

Longitudinal trajectory of disability in community-dwelling older adults: An observational cohort study in South Korea

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Research article

Keywords: Aged, Disability, Geriatric assessment, Patient-Centered Care, Quality of life, Trajectory

Posted Date: March 21st, 2020

DOI: <https://doi.org/10.21203/rs.3.rs-18186/v1>

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Version of Record: A version of this preprint was published on October 28th, 2020. See the published version at <https://doi.org/10.1186/s12877-020-01834-y>.

Abstract

Background Disability, which is considered a health-related condition, increases care demands and socioeconomic burdens for both families and communities. To confirm the trend of dynamic longitudinal changes in disability, this study aims to explore how disability is divided by the trajectory method, which deals with time-sequenced data. Additionally, this study examines the differences in demographics, geriatric conditions, and time spent at home among the trajectory groups in community-dwelling older adults. Home time is defined as the period during which the patient was not in hospital or health care facility during their lifetime.

Methods Records of 786 community-dwelling older participants were analyzed from the Aging Study of PyeongChang Rural Area, a population-based cohort study that took place over three years. Using 7 domains of activity of daily living and 10 domains of instrumental activity of daily living, participants were grouped into no dependency (0 disabled domain), mild (1 disabled domain), and severe (2 or more disabled domains) disability groups. The longitudinal trajectory group of disability was calculated as a trajectory method. Three distinct trajectory groups were calculated over time: a relatively-stable group (78.5%; n=617), a gradually-aggravated group (16.0%; n=126), and a rapidly-deteriorated group (5.5%; n=43).

Results It was found that 78.5% of patients showed relatively no dependence and 5.5% of older adults in rural area showed severe dependence. Through applying the trajectory method, it was shown that the Short Physical Performance Battery (SPPB) score was 10.2 points in the relatively-stable group and 3.1 points in the rapidly-deteriorating group by the 3rd year. Additionally, home time decrement was more pronounced in the trajectory method (3.33% between the rapidly-deteriorated group and the relatively-stable group), than in the conventional method (2.53% between the no dependency group and the severe-dependent group).

Conclusions This study shows the difference in demographics and geriatric conditions (such as SPPB) through the examination of longitudinal trajectory groups of disability in community-dwelling older adults. Significant differences were also found in the amount of home time among the trajectory groups.

1. Background

The number of countries facing an aging population is increasing worldwide [1, 2]. The increase in the world's older population implicates an increase in not only the prevalence of chronic diseases but also the burden of people with functional impairments and geriatric conditions (e.g., frailty and sarcopenia) [3–6]. Particularly, disability, which is regarded a health-related condition, increases care demands and socioeconomic burdens for both families and communities, increases care demands and socioeconomic burden for both families and communities [7–9].

The onset of disability varies substantially among individuals with similar chronological ages [10–13]. Studies have shown that differences exist among individuals in terms of presence of multimorbidity, frailty, and disability. Evidence also suggests that disability can be prevented or delayed when accompanied by appropriate multifactorial interventions to remove risk factors and improve functioning, making disability one of the most important outcome measures in studies targeting older populations [14].

The conventional method of assessment for disability focuses on the severity of the disability at the initial diagnosis; however, this does not reflect the individuality and time course of the disability. The trajectory method of assessment focuses on the changes in the later years of life [15]. Previous studies have shown different trajectory models based on mood, physical activity, and disability in the later years of life [8, 16–18]. However, the trajectory

and time course of various disabilities are still not well understood. Although some studies show trajectories and subsequent mortality with disability [17], other studies demonstrate that not all older individuals with disability in the community end up being institutionalized in chronic hospitals or other long-term care facilities [16, 18, 19]. It is unclear whether an older individual identifying with a disability has a high probability of readmission or long-term institutionalization. Furthermore, only a few studies have yet to focus on the dynamic trajectories of disability in community-dwelling older adults [19].

