubo, Kanauchi, & Saito, 2008). It is also related to high medical costs because it increases the probability of getting a disease (Robinson, Wu, Stiegmann, & Moss, 2011). In addition to being related to the deterioration in health at the individual level, frailty is also associated with social problems, as it increases the burden of families and society to care for the frail elderly (Covinsky et al., 2001).

Frailty is not a static state but a dynamic state that can worsen or improve

over time (Gajic-Veljanoski et al., 2018). A systematic review and meta-analysis on changes in frailty status among community-dwelling older adults reveled that after a mean follow-up time of 3.9 years, 13.7% improved, 29.1% worsened, and 56.5% maintained the same status (Kojima, Taniguchi, Iliffe, Jivraj, & Walters, 2019). Several studies have investigated factors related to frailty changes. Frailty progression is influenced by various factors, particularly, social demographics, brain pathology, and physical comorbidities (Welstead, Jenkins, Russ, Luciano, & Muniz-Terrera, 2021). Specifically, demographic factors including age, sex, and education (Stolz, Mayerl, & Freidl, 2019) and diseases such as diabetes (Aguayo et al., 2019) and osteoporotic fractures (Gajic-Veljanoski et al., 2018) affect frailty trajectory. In addition, vigorous physical activity significantly reduces frailty progression (Rogers et al., 2017), and cognitive decline (Thibeau, McDermott, McFall, Rockwood, & Dixon, 2019) was also found to influence the frailty trajectory.

Furthermore, there is heterogeneity between individuals in the frailty trajectory and there are subgroups with various change patterns (Howrey, Al Snih, Middleton, & Ottenbacher, 2020). In an 18-year longitudinal study of 1,362 Mexican-Americans aged 65 years and older, the frailty trajectory was found to have three subgroups: non-frail, moderate progressive, and progressive high (Howrey et al., 2020). A previous study using five waves of

the Hispanic Established Populations for the Epidemiologic Study of the Elderly, found three frailty trajectories among 2,061 Mexican Americans aged 65 and older over a 12-year period. The frailty trajectories included a consistently low group, progressive moderate group, and progressive high group (Peek, Howrey, Ternent, Ray, & Ottenbacher, 2012). According to a study analyzing the relationship between frailty trajectory and mortality, the rapid rising and moderately increasing frailty group increased the mortality rate by 180% and 65%, respectively, compared to the stable frailty group (Stow, Matthews, & Hanratty, 2018). Therefore, it is urgent to identify and intervene in people at high risk for frailty progression to prevent negative health consequences.

However, to date, studies that identify subgroups of frailty trajectories longitudinally and predictors that differentiate trajectory patterns are very limited. In addition, previous studies on frailty trajectories have been conducted only on the elderly, and studies on middle-aged individuals have been neglected. A recent study reported that the prevalence of pre-frailty and frailty among people aged 40–49 years was 45% and 1.4%, respectively, similar to those of people aged 70–75 years, and interventions should be initiated at the age of 40 to prevent frailty (Gordon, Baker, Kidd, Maeder, & Grimmer, 2020). However, there is still no study on the frailty trajectory including both middle-aged and older people, and the understanding of the

long-term frailty trajectory is insufficient. Thus, this study aimed to identify the frailty trajectory, subgroups of the frailty trajectory, and predictors that differentiate these subgroups among community-dwelling adults aged 45 years or older using the Korean Longitudinal Study of Aging (KLoSA).

2. Purpose of the study

This study aimed to identify the frailty trajectory, subgroups of the frailty trajectory, and predictors that differentiate these subgroups among community-dwelling adults aged 45 years or older using the KLoSA. The specific research questions are as below.

1) What is the frailty trajectory in community-dwelling adults aged 45 years or older?
2) What are the subgroups of frailty trajectories in community-dwelling adults aged 45 years or older?
3) What predictors differentiate frailty trajectory subgroups in community-dwelling adults aged 45 years or older?

3. Definition of terms

1) Middle-aged

Middle-aged refers to adults in the period before the onset of old age (The Editors of Encyclopaedia Britannica, 2007). Although there is no strict definition of the age division of the middle-aged, it is generally classified as 40–65 years (Kanesarajah, Waller, Whitty, & Mishra, 2018) or 45–64 years (Barnett, Mercer, Norbury, Watt, Wyke, & Guthrie, 2012; Ge, Yap, & Heng, 2018) in previous studies. In this study, middle-aged refers to subjects aged 45–64 years who participated in the KLoSA.

2) Older adults

Older adults are those who are at the last stage of their normal lifespan, generally defined as 60 or 65 years of age or older (The Editors of Encyclopaedia Britannica, 2022). In this study, older adults refer to subjects aged 65 years or older who participated in the KLoSA.

3) Frailty

Frailty is a dynamic condition that affects individuals experiencing loss in one or more of the physical, psychological, or social domains, which is

influenced by multiple variables and which increases the risk of negative health outcomes (Gobbens et al., 2010). In this study, frailty was measured using the frailty instrument (FI) developed by Kim and Sunwoo (2015), which defines frailty broadly in terms of physical phenotype and psychological and social aspects.

4) Smoking

Smoking is defined as the act of inhaling and exhaling the fumes of burning plant material (Rose, Henningfield, Hilton, & Sweanor, 2021). In the KLoSA, smokers were surveyed and divided into current, past, and never smokers. A person who is currently smoking was categorized as a current smoker. Persons who were not currently smoking but had smoked 100 or more cigarettes were classified as past smokers. Persons who have never smoked more than 100 cigarettes and are not currently smoking were classified as never smokers. In this study, smoking was classified into two categories: current smoker and current non-smoker (past or never smoker).

5) Drinking

Drinking is defined as the act of consuming alcoholic beverages (American Heritage® Dictionary of the English Language, 2011). In the KLoSA,

drinkers were surveyed and divided into current drinkers, former drinkers, and lifetime abstainers. Current drinker referred to a person who drinks alcohol occasionally or frequently. Lifetime abstainer referred a person who does not drink normally and has never drank alcohol. Those who did not fit into either of the two aforementioned categories were classified as former drinkers. In this study, drinking was classified into two categories: current drinkers and current non-drinkers (former drinker or lifetime abstainer).

6) Regular physical activity

Physical activity is defined as any movement of the body produced by skeletal muscles that requires energy expenditure (Caspersen, Powell, & Christenson, 1985). In the KLoSA, regular physical activity was measured with the question "Do you exercise at least once a week, on a regular basis?" Participants were given two response options, either yes or no. In this study, regular physical activity was treated as a dichotomy of yes or no.

7) Chronic diseases

Chronic diseases are conditions that lasts for a long time, progress slowly and are not transmitted from person to person (WHO, 2016). In the KLoSA, the participants were asked if they had a chronic disease that was diagnosed

by a physician. In this study, we used the total number of chronic diseases diagnosed as a chronic disease variable. The total score for chronic diseases ranged from 0 to 10, with a higher score indicating the presence of more chronic diseases.

8) Cognitive function

Cognitive function refers to an individual's ability to perform mental processes, including memory, attention, language, problem-solving, and planning (Pessoa, 2008). In this study, cognitive function was measured using the Korean version of the Mini-Mental State Examination (K-MMSE) validated in the Korean population (Park & Ko, 1990). The K-MMSE scores ranged 0–30, with a score of less than 24 regarded as cognitive dysfunction.

9) Social contact

Social contact is defined as having a face-to-face conversation of more than three words within two meters of another person (Latsuzbaia, Herold, Bertemes, & Mossong, 2020). In this study, social contact was measured on a 10-point Likert scale, with higher scores indicating active social contact.

II. Literature Review

1. Frailty among community-dwelling middle-aged and older adults

Many studies have been conducted to define frailty, both conceptually and operationally. However, there is still a lack of an international consensus on the definition of frailty (Clegg, Young, Iliffe, Rikkert, & Rockwood, 2013). To date, the Cardiovascular Health Study (CHS) frailty index developed by Fried et al. (2001) is the most cited definition of frailty (Buta et al., 2016). The CHS frailty index consists of five components: unintended weight loss, poor grip strength, exhaustion, reduced walking speed, and low physical activity level (Fried et al., 2001). Individuals who met three or more criteria were classified as frail, those who met one or two criteria were classified as pre-frail, and others were classified as robust (Fried et al., 2001). The CHS frailty index is a frailty measurement tool that focuses on physical function. Disadvantages of the CHS frailty index include the fact that it requires special equipment to directly measure grip strength and walking speed, and its interpretation is limited because, except physical functions, it cannot comprehensively evaluate cognitive or social functions (Kojima et al., 2019; Won, 2017).

The second most frequently cited definition of frailty is the Deficit Accumulation Index (DAI), advocated by Mitnitski et al (2001) (Buta et al., 2016). The DAI consists of 92 items and is a comprehensive evaluation model that includes not only physical diseases, but also cognitive disorders, impairments in ADL, and abnormal laboratory values (Mitnitski, Mogilner, & Rockwood, 2001). The total score was 1 point, with high scores indicating severe frailty. The advantage of DAI is that it comprehensively includes not only physical functions but also mental and social aspects (Won, 2017). However, a disadvantage of DAI is that the measurements are time consuming because the evaluation items are too broad (Dent, Kowal, & Hoogendijk, 2016).

The fatigue, resistance, ambulation, illness, and loss of weight (FRAIL) scale is a frailty assessment tool that can be easily applied in clinical practice with a minimum measurement time (Morley, Malmstrom, & Miller, 2012). The FRAIL scale does not require physical examination and consists of five items: fatigue, resistance, ambulation, illness, and loss of weight (Jung et al., 2016). The total score ranged from 0 to 5 and was divided into frail (3–5 points), pre-frail (1–2 points), and robust (0 points).

Frailty leads to a variety of negative health outcomes, such as death (Kojima, 2018b; Kojima, Taniguchi, Kitamura, & Shinkai, 2018), fall

(Kojima, 2015), disability (Kojima, 2018c), dementia (Kojima, Taniguchi, Iliffe, & Walters, 2016), hospitalization (Kojima, 2016), and institutionalization (Kojima, 2018a). Since it can cause poor quality of life (Kojima, Iliffe, Jivraj, & Walters, 2016) and increase health care costs (García-Nogueras, Aranda-Reneo, Peña-Longobardo, Oliva-Moreno, & Abizanda, 2017), prevention and management of frailty are important.