Previously, trajectories of disability were not researched in relation to patient-centered outcomes. Patient-centered outcomes are the result of a healthcare system that prioritizes a patient's needs in conjunction with the healthcare professional's medical expertise. It focuses on health status that is meaningful to patients such as quality of life, functional status, and independent living [20–22]. In recent studies, 'home time' has been proposed as a patient-centered measure relevant to the quality of life for older people [23–25]. Home time, meaning the number of days alive and spent at home, comes from the concept of patients' wanting to maximize the number of days they can be at home rather than in hospital or nursing facilities at the end of their life. Home time focuses on priority values and meanings that are important to older patients or their families, and shows its relationship with self-rated health, mobility, self-care difficulties, and limited social activity [23–25].

The objective of this study is to explore the following: (1) how disability is divided by the trajectory method in relation to time-sequenced data in a longitudinal cohort, (2) whether the demographic and geriatric conditions differ among the trajectory groups, and (3) whether home time, a patient-centered outcome, is differentiated by the trajectory groups.

2. Methods

2.1. Study Design and Sample

Records from the Aging Study of Pyeongchang Rural Area (ASPRA) were analyzed. This population-based, prospective cohort study has been established to analyze aging-related changes and major health outcomes of the older population as part of an academic-public health collaborative model. The details of this study are described elsewhere [26]. To summarize, older Korean adults in Pyeongchang-gun, who met the required criteria, were enrolled beginning in November 2014. The inclusion criteria of the ASPRA cohort included: (1) being aged ≥ 65 years; (2) being registered in the National Healthcare Service; (3) being ambulatory with or without an assistive device; (4) living at home; and (5) being able to provide informed consent. Those who were living in a nursing home, hospitalized, or bed-ridden and receiving nursing-home-level care at the time of enrollment were excluded [26]. The cohort had a participation rate of more than 90%. A baseline study on the ASPRA population showed that demographic characteristics in this population were in accordance with those of nationwide rural-dwelling older adults [26]. The Institutional Review board of Asan Medical Center, Seoul, Korea, approved the protocol for this study (IRB No. 2014 – 0988).

Of the 1,355 participants who received usual care in public health settings, those participants who had a follow-up period of less than three years were excluded. Among individuals, 233 people were excluded because the follow-up period was less than three years. By then, 336 people dropped out due to either medical reasons ($n = 170$) or follow-up loss ($n = 166$). Among the medical reasons, 35 people had died, 103 people were admitted to nursing homes, and 32 people moved out due to health problems. Of the 166 people with follow-up loss, 53 people moved out due to other problems, 89 people declined to participate, and 24 people had lost contact. Finally, 786

participants who completed routine measurements for three years were analyzed in this study (Fig. 1). For participants with a follow-up period longer than three years, the baseline point was defined as the first measurement after enrollment.

*Among the 170 patients who dropped out for medical reasons, 35 patients (20.6%) had died, 103 patients (60.6%) were admitted to nursing homes due to deterioration of health, and 32 patients (18.8%) had moved or were withdrawn due to health problems.

** Among the 166 patients who dropped out due to loss to follow-up, 53 patients (31.9%) moved due to other problems (except for health), 89 patients (53.6%) declined to participate, and 24 patients (14.5%) had lost contact.

2.2. Assessment of Disability

Trained nurses assessed disability and other geriatric conditions utilizing standardized instruments every year [7]. Disability was assessed according to a 7-item activity of daily living (ADL; bathing, continence, dressing, eating, toileting, transferring, and washing face and hands) [5, 27] or a 10-item instrumental activity of daily living (IADL; food preparation, household chores, going out short distance, grooming, handling finances, laundry, managing own medications, shopping, transportation, and using a telephone) [5, 28, 29]. Disability was defined as being dependent in more than one domain in ADL and IADL. The severity of disability was conventionally operationalized into three groups: no dependency (disabled domain: 0), mild disability (disabled domain: 1), and severe disability (disabled domain: 2 or more) [30, 31].