According to a systematic review of 21 cohort studies abroad, the prevalence of frailty among community-dwelling older adults had a wide range from 4.0% to 59.1% (Collard et al., 2012). Specifically, the overall weighted prevalence of frailty and pre-frailty among older adults was 10.7% and 41.6%, respectively (Collard et al., 2012). According to a recent systematic review and meta-analysis targeting the elderly living in Chinese communities, the pooled prevalence rates of frailty and pre-frailty were 10% and 43%, respectively (He et al., 2019). Meanwhile, in a domestic study using data from the Korean Frailty and Aging Cohort Study, the prevalence of frailty and pre-frailty among adults aged 70 years or older was 14.1% and 45.9%, respectively (Jang et al., 2021). Generally, the prevalence of frailty tends to increase with age. In Korea, the prevalence of frailty in the young-old group (75–84 years) and the old-old group (85 years and older) was 37% and 52%, respectively, indicating a higher prevalence of frailty in the old-old

group (Cho, Choi, Oh, Kim, & Kim, 2017).

Previously, frailty studies were conducted mainly on the elderly, but recently, interest in frailty research widened the age range to include middle-aged individuals. A prospective study in the UK analyzed the prevalence of frailty by dividing middle-aged participants into several age groups (37–45, 45–55, and 55–65 years) (Hanlon et al., 2018). In middle-aged females, the prevalence of frailty in each age group was 3–4%, and the prevalence of pre-frailty was 38–39%; in middle-aged males, the prevalence of frailty in each age group was 2–3%, and the prevalence of pre-frailty was 35% (Hanlon et al., 2018). In another study of 8,095 community-dwelling middle-aged individuals aged 50–65 years, the prevalence rates of frailty and pre-frailty were 3.9% and 31.6%, respectively (Palmer et al., 2017). According to the results of a recent study, there is a significant prevalence of frailty in individuals in their 40s, and hence, there is a need to implement strategies to prevent frailty in this age group (Gordon et al., 2020). However, to date, there has not been a study focusing on frailty among middle-aged people living in Korea. Therefore, it is necessary to actively conduct research on frailty in community-dwelling middle-aged people in Korea.

2. Frailty trajectory and subgroups of the frailty trajectory among community-dwelling middle-aged and older adults

Various studies have investigated average trajectories of frailty over time in community-dwelling older adults. Hoogendijk, Heymans, Deeg, and Huisman (2018) measured frailty scores over 17 years using DAI for 1,659 Dutch older adults aged 65 years or older. The overall mean DAI score increased from 0.17 at baseline to 0.39 after 17 years, indicating that the frailty scores significantly increased over time. Gajic-Veljanoski et al. (2018) analyzed changes in frailty trajectories over 10 years using DAI in community-dwelling adults aged 50 years and older who participated in the Canadian Multicentre Osteoporosis Study. The average baseline DAI score was 0.14. Five years later, this frailty score had increased by 0.03, but a 0.02 decrease was noted during 5 to 10 years; thus, showing a nonlinear trajectory pattern of frailty. Lohman, Mezuk, and Dumenci (2017) used data from 5 waves of the Health and Retirement Study (2004–2012) to determine the frailty trajectory of adults aged 51 and older living in the community. The mean slope parameters of frailty significantly increased, and an average of 0.56 frailty deficits accumulated at each wave. Marshall, Nazroo, Tampubolon, and Vanhoutte (2015) tracked the frailty trajectory among community-dwelling individuals aged 50 years or older using five waves

(2002–2010) from the English Longitudinal Study of Ageing. They found that the frailty of participants significantly worsened over time. Stolz, Mayerl, Waxenegger, Rásky, and Freidl (2017) used 4 waves (2004–2013) of the Survey of Health, Aging and Retirement in Europe to identify 10-year frailty trajectories in adults aged 50 and older living in communities in 10 countries. By applying the quadratic growth model, it was found that DAI scores increased non-linearly.

In the case of middle-aged people living in the community, two frailty trajectory studies were confirmed. Machado-Fragua et al. (2020) identified the frailty trajectory of 644 community-dwelling middle-aged (55–65 years). At baseline, the mean DAI score was 0.13, which after 13 years of follow-up increased to 0.17, indicating a linear increase in the frailty score. Yang and Lee (2010) collated various birth cohorts from the Health and Retirement Survey in the United States to identify frailty trajectories in community-dwelling populations. In middle-aged adults aged 49–64 years, the initial average DAI was 0.089, which gradually increased over time.

In addition, several studies have found subgroups of frailty trajectories in community-dwelling older adults. Peek et al. (2012) identified latent subpopulations of frailty trajectories for 12 years in Mexican Americans aged 65 years and older. The analysis was performed using trajectory mixture modeling, and a total of three frailty trajectories were derived: the stable low

frailty group, progressive moderate frailty group, and progressive high frailty group. Howrey et al. (2020) analyzed subgroups of frailty trajectories over an 18-year follow-up period in which included 3,050 non-institutionalized Mexican Americans aged 65 years and older. Three subgroups were derived using group-based mixture modeling: a non-frail group, moderate progressive group, and progressive high group. Liu, Han, Gahbauer, Allore, and Gill (2018) investigated joint trajectories of cognition and frailty among 690 community-living persons aged 70 or older. Using a group-based mixture modeling approach, four joint trajectories were identified during the 9 years of follow-up: no cognitive frailty (27.8%), slow cognitive decline and progressive frailty (45.5%), rapid cognitive decline and progressive frailty (20.2%), and cognitive frailty (6.5%).

Several studies have attempted to analyze subgroups of frailty trajectories in community-dwelling older adults, but previous studies targeting middle-aged people have not been identified. Since the developmental process and mechanism of frailty trajectories among middle-aged and older adults may differ, it is necessary to analyze them separately by age group and accumulate evidence through additional studies.

3. Factors affecting frailty trajectory among community-dwelling middle-aged and older adults

1) General characteristics

General characteristics influencing the frailty trajectory include age, sex, education, marital status, and area of residence.

Many studies have found that older age is associated with frailty trajectories (Welstead et al., 2021). In a 10-year longitudinal study of older adults who participated in the English Longitudinal Study of Aging, older age was associated with an increase in the DAI scores (Rogers et al., 2017). Peek et al. (2012) also found that increasing age significantly influenced frailty over time in older Mexican American adults.

Sex has also been pointed out as a factor that can affect the frailty trajectory (Welstead et al., 2021). In a study of 20,965 participants aged 50 years and older, who participated in the Survey of Health, Aging, and Retirement in Europe, females were found to be frailer than males, and the females accumulated health deficits at higher rates (Stolz et al., 2017). However, some studies have found no significant association between sex and frailty trajectories, indicating that further studies using robust methodologies are needed (Howrey et al., 2020; Peek et al., 2012).

Several studies have shown that there is a correlation between education and frailty trajectories (Welstead et al., 2021). In a longitudinal study of middle-aged and older adults living in Europe, differences in education levels persisted disparities in frailty status (Stolz et al., 2017). Those with primary education had consistently higher DAI scores than those with postsecondary education. In another population-based cohort study, having less than a high school education was associated with a high frailty trajectory for those aged 60–79 years (Chamberlain et al., 2016).

One study reported that marital status may also affect the trajectory of frailty. In an 8-year population-based cohort study, being unmarried was a predictor of high frailty trajectories among older adults aged 60–79 years (Chamberlain et al., 2016).

Area of residence can also affect the rate of frailty change (Welstead et al., 2021). Stolz et al. (2017) found a noticeable difference in the frailty trajectory according to the participant's country of residence. This difference showed that middle-aged and older adults living in Southern European countries have steeper DAI trajectories compared to those living in northern countries.

2) Health-related behavior factors

Health-related behaviors that affect frailty trajectory include smoking,

drinking, and physical activity.

Chamberlain et al. (2016) longitudinally analyzed the relationship between frailty trajectories and behavioral factors in 12,270 older adults aged 60–89 years living in Olmsted County, Minnesota. After adjustment for age, sex, and baseline frailty index, smoking was a predictor of a high frailty trajectory in participants aged 60–79 years. Regarding drinking, older adults aged 70–79 years who answered, “I ever felt the need to cut down on alcohol consumption,” were associated with a high frailty trajectory. In addition, among those aged 60–69 years, “concerns from family and friends about one’s alcohol consumption” were related to a high frailty trajectory, showing slightly different results for each age group.

Higher physical activity is a protective factor against the deterioration of frailty (Welstead et al., 2021). Rogers et al. (2017) analyzed the relationship between the progression of frailty and physical activity over 10 years in 8,649 non-frail adults aged 50 years and older residing in England. In middle-aged individuals aged 50–64 years, vigorous physical activity significantly reduced the progression of frailty. Additionally, moderate physical activity was effective in preventing the progression of frailty of participants aged 50–54 years of age. Meanwhile, in adults aged 65 years and older, both vigorous and moderate physical activity significantly reduced the progression of frailty.

Mild physical activity did not play a significant role in preventing the deterioration of frailty in all age groups.

3) Physical and psychosocial factors

Physical and psychosocial factors affecting the trajectory of frailty include chronic diseases, cognitive function, and social factors.

An 18-year follow-up study of 1,362 Mexican Americans aged 65 years and older showed that various chronic diseases were associated with the trajectory of frailty. Those with arthritis and diabetes were significantly more likely to be included in the moderate and high progressive frailty groups (Howrey et al., 2020). In a 12-year follow-up study of older Mexican Americans, more chronic diseases were significantly associated with worsening frailty (Peek et al., 2012).

Frailty and cognitive function have been reported to be closely related, resulting in the emergence of a new concept called cognitive frailty (Kelaiditi et al., 2013). Thibeau et al. (2019) analyzed the relationship between change in frailty and cognitive domain using the DAI for 632 community-dwelling older adult volunteers in the Victoria Longitudinal Study. The results showed that an increase in frailty is strongly associated with a decrease in cognitive function. However, there were differences in the results according to sex,

which were significant in females but not in males.

Social factors, namely cultural engagement and weekly church attendance, were associated with frailty trajectories. Rogers and Fancourt (2020) investigated the relationship between cultural engagement and frailty incidence and trajectory. Participants who frequently participated in cultural activities were less likely to become frail over time. In addition, active participation in cultural activities effectively reduced the rate of frailty progression. Another study found that social activity was associated with frailty trajectories. Howrey et al. (2020) showed that participating in social activities, such as attending church on a weekly basis, reduced the likelihood of belonging to the moderate progressive frailty group; thus confirming that social activity is a protective factor for frailty. Social isolation and loneliness were identified as another social factors that influences changes in frailty status (Gale, Westbury, & Cooper, 2018). High levels of loneliness increased the risk of frailty, and high levels of isolation increased the risk of frailty in males, emphasizing the importance of social relationships with others.

III. Conceptual Framework

In this study, a conceptual framework for factors affecting the frailty trajectory was constructed based on a literature review of previous studies (Figure 1).

Among the factors that were significant in the preceding literature, we selected variables available from the KLoSA as research variables and classified them into three domains: general characteristics, health-related behavior factors, and physical and psychosocial factors.

First, general characteristics included age, education, marital status, and area of residence. Second, health-related behavior factors included smoking, drinking, and regular physical activity. Lastly, chronic diseases, cognitive function, and social contact were selected as physical and psychosocial factors.

The conceptual framework of this study lies in the fact that these general characteristics, health-related behavior factors, and physical and psychosocial factors affect frailty trajectory among community-dwelling adults aged 45 years and older.

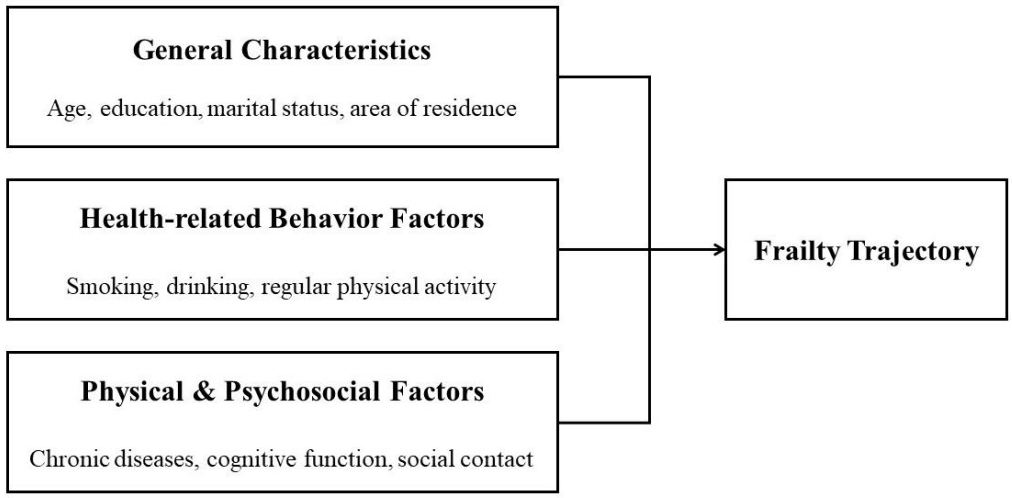

Figure 1. Conceptual framework of this study

IV. Methods

1. Study design

This study was conducted to identify the frailty trajectory, subgroups of the frailty trajectory, and the predictors that differentiate these subgroups among community-dwelling middle-aged and older adults. The design of this study is a longitudinal and descriptive study using a national population data.

2. Study data

The KLoSA is a longitudinal panel survey of community-dwelling older adults aged ≥ 45 years in South Korea. The first survey was conducted in 2006, and then performed every two years, of which the seventh survey was completed in 2018. The questionnaire items were broadly structured, such as demographics, family characteristics, physical and mental health, and employment. To represent the Korean population, households stratified by region and residential type were selected using simple random sampling. The interview was conducted using a computer-assisted personal interviewing technique. KLoSA is public; anonymized data can be accessed by anyone who requests the data from an address (https://survey.keis.or.kr).

In this study, data of all waves from the first (2006) to the seventh survey (2018) were used.

3. Study subjects

The target population of this study is community-dwelling middle-aged and older adults aged 45 years and older in the Korea.

In 2006, the total number of participants in KLoSA was 10,254, of which 9,775 who participated in the survey twice or more were included as the final participants in this study.

4. Study variables

1) Frailty

Frailty was measured using the frailty instrument (FI), which defines frailty broadly in terms of physical phenotype and psychological and social aspects. FI consisted of three items assessing weakness in grip strength, exhaustion, and social isolation. For grip strength weakness, 1 point was given to less than 15 kg for women and less than 24 kg for men. For exhaustion, 1 point was given if the self-reported response was more than 3 days in one or more of the following two questions: “I feel difficult about everything” and “I cannot do anything at all” in the past week. Social isolation was given 1 point if the respondents answered that they did not participate in any of the following groups: social, religious, cultural, sports, civic, political, volunteer, and learning groups. The total range of the frailty score ranged from 0 to 3 and was categorized as follows: robust (0), pre-frail (≥1), and frail (≥2) (Kim, Shin, Choi, & Won, 2018). The FI has been validated in the Korean elderly and shows high predictive validity, discrimination, and calibration ability for adverse health outcomes such as disability, institutionalization, and mortality (Kim & Sunwoo, 2015; Kim et al., 2018).

2) Smoking

Smoking was classified into two categories: current smoker or currently non-smoker (past or never smoker).

3) Drinking

Drinking was classified into two categories: currently drinker or currently non-drinker (former drinker or lifetime abstainer).

4) Regular physical activity

Regular physical activity was assessed using the question, “Do you exercise at least once a week on a regular basis?”; participants answered as either yes or no. In this study, regular physical activity was categorized into yes and no.

5) Chronic diseases

Ten chronic diseases were selected, and the number of chronic diseases a participant had was assessed by the presence or absence of a diagnosis by physicians. The 10 chronic diseases selected were as follows: hypertension, diabetes, cancer, chronic pulmonary disease, liver disease, cardiovascular

disease, cerebrovascular disease, mental disease, arthritis and rheumatism, and prostate diseases. All items were treated as dichotomous, with 1 point given to those with the disease and 0 points given to those without the disease. The scores for chronic diseases ranged from 0–10, with a higher score indicating the presence of a greater number of chronic diseases.

6) Cognitive function

The MMSE, developed by Folstein, Folstein, and McHugh (1975), is a widely used tool to measure cognitive function. In this study, we measured cognitive function using the K-MMSE, which is the Korean translation of the MMSE and which is also validated in the Korean population (Kang, Na, & Hahn, 1997; Park & Ko, 1990). MMSE scores were highly correlated with other validated measures, such as Montreal Cognitive Assessment scores (Lee et al., 2008). The K-MMSE consists of seven items: time orientation, spatial orientation, memory registration, attention and calculation, memory recall, language, and visual configuration (Kang et al., 1997). The K-MMSE scores range from 0 to 30, with a score of less than 24 regarded as cognitive dysfunction (Park & Ko, 1990).

7) Social contact

Social contact was measured as the frequency of meetings that participants had with their acquaintances. Participants answered on a 10-point Likert scale from 1 (no one to get along with) to 10 points (meeting almost every day), with higher scores indicating active social contact.

8) General characteristics

General characteristics included age (years), education level (less than elementary school or more than middle school), marital status (married or single/widowed/divorced/unmarried), and area of residence (urban or rural).

5. Statistical analysis

1) Baseline characteristics, according to the sex of the middle-aged and older adults, were compared using a $\chi 2$-test and an independent t-test for categorical and continuous variables, respectively.

2) Latent growth curve modeling (LGCM), which can quantify individual change over time, was performed to identify the frailty trajectory from 2006 to 2018. The mean and variance of the intercept, slope, and quadratic term of the frailty trajectory were estimated by applying an unconditional model analysis without covariates. The goodness of fit was confirmed using chi-square values, comparative fit index (CFI), Tucker–Lewis index (TLI), root mean square error of approximation (RMSEA), and standardized root mean square residual (SRMR).

3) Latent class growth modeling (LCGM), which combines the latent growth model and the latent class model, was used to confirm the latent class type for the frailty trajectory. To determine the number of latent classes of middle-aged and older adults, various model fit indices were used. The Akaike information criterion (AIC), Bayesian information criterion (BIC), adjusted BIC, negative log likelihood, entropy, Lo-Mendell-Rubin likelihood ratio test (LMR), and proportions for the latent classes were assessed, and the model with the best fit indices was selected.

4) After identifying the latent classes with different frailty trajectories, multinomial logistic regression was performed to confirm the predictors that classified the classes.

Full-information maximum likelihood (FIML) was used to handle missing data. Descriptive and multinomial logistic regression analyses were performed using SPSS (version 26.0; IBM, Armonk, NY, USA). LGCM and LCGM were performed using Mplus version 8.6.

6. Study ethics

The study procedures were reviewed and approved by the Institutional Review Board (IRB) of Seoul National University. We received a waiver of informed consent, and all research procedures were performed after IRB approval (IRB No. E2105/002-006). This study was conducted in accordance with the principles of the Declaration of Helsinki.

V. Results

1. The baseline characteristics of the participants

The baseline characteristics of the participants are presented in Table 1. Of the total 9,775 participants, 5,999 (61.4%) were middle-aged adults and 3,776 (38.6%) were older adults.

In the middle-aged, the mean age was 53.96 ± 5.86 years, and males represented 44.6% of the group. For middle-aged male, the majority had middle school education or higher (n = 2,184, 81.7%), were currently married (n = 2,490, 93.0%) were urban dwellers (n = 2,189, 81.8%), were currently non-smokers (n = 1,441, 53.8%), were current drinkers (n = 1,904, 71.2%), did not engage in regular physical activity (n = 1,476, 55.2%), and had normal cognitive function (n = 2,468, 93.5%). In addition, they had an average of 0.47 chronic diseases and the average score of social contact was 7.29. For middle-aged female, those who had middle school education or above (n = 2,047, 61.7%), were currently non-married (n = 2,802, 84.3%), were urban dwellers (n = 2,699, 81.2%), were currently non-smokers (n = 3,234, 97.3%), were current non-drinkers (n = 2,530, 76.1%), did not engage in regular physical activity (n = 1,924, 57.9%), had normal cognitive function (n = 2,863, 87.1%) accounted for the majority. Moreover, they had an average of 0.54

chronic diseases, and an average social contact score of 7.62.

In older adults, the mean age was 72.45 ± 5.88 years, and males accounted for 42.9% of the group. Among the older adult males, 840 (51.9%) had less than middle school education, 1,463 (90.3%) were married, 1,131 (69.8%) were urban dwellers, 1,112 (68.7%) were currently non-smokers, 862 (53.2%) were current drinkers, 945 (58.3%) did not engage in regular physical activity, and 1,200 (74.5%) had normal cognitive function. They had an average of 0.93 chronic diseases, and their average social contact score was 7.41. Among older adult female, 1,852 (86.0%) had less than middle school education, 1,189 (55.1%) were non-married, 1,555 (72.1%) were urban-dwellers, 2,072 (96.1%) were currently non-smoker, 1,900 (88.1%) were currently non-drinker, 1,572 (72.9%) did not engage in regular physical activity, and 1,171 (55.1%) had cognitive dysfunction. They had an average of 1.16 chronic diseases, and the average social contact score was 7.60.

Table 1. Baseline characteristics of participants (N=9775)

Variables	Total (n=9775)	Middle-aged (n=5999)			Older adults (n=3776)		
		Male (n=2676)	Female (n=3323)	*P*-value	Male (n=1620)	Female (n=2156)	*P*-value
Age (years)	61.10 ± 10.75	54.09 ± 5.79	53.86 ± 5.91	0.125	71.92 ± 5.48	72.85 ± 6.14	<0.001
Education							
≥ Middle school	5312 (54.3)	2184 (81.7)	2047 (61.7)	<0.001	779 (48.1)	302 (14.0)	<0.001
< Middle school	4455 (45.6)	490 (18.3)	1273 (38.3)		840 (51.9)	1852 (86.0)	
Marital status							
Married	7722 (79.0)	2490 (93.0)	521 (15.7)	<0.001	1463 (90.3)	967 (44.9)	<0.001
Single/divorced/widowed	2053 (21.0)	186 (7.0)	2802 (84.3)		157 (9.7)	1189 (55.1)	
Area of residence							
Urban	7574 (77.5)	2189 (81.8)	2699 (81.2)	0.566	1131 (69.8)	1555 (72.1)	0.121
Rural	2201 (22.5)	487 (18.2)	624 (18.8)		489 (30.2)	601 (27.9)	
Smoking							
Currently non-smoker	7859 (80.4)	1441 (53.8)	3234 (97.3)	<0.001	1112 (68.7)	2072 (96.1)	<0.001
Current smoker	1915 (19.6)	1235 (46.2)	89 (2.7)		507 (31.3)	84 (3.9)	
Drinking							
No	5960 (61.0)	772 (28.8)	2530 (76.1)	<0.001	758 (46.8)	1900 (88.1)	<0.001
Yes	3815 (39.0)	1904 (71.2)	793 (23.9)		862 (53.2)	256 (11.9)	
Regular physical activity							
Yes	3858 (39.5)	1200 (44.8)	1399 (42.1)	0.033	675 (41.7)	584 (27.1)	<0.001
No	5917 (60.5)	1476 (55.2)	1924 (57.9)		945 (58.3)	1572 (72.9)	
Number of chronic diseases (0–10)	0.73 ± 0.94	0.47 ± 0.79	0.54 ± 0.83	0.001	0.93 ± 0.98	1.16 ± 1.05	<0.001
Cognitive function							
Normal	7487 (76.6)	2468 (93.5)	2863 (87.1)	<0.001	1200 (74.5)	956 (44.9)	<0.001
Cognitive dysfunction	2177 (22.3)	171 (6.5)	425 (12.9)		410 (25.5)	1171 (55.1)	
Social contact (1–10)	7.49 ± 2.85	7.29 ± 2.71	7.62 ± 2.75	<0.001	7.41 ± 3.01	7.60 ± 3.02	0.052

Frailty instrument scores (0–3)							
Survey 1: 2006 (n=9386)	0.55 ± 0.77	0.31 ± 0.56	0.39 ± 0.62	<0.001	0.73 ± 0.86	0.99 ± 0.90	<0.001
Survey 2: 2008 (n=7717)	0.54 ± 0.78	0.26 ± 0.53	0.37 ± 0.63	<0.001	0.76 ± 0.84	1.03 ± 0.95	<0.001
Survey 3: 2010 (n=6936)	0.60 ± 0.80	0.35 ± 0.62	0.42 ± 0.67	<0.001	0.85 ± 0.86	1.09 ± 0.91	<0.001
Survey 4: 2012 (n=6411)	0.56 ± 0.76	0.34 ± 0.58	0.39 ± 0.64	0.003	0.81 ± 0.84	1.02 ± 0.90	<0.001
Survey 5: 2014 (n=5846)	0.54 ± 0.76	0.34 ± 0.60	0.39 ± 0.66	0.007	0.80 ± 0.83	1.03 ± 0.92	<0.001
Survey 6: 2016 (n=5436)	0.54 ± 0.77	0.34 ± 0.60	0.43 ± 0.68	<0.001	0.85 ± 0.91	0.98 ± 0.92	0.007
Survey 7: 2018 (n=4954)	0.52 ± 0.75	0.33 ± 0.58	0.38 ± 0.64	0.008	0.96 ± 0.87	0.99 ± 0.93	0.598
Frailty instrument components							
A. Weakness of grip strength							
No	8012 (82.0)	2515 (96.7)	3003 (93.1)	<0.001	1190 (75.5)	1304 (64.7)	<0.001
Yes	1407 (14.4)	87 (3.3)	222 (6.9)		386 (24.5)	712 (35.3)	
B. Exhaustion							
No	8488 (86.8)	2482 (93.1)	3008 (91.0)	0.751	1369 (84.7)	1629 (75.9)	<0.001
Yes	1245 (12.7)	184 (6.9)	297 (9.0)		248 (15.3)	516 (24.1)	
C. Social isolation							
No	7023 (71.8)	2103 (78.6)	2552 (76.8)	0.098	1074 (66.3)	1294 (60.0)	<0.001
Yes	2752 (28.2)	573 (21.4)	771 (23.2)		546 (33.7)	862 (40.0)	
Combinations of frailty instrument components							
A. Weakness of grip strength + exhaustion							
No	9258 (94.7)	2636 (99.1)	3241 (98.2)	0.007	1492 (92.8)	1889 (89.6)	0.001
Yes	417 (4.3)	25 (0.9)	58 (1.8)		115 (7.2)	219 (10.4)	
B. Weakness of grip strength + social isolation							
No	9015 (92.2)	2618 (98.9)	3217 (97.7)	<0.001	1430 (89.0)	1750 (83.5)	<0.001
Yes	628 (6.4)	29 (1.1)	76 (2.3)		177 (11.0)	346 (16.5)	
C. Exhaustion + social isolation							
No	9160 (93.7)	2583 (96.7)	3202 (96.5)	0.714	1483 (91.5)	1892 (88.0)	<0.001
Yes	599 (6.1)	88 (3.3)	115 (3.5)		137 (8.5)	259 (12.0)	

Note. Data are shown as the mean ± SD or N (%). Middle-aged, participants aged <65 years at baseline; Older adults, participants aged ≥65 years at baseline. Reprinted from "Frailty trajectory among community-dwelling middle-aged and older adults in Korea: evidence from the Korean Longitudinal Study of Aging," by A. R. Jang, H. Sagong and J. Y. Yoon, 2022, *BMC Geriatrics, 22*(1), 524.

2. Frailty trajectory among participants using latent growth curve modeling

Using the LGCM, we analyzed the change in frailty over 12 years (Table 2). Overall, the slope of the frailty trajectory among all participants showed a gradual increase (Figure 2).

Specifically, in middle-aged males, the means of the intercept, slope, and quadratic terms were 0.291, 0.029, and -0.003, respectively. In middle-aged females, the means of the intercept, slope, and quadratic terms were 0.383, 0.020, and -0.002, respectively.

In older males, the means of the intercept, slope, and quadratic terms were 0.740, 0.057, and 0.000, respectively. In older females, the means of the intercept, slope, and quadratic terms were 0.998, 0.070, and -0.009, respectively.

The mean variance of the intercept, slope, and quadratic terms in all groups were significant, indicating significant individual differences in the frailty trajectory among participants. Therefore, it was determined that there would be several latent classes showing a heterogeneous change pattern according to the frailty trajectory, and LCGM was applied to estimate these latent classes.

Table 2. Results of the frailty trajectory among participants using latent growth curve modeling (N=9775)

			Mean (SE)	Variance (SE)	Model fit				
					χ^2 (*df*)	CFI	TLI	RMSEA	SRMR
Middle-aged	Male	Intercept	0.291*(0.010)	0.136*(0.011)	174.979*(19)	0.939	0.932	0.055	0.041
		Slope	0.029*(0.008)	0.034*(0.005)					
		Quadratic	-0.003*(0.001)	0.001*(0.000)					
	Female	Intercept	0.383*(0.010)	0.166*(0.012)	132.501*(19)	0.970	0.967	0.042	0.029
		Slope	0.020*(0.007)	0.035*(0.005)					
		Quadratic	-0.002*(0.001)	0.001*(0.000)					
Older adults	Male	Intercept	0.740*(0.021)	0.409*(0.035)	69.537*(19)	0.965	0.962	0.041	0.039
		Slope	0.057*(0.016)	0.094*(0.017)					
		Quadratic	0.000(0.003)	0.002*(0.000)					
	Female	Intercept	0.998*(0.019)	0.384*(0.034)	47.571*(19)	0.987	0.985	0.026	0.033
		Slope	0.070*(0.014)	0.073*(0.016)					
		Quadratic	-0.009*(0.002)	0.002*(0.000)					

Note. Middle-aged, participants aged <65 years at baseline; Older adults, participants aged ≥65 years at baseline. SE, standard error; CFI, comparative fit index; TLI, Tucker–Lewis index; RMSEA, root mean square error of approximation; SRMR, standardized root mean square residual. *p<.001. Reprinted from "Frailty trajectory among community-dwelling middle-aged and older adults in Korea: evidence from the Korean Longitudinal Study of Aging," by A. R. Jang, H. Sagong and J. Y. Yoon, 2022, *BMC Geriatrics, 22*(1), 524.

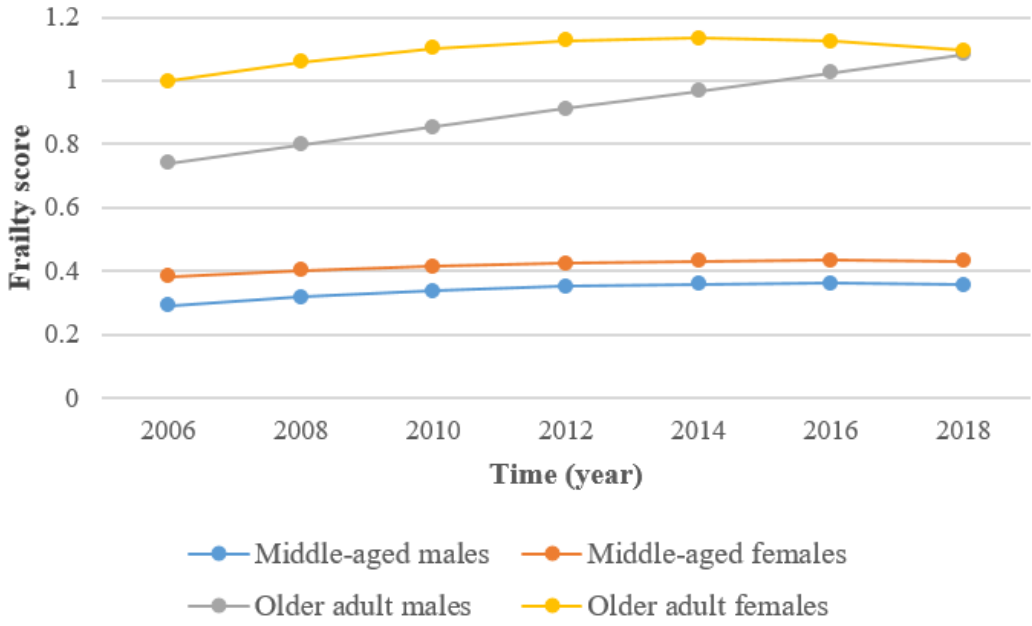

Figure 2. Frailty trajectory plots in middle-aged and older adults according to sex using latent growth curve modeling.

3. Subgroups of frailty trajectory using latent class growth modeling

LCGM was performed to determine the number of latent subgroups according to the frailty trajectories. In middle-aged individuals, the LMR P value of the three-class model was not significant, and the number of class 3 samples was too small to make a conceptual sense (Weller, Bowen, & Faubert, 2020) (Table 3). Therefore, the two-class model was selected as a suitable model. In older adults, the number of samples in class 4 in the four-class model was small (Table 4). Additionally, the BIC and adjusted BIC values of the four-class model increased compared to that of the three-class model in the female group, so the three-class model was selected as the optimal model.

The patterns of the frailty trajectories in each latent class are presented in Figure 3 and 4. In middle-aged individuals, both males and females were divided into two groups: maintaining robustness and changing from pre-frailty to robustness (Figure 3). In older adults, both sexes were divided into three groups: maintaining robustness, maintaining pre-frailty, and changing from frailty to pre-frailty (Figure 4).

Table 3. Model fit for latent class growth modeling in middle-aged (N=5999)

	Model fit indices	Two-class model	Three-class model
Male	AIC	19932.569	14048.593
	BIC	20050.410	14190.003
	Adjusted BIC	19986.864	14113.747
	Entropy	0.983	0.986
	Negative LL	9946.284	7000.296
	LMR *P* value	.0170	.505
	Class counts	Class 1: 1980 (74.0%)	Class 1: 1981 (74.0%)
		Class 2: 696 (26.0%)	Class 2: 577 (21.6%)
			Class 3: 118 (4.4%)
Female	AIC	29436.551	23479.520
	BIC	29558.723	23626.127
	Adjusted BIC	29495.174	23549.869
	Entropy	0.963	0.981
	Negative LL	14698.275	11715.76
	LMR *P* value	.043	.088
	Class counts	Class 1: 2262 (68.1%)	Class 1: 2266 (68.2%)
		Class 2: 1061(31.9%)	Class 2: 868 (26.1%)
			Class 3: 189 (5.7%)

Note. AIC, Akaike information criterion; BIC, Bayesian information criterion; LL, log likelihood; LMR, Lo-Mendell-Rubin likelihood ratio test. Reprinted from "Frailty trajectory among community-dwelling middle-aged and older adults in Korea: evidence from the Korean Longitudinal Study of Aging," by A. R. Jang, H. Sagong and J. Y. Yoon, 2022, *BMC Geriatrics, 22*(1), 524.

Table 4. Model fit for latent class growth modeling in older adults (N=3776)

	Model fit indices	Two-class model	Three-class model	Four-class model
Male	AIC	15544.344	14298.695	14260.762
	BIC	15652.147	14428.059	14411.687
	Adjusted BIC	15588.611	14351.815	14322.736
	Entropy	0.859	0.979	0.906
	Negative LL	7752.172	7125.347	7102.381
	LMR *P* value	.000	.002	.000
	Class counts	Class 1: 1319 (81.4%)	Class 1: 802 (49.5%)	Class 1: 802 (49.5%)
		Class 2: 301 (18.6%)	Class 2: 515 (31.8%)	Class 2: 425 (26.2%)
			Class 3: 303 (18.7%)	Class 3: 304 (18.8%)
				Class 4: 89 (5.5%)
Female	AIC	21022.810	20102.617	20100.957
	BIC	21136.33	20238.841	20259.886
	Adjusted BIC	21072.787	20162.590	20170.926
	Entropy	0.690	0.943	0.922
	Negative LL	10491.405	10027.308	10022.479
	LMR *P* value	.000	.000	.007
	Class counts	Class 1: 623 (28.9%)	Class 1: 742 (34.4%)	Class 1: 804 (37.3%)
		Class 2: 1533 (71.1%)	Class 2: 802 (37.2%)	Class 2: 730 (33.9%)
			Class 3: 612 (28.4%)	Class 3: 612 (28.4%)
				Class 4: 10 (0.5%)

Note. AIC, Akaike information criterion; BIC, Bayesian information criterion; LL, log likelihood; LMR, Lo-Mendell-Rubin likelihood ratio test. Reprinted from "Frailty trajectory among community-dwelling middle-aged and older adults in Korea: evidence from the Korean Longitudinal Study of Aging," by A. R. Jang, H. Sagong and J. Y. Yoon, 2022, *BMC Geriatrics, 22*(1), 524.

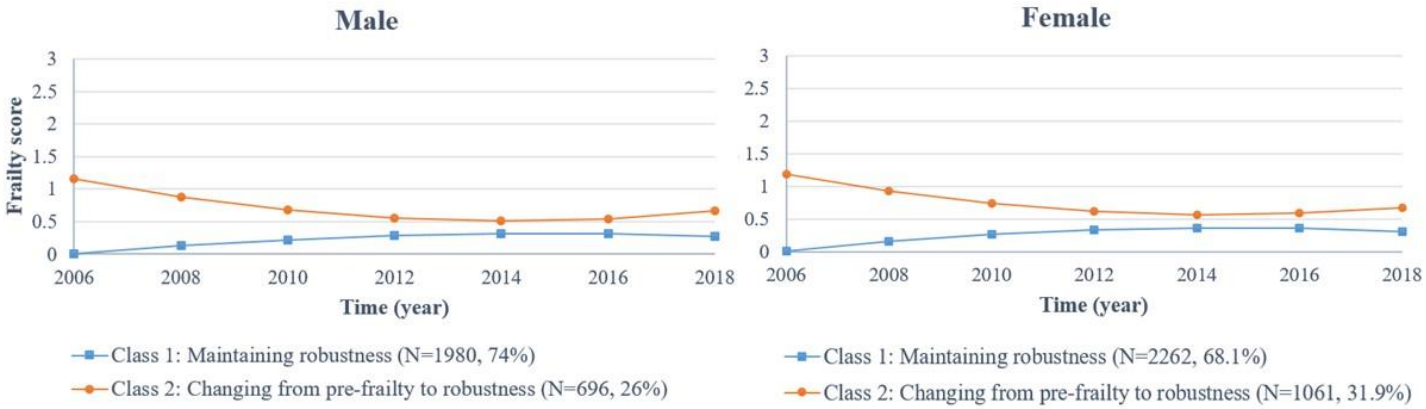

Figure 3. Growth trajectories of frailty by each latent class of middle-aged according to sex.

Note. Middle-aged, participants aged <65 years at baseline. A higher frailty score indicates a severe frailty status. **[Male]** Class 1: intercept = 0.003*, slope = 0.141*, quadratic = -0.016*; Class 2: intercept = 1.163*, slope = -0.324*, quadratic = 0.040*. **[Female]** Class 1: intercept = 0.012*, slope = 0.164*, quadratic = -0.019*; Class 2: intercept = 1.185*, slope = -0.294*, quadratic = 0.035*. *p<.05. Reprinted from "Frailty trajectory among community-dwelling middle-aged and older adults in Korea: evidence from the Korean Longitudinal Study of Aging," by A. R. Jang, H. Sagong and J. Y. Yoon, 2022, *BMC Geriatrics, 22*(1), 524.

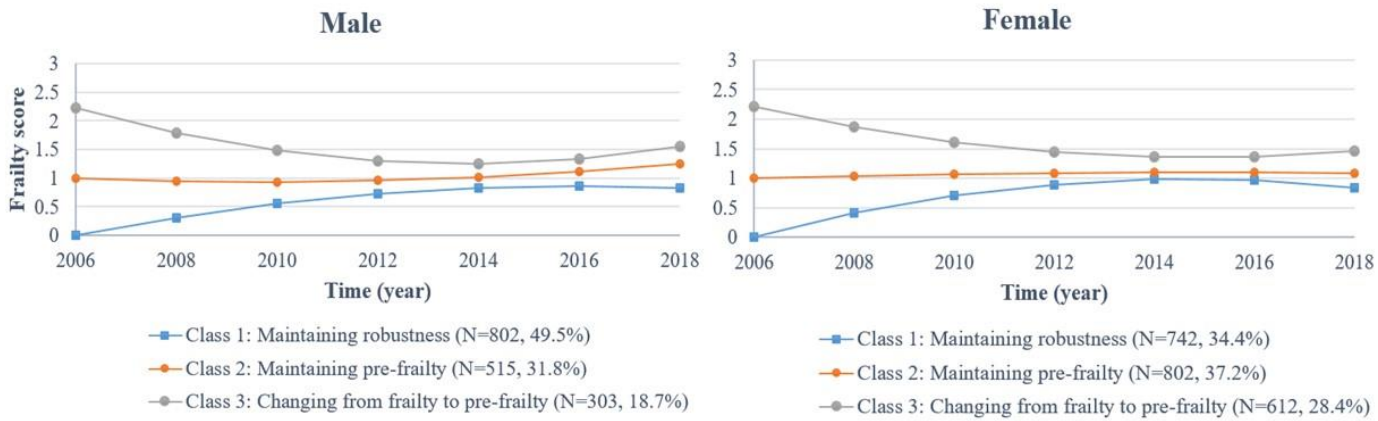

Figure 4. Growth trajectories of frailty by each latent class of older adults according to sex.

Note. Older adults, participants aged ≥65 years at baseline. A higher frailty score indicates a severe frailty status. **[Male]** Class 1: intercept = 0.004*, slope = 0.342*, quadratic = -0.034*; Class 2: intercept = 0.999*, slope = -0.068*, quadratic = 0.018*; Class 3: intercept = 2.225*, slope = -0.503*, quadratic = 0.065*. **[Female]** Class 1: intercept = 0.005*, slope = 0.451*, quadratic = -0.052*; Class 2: intercept = 1.000*, slope = 0.044*, quadratic = -0.005*; Class 3: intercept = 2.218*, slope = -0.391*, quadratic = 0.044 *. *p<.05. Reprinted from "Frailty trajectory among community-dwelling middle-aged and older adults in Korea: evidence from the Korean Longitudinal Study of Aging," by A. R. Jang, H. Sagong and J. Y. Yoon, 2022, *BMC Geriatrics, 22*(1), 524.

4. Predictors that differentiate the subgroups of frailty trajectory

Factors predicting membership in latent classes were identified using multinomial logistic regression analysis.

In middle-aged males, those who were older (OR = 1.022, 95% CI 1.003–1.040), had lower than middle school education (OR = 1.748, 95% CI 1.362–2.243), were single/divorced/widowed (OR = 3.673, 95% CI 2.607–5.173), were currently smoking (OR = 1.297, 95% CI 1.057–1.591), did not exercise regularly (OR = 1.654, 95% CI 1.347–2.031), were afflicted with several chronic diseases (OR = 1.227, 95% CI 1.086–1.386), had cognitive dysfunction (OR = 1.659, 95% CI 1.152–2.391), and had low social contact (OR = 0.757, 95% CI 0.731–0.785) were more likely to belong to the changing from pre-frailty to robustness group compared with the maintaining robustness group (Table 5).

In middle-aged females, those who had lower than middle school education (OR = 2.041, 95% CI 1.690–2.465), were single/divorced/widowed (OR = 1.517, 95% CI 1.225–1.877), were rural-dwellers (OR = 1.249, 95% CI 1.017–1.534), were currently smoking (OR = 2.751, 95% CI 1.679–4.506), did not exercise regularly (OR = 1.435, 95% CI 1.210–1.701), were afflicted with several chronic diseases (OR = 1.255, 95% CI 1.136–1.387), had

cognitive dysfunction (OR = 1.459, 95% CI 1.151–1.849), and had low social contact (OR = 0.801, 95% CI 0.778–0.825) were more likely to belong to the changing from pre-frailty to robustness group than the maintaining robustness group (Table 5).

In older males, participants who were older (OR = 0.959, 95% CI 0.937–0.982), had lower than middle school education (OR = 0.576, 95% CI 0.447–0.742), were currently smoking (OR = 0.713, 95% CI 0.552–0.922), were currently non-drinking (OR = 1.391, 95% CI 1.096–1.765), did not exercise regularly (OR = 0.760, 95% CI 0.590–0.980), had cognitive dysfunction (OR = 0.653, 95% CI 0.487–0.876), and had low social contact (OR = 1.183, 95% CI 1.134–1.235) were less likely to belong to the maintaining robustness group compared with the maintaining pre-frailty group. In addition, those who were older (OR = 1.050, 95% CI 1.022–1.078), had lower than middle school education (OR = 1.532, 95% CI 1.080–2.173), were single/divorced/widowed (OR = 1.976, 95% CI 1.258–3.102), did not exercise regularly (OR = 1.917, 95% CI 1.339–2.746), were afflicted with several chronic diseases (OR = 1.313, 95% CI 1.128–1.528), had cognitive dysfunction (OR = 2.002, 95% CI 1.445–2.773), and had low social contact (OR = 0.909, 95% CI 0.868–0.952) were more likely to belong to the changing from frailty to pre-frailty group than the maintaining pre-frailty group (Table 6).

In older females, participants who were older (OR = 0.971, 95% CI 0.951–0.991), had lower than middle school education (OR = 0.730, 95% CI 0.538–0.990), were single/divorced/widowed (OR = 0.772, 95% CI 0.616–0.966), did not exercise regularly (OR = 0.686, 95% CI 0.540–0.872), had cognitive dysfunction (OR = 0.540, 95% CI 0.429–0.679), and had low social contact (OR = 1.168, 95% CI 1.119–1.219) were less likely to belong to the maintaining robustness group than the maintaining pre-frailty group. Furthermore, those who were older (OR = 1.037, 95% CI 1.018–1.057), did not exercise regularly (OR = 1.361, 95% CI 1.024–1.807), had cognitive dysfunction (OR = 1.379, 95% CI 1.075–1.770), and had low social contact (OR = 0.906, 95% CI 0.875–0.938) were more likely to belong to the changing from frailty to pre-frailty group compared with the maintaining pre-frailty group (Table 6).

Table 5. Multinomial logistic regression analysis predicting membership of latent classes in middle-aged (N=5999)

Variables	Male	Female
	Class 2: Changing from pre-frailty to robustness (n=696)	Class 2: Changing from pre-frailty to robustness (n=1061)
	OR (95% CI)	OR (95% CI)
Age (years)	1.022 (1.003–1.040)	1.002 (0.986–1.018)
Education		
≥ Middle school	1	1
< Middle school	1.748 (1.362–2.243)	2.041 (1.690–2.465)
Marital status		
Married	1	1
Single/divorced/widowed	3.673 (2.607–5.173)	1.517 (1.225–1.877)
Area of residence		
Urban	1	1
Rural	1.141 (0.884–1.473)	1.249 (1.017–1.534)
Smoking		
Currently non-smoker	1	1
Current smoker	1.297 (1.057–1.591)	2.751 (1.679–4.506)
Drinking		
No	1	1
Yes	0.891 (0.716–1.109)	1.080 (0.890–1.311)
Regular physical activity		
Yes	1	1
No	1.654 (1.347–2.031)	1.435 (1.210–1.701)
Number of chronic diseases (0–10)	1.227 (1.086–1.386)	1.255 (1.136–1.387)
Cognitive function		
Normal	1	1
Cognitive dysfunction	1.659 (1.152–2.391)	1.459 (1.151–1.849)
Social contact (1–10)	0.757 (0.731–0.785)	0.801 (0.778–0.825)

Note. The reference group is class 1(maintaining robustness) of each age group. OR, odds ratio; CI, confidence interval. Reprinted from "Frailty trajectory among community-dwelling middle-aged and older adults in Korea: evidence from the Korean Longitudinal Study of Aging," by A. R. Jang, H. Sagong and J. Y. Yoon, 2022, *BMC Geriatrics, 22*(1), 524.

Table 6. Multinomial logistic regression analysis predicting membership of latent classes in older adults (N=3776)

Variables	Male		Female	
	Class 1: Maintaining robustness (n=802)	Class 3: Changing from frailty to pre-frailty (n=303)	Class 1: Maintaining robustness (n=742)	Class 3: Changing from frailty to pre-frailty (n=612)
	OR (95% CI)		OR (95% CI)	
Age (years)	0.959 (0.937–0.982)	1.050 (1.022–1.078)	0.971 (0.951–0.991)	1.037 (1.018–1.057)
Education				
≥ Middle school	1	1	1	1
< Middle school	0.576 (0.447–0.742)	1.532 (1.080–2.173)	0.730 (0.538–0.990)	1.479 (0.981–2.229)
Marital status				
Married	1	1	1	1
Single/divorced/widowed	0.770 (0.505–1.172)	1.976 (1.258–3.102)	0.772 (0.616–0.966)	1.178 (0.925–1.500)
Area of residence				
Urban	1	1	1	1
Rural	1.104 (0.835–1.459)	1.368 (0.967–1.937)	0.814 (0.637–1.041)	1.016 (0.791–1.305)
Smoking				
Currently non-smoker	1	1	1	1
Current smoker	0.713 (0.552–0.922)	0.990 (0.710–1.380)	0.537 (0.284–1.015)	1.178 (0.710–1.954)
Drinking				
No	1	1	1	1
Yes	1.391 (1.096–1.765)	0.854 (0.625–1.166)	1.104 (0.801–1.523)	0.849 (0.597–1.207)
Regular physical activity				
Yes	1	1	1	1
No	0.760 (0.590–0.980)	1.917 (1.339–2.746)	0.686 (0.540–0.872)	1.361 (1.024–1.807)
Number of chronic diseases (0–10)	0.966 (0.854–1.094)	1.313 (1.128–1.528)	0.913 (0.825–1.010)	1.097 (0.990–1.215)
Cognitive function				
Normal	1	1	1	1
Cognitive dysfunction	0.653 (0.487–0.876)	2.002 (1.445–2.773)	0.540 (0.429–0.679)	1.379 (1.075–1.770)
Social contact (1–10)	1.183 (1.134–1.235)	0.909 (0.868–0.952)	1.168 (1.119–1.219)	0.906 (0.875–0.938)

Note. The reference group is class 2 (maintaining pre-frailty) of each age group. OR, odds ratio; CI, confidence interval. Reprinted from "Frailty trajectory among community-dwelling middle-aged and older adults in Korea: evidence from the Korean Longitudinal Study of Aging," by A. R. Jang, H. Sagong and J. Y. Yoon, 2022, *BMC Geriatrics, 22*(1), 524.

VI. Discussion

In this study, we investigated the frailty trajectory, latent subgroups of the frailty trajectory, and predictors that differentiate these subgroups among community-dwelling middle-aged and older adults using the KLoSA data from 2006 to 2018. Factors predicting membership in latent subgroups were analyzed by classifying them into three domains: general characteristics, health-related behavior factors, and physical and psychosocial factors. A detailed discussion of each result is as follows.

1. Frailty trajectory among participants

In the present study, the frailty trajectory was confirmed using LGCM, and frailty became more severe over time in all age groups. In previous studies, the frailty score showed a gradual increase over time, consistent with the results of this study (Hoogendijk et al., 2018; Lohman et al., 2017; Machado-Fragua et al., 2020; Yang & Lee, 2010). Since most previous studies have estimated the frailty trajectory using the DAI or CHS frailty index, it is difficult to compare the values directly because of the different measurement tools used in this study.

In this study, a difference was noted in the frailty trajectory according to

age and sex. Older adults had higher mean intercept coefficients of frailty than middle-aged adults, and the gap in frailty levels did not narrow over time, suggesting that older adults were more frail. Furthermore, in the same age group, the mean intercept of frailty was higher in females than in males. Over time, females consistently had higher frailty scores than males, suggesting that female frailty was more severe. These results were consistent with previous studies which showed that frailty is more prominent in older people and females (Rogers et al., 2017; Stolz et al., 2017). A possible mechanism for females to be frailer than males is that they accumulated health deficits more rapidly than males (Stolz et al., 2017). Since older adults and females are vulnerable populations with high levels of frailty, preferential intervention strategies targeting them are required.

2. Subgroups of frailty trajectory

We found different latent classes in frailty trajectories for each age group using the LCGM. In middle-aged individuals, a total of two trajectories were found for both males and females, maintaining robustness and changing from pre-frailty to robustness. In the change from pre-frailty to robustness subgroup, the participants showed initial pre-frailty but then improved to robustness. These results are consistent with previous studies showing that

younger people are more likely to improve from frailty (Thompson, Theou, Adams, Tucker, & Visvanathan, 2018). In addition, the middle-aged group in this study had a lower frailty score than that of the older adults' group, and there was no subgroup within the trajectory corresponding to frailty status. This indicates that the incidence of frailty in middle age is low. However, another possible explanation is that frailty is an age-related geriatric syndrome (Chen, Mao, & Leng, 2014), so the trajectory of frailty due to aging may not be well revealed in middle-aged individuals.

The older adults were divided into three groups for both males and females. Unlike middle-aged individuals, most of them were initially frail or pre-frail. In addition, there was no improvement from pre-frailty or frailty to the robustness group, only maintenance or slight improvement. While frailty is a dynamic condition (Gajic-Veljanoski et al., 2018), it worsens with age (Thompson et al., 2018), suggesting that it is difficult to improve into a robust group, especially for the older adults. In a previous 18-year longitudinal study of the Mexican American elderly, the frailty trajectory was classified into three categories: non-frail, moderate progressive, and progressive high (Howrey et al., 2020). In another 12-year longitudinal study of Mexican Americans elderly, a total of three subgroups of frailty trajectory were derived: stable low frailty group, progressive moderate frailty group, and progressive high frailty group (Peek et al., 2012). These previous studies revealed the

presence of three subgroups, similar to the ones found in our study. However, their trajectory patterns differed from those in our study since there were groups that deteriorated over time. As there are few longitudinal studies to identify subgroups within the frailty trajectory, the exact mechanism for the difference in these results is not well known, but it may be due to attrition. As such, it is necessary to acquire more evidence through longitudinal studies in the future.

3. Predictors that differentiate the subgroups of frailty trajectory

Multinomial logistic regression analysis was used to identify predictors that differentiated latent classes. Predictors were classified into three domains: general characteristics, health-related behavior factors, and physical and psychosocial factors.

1) General characteristics

Age was a predictor that differentiated the latent classes of middle-aged males and older adults. A previous systematic review showed that age is frequently associated with frailty levels and changes in frailty status

(Welstead et al., 2021). In a 4-year longitudinal study, an increase in age was associated with the occurrence of frailty (Doi et al., 2018). In a 10-year follow-up study, Rogers et al. (2017) also found that an increase in age was associated with an increase in the frailty score, supporting the results of this study. According to an integral conceptual model of frailty (Gobbens, Luijkx, Wijnen-Sponselee, & Schols, 2010), increasing age may reduce physiological preservation capacity, leading to frailty status.

Educational level was a significant predictor in both middle-aged and older adults. These findings are consistent with previous findings (Chen, Mair, Bao, & Yang, 2015; Peek et al., 2012). Peek et al. (2012) identified three subgroups of frailty trajectories in older Mexican Americans. Higher education was associated with a reduced likelihood of belonging to the high frailty trajectory group. In addition, these results correspond well with a longitudinal study following older adults' health trajectories that higher education is associated with lower frailty scores (Chen et al., 2015). Educational level has been pointed out as a major life-course determinant affecting frailty status in an integral conceptual model of frailty (Gobbens et al., 2010).

Marital status was a significant predictor that differentiated each class in middle-aged and older adults, showing the similarity to those found in the earlier study (Chamberlain et al., 2016). Chamberlain et al. (2016) identified distinct frailty trajectories in older adults and confirmed that non-married

marital status was a predictor of high frailty trajectory. The exact mechanism of why unmarried people are getting frailer than married people is unknown, but it has been reported that stress from widowhood, divorce, or separation may increase frailty (Kojima, Walters, Iliffe, Taniguchi, & Tamiya, 2020). Divorce or being unmarried may also lead to unhealthy behaviors, such as heavy drinking or smoking (Keenan, Ploubidis, Silverwood, & Grundy, 2017), which may be linked to frailty.

2) Health-related behavior factors

Current smoking had a significant effect on the difference in frailty trajectories of middle-aged and older adult males. The result of the present study coincides well with the results of the previous 4-year longitudinal study reporting a higher rate of deterioration in frailty after 4 years in current smokers than in non-smokers (Kojima, Iliffe, Jivraj, Liljas, & Walters, 2018). Smoking causes various diseases such as cancer, heart attack, coronary heart disease, and lung diseases (National Health Service, 2018), which can affect frailty. As smoking is a modifiable lifestyle factor, smoking cessation has the potential to prevent or delay frailty in older adults (Kojima et al., 2018).

Interestingly, in older males, current drinkers were more likely to belong to the maintaining robustness group, which was a different result from the

previous frailty trajectory study (Chamberlain et al., 2016). “Ever felt the need to cut down on alcohol consumption” and “Relatives/friends worry or complain about your alcohol consumption” were predictors of high frailty trajectories (Chamberlain et al., 2016). However, in another previous meta-analysis study, heavy drinking was associated with a lower incidence of frailty (Kojima, Liljas, Iliffe, Jivraj, & Walters, 2018), showing conflicting results between studies. The results of this study may be due to unadjusted effect measures, residual confounding, sick quitter effect, or survival bias; therefore, caution is needed in the interpretation (Kojima et al., 2018).

Lack of regular physical activity is a predictor influencing the frailty trajectory in both middle-aged and older adults. According to the results of a systematic review of frailty trajectories, physical activity has been identified as a protective factor against frailty (Welstead et al., 2021). Rogers et al. (2017) used panel data from the English Longitudinal Study of Aging to investigate the relationship between physical activity and frailty progression in middle-aged and older adults. In this previous study, regular physical activity was associated with frailty trajectories; in particular, there were differences in the results by age group according to the intensity of physical activity. Mild physical activity had no significant effect on preventing the progression of frailty in middle-aged and older adults. Additionally, moderate physical activity contributed to reducing the progression of frailty in adults aged older

than 65 years. Vigorous physical activity had a significant effect on reducing frailty in both middle-aged and older adults. This previous study has shown that regular physical activity is important in preventing the progression of frailty, and it was confirmed that different intensities of physical activity are needed between middle-aged and older adults to prevent frailty. To prevent the progression of frailty, more than moderate physical activity for older adults and more than vigorous physical activity for middle-aged adults has been recommended. However, as literature on the relationship between physical activity and frailty trajectory is still limited, additional research is required.

3) Physical and psychosocial factors

The number of chronic diseases also had a significant effect on classification into frailty groups in middle-aged and older adult males. The result of the present study resembles those found in a previous longitudinal study, which confirmed that chronic diseases such as arthritis and diabetes were significant factors in predicting membership of progressive frailty trajectory groups (Howrey et al., 2020). The two concepts of chronic disease and frailty are related to each other and chronic diseases can contribute to the occurrence of frailty (Zazzara, Vetrano, Carfì, & Onder, 2019). However,

despite these associations, few longitudinal studies analyze the relationship between the frailty trajectory and chronic diseases (Welstead et al., 2021), so further research is needed.

Cognitive dysfunction was also found to be a strong risk factor that differentiated each group, consistent with the results of previous literature (Robertson, Savva, & Kenny, 2013; Thibeau et al., 2019). Frailty and cognitive decline share risk factors including chronic disease, poor cardiovascular health, inflammation, or hormonal dysregulation (Robertson et al., 2013). Also, behavioral changes due to cognitive decline can lead to frailty through reduced physical activity and nutritional deficiencies (Robertson et al., 2013).

Furthermore, social contact was a significant predictor that differentiated between each group in both middle-aged and older adults. There was limited literature on the association between social contact and frailty trajectory; instead, social factors such as cultural engagement (Rogers & Fancourt, 2020) and social support (Chen et al., 2015; Peek et al., 2012) have been pointed out as protective factors for frailty trajectory. In a previous longitudinal study analyzing the association between social contact and frailty progression, less frequent contact and high levels of loneliness increased the likelihood of frailty (Gale et al., 2018). However, in a study of 1428 community-dwelling older adults in Korea, it was found that active

social contact with family, friends, and neighbors did not significantly reverse frailty progression after 2 years (Jang et al., 2021), which is inconsistent with our findings. Although many studies have reported a positive effect of frequent social contact on health (Gale et al., 2018; Woo, Goggins, Sham, & Ho, 2005), some studies mentioned a negative effect (Gale et al., 2012). Some individuals may perceive social contact negatively, which can increase stress hormones and lead to negative health outcomes (Chon, Lee, Kim, & Lee, 2018; Gale et al., 2012). Nevertheless, we cannot conclude that social contact negatively impacts frailty because the underlying mechanisms of these two concepts are still uncertain. Further research is needed to clarify the relationship between them.

4. Implications

1) Nursing research aspects

The present study contributes to the understanding of the long-term trajectory of frailty and provides new insights to prevent the progression of frailty. We comprehensively identified predictors that differentiate the subgroups of frailty trajectory among community-dwelling middle-aged and older adults, providing basic data for future intervention studies. This study has also made a significant contribution in that it revealed the frailty trajectory representing the Korean population by using Korean big data with low selection bias and high representativeness of the population. In addition, this study tracked the frailty trajectory longitudinally among middle-aged people, which had not been conducted before; we can particularly contribute to providing basic data for research on the management of frailty among middle-aged people.

2) Nursing practice aspects

This study is meaningful as it provides comprehensive evidence about predictors that affect the frailty trajectory required to deliver evidence-based frailty interventions in community settings. In addition, it contributes to the development of tailored frailty management programs for each age group of

middle-aged and older adults. In particular, since frailty is more severe in older adults than in the middle-aged, we can make a policy suggestion that the prevention and management of frailty are urgent, especially for older adults.

5. Limitations

This study has some limitations. First, since the independent variable was used from the baseline, the change in the independent variable during the study period could not be considered. Second, caution is needed when interpreting the results as missing data occur in longitudinal studies. Those excluded from the study were older and had higher rates of chronic diseases and cognitive dysfunction (Appendix 1, 2), which may have resulted in an underestimation of frailty. Third, since there are no frailty measuring tools made exclusively for middle-aged people, the FI, which was developed for the older adults, was used to identify frailty among the middle-aged. This may have underestimated the frailty of the middle-aged, suggesting the need to develop a frailty tool targeting this population in the future. Fourth, we only used the FI for the measurement of frailty because the available variables in the KLoSA were limited. Fifth, factors for the social domain were measured in both independent (e.g., social contact) and dependent variables (e.g., social isolation). Lastly, in chronic diseases, prostate diseases were measured only in males due to the nature of the disease.

VII. Conclusion and future research

To the best of our knowledge, this is the first study to identify various change patterns in frailty trajectories and predictors causing such different patterns in middle-aged and older adults.

In conclusion, various subgroups within the frailty trajectory existed in the community-dwelling middle-aged and older adults. The middle-aged and older adults were divided into two and three groups, respectively. Most of the middle-aged people were in the maintaining robustness group, and those who were pre-frail at the beginning also showed a tendency to return to the robustness group as time passed. On the other hand, most older adults were initially in a state of pre-frailty or frailty, and there was no improvement to the robustness group over time; therefore, preventing or delaying the onset of frailty is necessary for the older adults because it is likely that the condition will continue once it commences.

In addition, to maintain a robust state, interventions focusing on modifiable factors such as smoking cessation, regular exercise, prevention of chronic diseases, cognitive function improvement, and social participation enhancement are necessary for middle-aged individuals. For older adults, interventions targeting regular exercise, cognitive function improvement, and

social participation enhancement are necessary to maintain a robust state and prevent frailty.

We would like to make the following suggestions for future research.

First, frailty was measured using only the FI instrument. Depending on the instrument used to measure frailty, the results obtained may vary (Kim et al., 2018). Therefore, future studies are needed to compare the difference in the frailty trajectory using widely used instruments such as the CHS frailty index, DAI, or Study of Osteoporotic Fractures Index.

Second, although physiologic factors such as activated inflammation, immune system dysfunction, anemia, and endocrine system alterations have been reported to influence frailty (Espinoza & Fried, 2007), these variables were unavailable in the KLoSA. In the future, it is suggested to conduct research by including these factors in the analysis.

Lastly, based on the results of this study, we recommend conducting a tailored intervention study to reduce frailty by classifying age and sex. In particular, a differentiated approach by age group is necessary because the trajectories and predictors of frailty differ between middle-aged and older adults.

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Appendix

Appendix 1. Baseline characteristics of included and excluded middle-aged, mean ± SD or N (%)

Variables	Included (n=5999)	Excluded (n=91)	*P*
Age (years)	53.96 ± 5.86	55.59 ± 6.41	0.018
Sex			
Male	2676 (44.6)	46 (50.5)	0.258
Female	3323 (55.4)	45 (49.5)	
Education			
≥ Middle school	4231 (70.6)	56 (61.5)	0.060
< Middle school	1763 (29.4)	35 (38.5)	
Marital status			
Married	5292 (88.2)	70 (76.9)	0.001
Single/divorced/widowed	707 (11.8)	21 (23.1)	
Area of residence			
Urban	4888 (81.5)	81 (89.0)	0.066
Rural	1111 (18.5)	10 (11.0)	
Smoking			
Currently non-smoker	4675 (77.9)	72 (79.1)	0.786
Current smoker	1324 (22.1)	19 (20.9)	
Drinking			
No	3302 (55.0)	69 (75.8)	<0.001
Yes	2697 (45.0)	22 (24.2)	
Regular physical activity			
Yes	2599 (43.3)	23 (25.3)	0.001
No	3400 (56.7)	68 (74.7)	
Number of chronic diseases (0–10)	0.51 ± 0.81	1.11 ± 1.06	<0.001
Cognitive function			
Normal	5331 (89.9)	39 (55.7)	<0.001
Cognitive dysfunction	596 (10.1)	31 (44.3)	
Social contact (1–10)	7.47 ± 2.74	5.27 ± 3.60	<0.001
Frailty instrument scores (0–3)	0.32 ± 0.59	1.00 ± 1.03	0.018

Note. SD, standard deviation. Reprinted from "Frailty trajectory among community-dwelling middle-aged and older adults in Korea: evidence from the Korean Longitudinal Study of Aging," by A. R. Jang, H. Sagong and J. Y. Yoon, 2022, *BMC Geriatrics, 22*(1), 524.

Appendix 2. Baseline characteristics of included and excluded older adults, mean ± SD or N (%)

Variables	Included (n=3776)	Excluded (n=388)	*P*
Age (years)	72.45 ± 5.88	78.31 ± 7.69	<0.001
Sex			
Male	1620 (42.9)	121 (31.2)	<0.001
Female	2156 (57.1)	267 (68.8)	
Education			
≥ Middle school	1081 (28.7)	54 (13.9)	<0.001
< Middle school	2692 (71.3)	334 (86.1)	
Marital status			
Married	2430 (64.4)	179 (46.1)	<0.001
Single/divorced/widowed	1346 (35.6)	209 (53.9)	
Area of residence			
Urban	2686 (71.1)	275 (70.9)	0.915
Rural	1090 (28.9)	113 (29.1)	
Smoking			
Currently non-smoker	3184 (84.3)	345 (88.9)	0.017
Current smoker	591 (15.7)	43 (11.1)	
Drinking			
No	2658 (70.4)	336 (86.6)	<0.001
Yes	1118 (29.6)	52 (13.4)	
Regular physical activity			
Yes	1259 (33.3)	51 (13.1)	<0.001
No	2517 (66.7)	337 (86.9)	
Number of chronic diseases (0–10)	1.06 ± 1.03	1.35 ± 1.13	<0.001
Cognitive function			
Normal	2156 (57.7)	42 (13.7)	<0.001
Cognitive dysfunction	1581 (42.3)	265 (86.3)	
Social contact (1–10)	7.52 ± 3.02	5.78 ± 3.53	<0.001
Frailty instrument scores (0–3)	0.91 ± 0.91	1.71 ± 0.97	<0.001

Note. SD, standard deviation. Reprinted from "Frailty trajectory among community-dwelling middle-aged and older adults in Korea: evidence from the Korean Longitudinal Study of Aging," by A. R. Jang, H. Sagong and J. Y. Yoon, 2022, *BMC Geriatrics, 22*(1), 524.

Appendix 3. IRB approval letter

심의 면제 확인서

수신

연구책임자	**이름:** 윤주영	**소속:** 간호대학 간호학과	**직위:** 교수
지원기관	해당없음		

과제정보

승인번호		IRB No. E2105/002-006
연구과제명		농촌 거주가 노쇠 궤적에 미치는 영향: 고령화연구패널조사를 사용하여
연구종류		공개된 정보 이용 연구
면제일자		2021-05-06
심의결과		면제승인
검토의견	면제 검토의견	본 연구는 공개된 자료인 한국고용정보원의 '고령화연구패널조사 제1차(2006년)~제7차(2018년)' 자료를 이용하는 연구로 「생명윤리 및 안전에 관한 법률 시행규칙」 제13조 제1항에 근거하여 심의를 면제합니다.

상기 연구과제에 대하여 본 위원회에서는 심의면제대상임을 확인합니다.

2021년 05월 06일

서울대학교 생명윤리위원회 위원장

본 위원회가 승인한 연구를 수행하는 연구자들은 다음의 사항을 준수해야 합니다.

1. 모든 연구자들은 아래의 사항을 준수하여야 합니다.
2. 연구자께서는 제출하신 계획서에 따라 연구를 수행하여야 하며, 이와 다르게 연구를 진행하실 경우 다시 심의를 진행하셔야 함을 유의하시기 바랍니다.
3. 위원회의 요구가 있을 때에는 연구의 진행과 관련된 보고를 위원회에 제출하여야 합니다.
4. 연구윤리를 위하여 관련부처가 필요시 조사 및 감독 차원에서 현장점검을 실시할 수 있습니다.
5. 연구와 관련된 기록은 연구가 종료된 시점을 기준으로 최소 3년간 보관하여야 합니다.

국문 초록

지역사회 거주 중·고령자 노쇠 궤적의 잠재계층유형 및 예측요인

장 아 람
간호학과
서울대학교 대학원
지도교수 윤 주 영

현재까지 중년층과 노년층 모두를 포함한 노쇠 궤적에 대한 연구는 이루어지지 않았으며, 장기적인 노쇠 궤적에 대한 이해가 부족한 실정이다. 본 연구는 지역사회에 거주하는 중년 및 노년층의 노쇠 궤적, 노쇠 궤적의 하위 그룹 및 이러한 하위 그룹을 구분 짓는 예측 요인을 파악하는 것을 목표로 한다.

연구대상자는 2006~2018 년 고령화연구패널조사에 참여한 지역사회 거주 45 세 이상 성인 9,775 명이었다. 노쇠는 악력 약화, 피로, 사회적 고립의 세 가지 항목으로 구성된 노쇠 도구(Frailty instrument)를 사용하여 측정하였다. 노쇠 궤적을 파악하기 위하여 잠재성장곡선모형을, 노쇠 궤적에 따른 하위 그룹인 잠재계층을 파악하기 위하여

잠재계층성장모형을 사용하였다. 또한 잠재계층을 구분 짓는 예측 요인을 확인하기 위하여 다항 로지스틱 회귀분석을 사용하였다.

잠재성장곡선모형 분석 결과, 전 연령층에서 12 년간의 노쇠 궤적은 점진적으로 증가하는 추세를 보였다. 잠재계층성장모형 분석 결과, 노쇠 궤적의 잠재계층 수 및 양상은 연령에 따라 차이가 있었다. 중년층에서는 총 2 개의 잠재계층이(건강 유지군, 전노쇠에서 건강으로의 변화군), 노년층에서는 총 3 개의 잠재계층이(건강 유지군, 전노쇠 유지군, 노쇠에서 전노쇠로의 변화군) 도출되었다. 다항 로지스틱 회귀분석 결과, 중년층과 고령층 모두에서 규칙적인 운동, 인지 기능 장애, 사회 참여가 잠재계층을 구분 짓는 주요 요인으로 파악되었다. 추가적으로, 중년층에서는 흡연 및 만성질환의 수가 잠재계층을 구분 짓는 유의한 요인으로 확인되었다.

지역사회 거주 중년층 및 고령층에서 노쇠 발달 궤적이 상이한 다양한 하위 그룹이 존재함을 확인하였다. 또한 이러한 노쇠 궤적에 영향을 미치는 요인이 연령에 따라 차이가 있기 때문에, 각 연령대에 적합한 수정 가능한 요인을 사용하여 중재를 제공하는 것이 필요하다.

주요어 : 노쇠, 노쇠 궤적, 중년, 노인, 고령화연구패널조사, 전국민 기반 코호트 연구

학 번 : 2017-21146