2.3. Assessment of Geriatric Conditions

Baseline demographic factors (e.g., age, gender, education year, living alone, and medical aid) of participants were further examined. Physician-diagnosed chronic diseases, including angina, arthritis, asthma, cancer, chronic lung disease, heart failure, diabetes mellitus, heart attack, hypertension, kidney disease, and stroke were identified [5]. Cognitive function was assessed by the Korean version of the Mini Mental State Examination-Dementia Screening [MMSE-DS; ranged from 0 (no problem) to 30 (severe cognitive impairment)] [32]. Mood status was examined by the Korean version of the center for Epidemiological Studies Depression scale [CES-D; ranged from 0 (not depressed) to 60 (severely depressed)] [33]. Nutritional status was assessed by a Mini Nutritional Assessment-Short Form [MNA-SF; ranged from 0 (malnutrition) to 14 (well-nourished)] [34]. Physical function were measured using Short Physical Performance Battery [SPPB; ranged from 0 (worst performance) to 12 (best performance)] that covered chair stand, standing balance, and gait speed [35, 36]. The Korean version of 5-item frail scale was administered to screen frailty status [37]. Participants were interviewed concerning their history of falls in the past year.

2.4. Calculation of Home Time

Registered nurses assessed the participants' hospital use, visits to the emergency room, and institutionalization period every three months. Home time was calculated to be 365 days excluding the dates sent from the hospital and healthcare facilities [23, 24].

2.5. Statistical Analysis

To identify differences in home time among groups, a one-way analysis of variance (ANOVA) test was utilized in home time which is a numeric variable. Regarding the categorical variables within the study, the difference among the variables was examined by employing a chi-square test. In order to examine the statistical association between

home time and disability, a Poisson regression model was applied. The variables of age and gender were adjusted. In the conventional group, the year of measure was additionally adjusted.

Based on the discrepancy of the results, separate trajectories were identified according to the severity of disability using the Proc Traj procedure in SAS 9.4 [38]. The groups were divided according to the following criteria: (a) the lowest value in Bayesian Information Criteria (BIC), (b) the average posterior probability of group assignment (≥ 0.7), and (c) group size such that no less than 5% of the study sample were assigned to one trajectory group [39]. These analyses were performed with the 3.5.3 version in R. Two-sided P values of $< .05$ was considered statistically significant.

3. Results

3.1. Disability Trajectories

Three trajectory groups were defined according to the degree of disability by the number of impaired domains from the 1st year to 3rd year (Fig. 2). The model with three trajectory groups was the best fit for our data based on BIC, considering the proportions of each group (see Table S1 on Additional file 1). The average posterior probability was assigned to each group ($p = 0.9, 0.82, \text{ and } 0.96$, respectively) [39].

The 'relatively-stable group' (78.5%; $n = 617$) was characterized by the lowest levels of disability. The 'gradually-aggravated group' (16.0%; $n = 126$) was characterized by slightly increasing levels of disability over time. The remaining 5.5% of the population ($n = 43$) with high baseline disability that was also rapidly aggravating disability over time was categorized as the 'Rapidly-deteriorated' group (Fig. 2) [40].

3.2. Comparisons of Characteristics Between Trajectory Groups

Baseline demographic factors of participants including age, gender, education year, living alone (or not), and medical aid (or not) were examined according to the trajectory groups of disability (Table 1). Geriatric conditions including the number of comorbidities, MMSE-DS, the number of regular medications, FRAIL scale, SPPB score, CES-D score, MNA-SF score, and the number of falls were included.

Table 1
Demographic characteristics and geriatric conditions by trajectory group.

Variable	Relatively-stable group (n = 617)	Gradually-aggravated group (n = 126)	Rapidly-deteriorated group (n = 43)	Total (n = 786)	P value*
Demographic characteristics					
Age mean (SD)	72.1 (4.9)	76.6 (5.9)	81.1 (6.6)	73.3 (5.8)	< .001
Gender female no. (%)	278 (45.1%)	103 (81.8%)	33 (76.7%)	414 (52.7%)	< .001
Education year mean (SD)	5.5 (3.5)	3.9 (2.1)	3.4 (1.2)	5.2 (3.3)	< .001
Living alone no. (%)	95 (15.4%)	19 (15.1%)	10 (23.3%)	124 (15.8%)	0.382
Medical aid no. (%)	16 (2.6%)	2 (1.6%)	5 (11.6%)	23 (2.9%)	0.001
Severity of disability					
The number of ADL domains, mean (SD)					
1st year	0.1 (0.2)	0.3 (0.5)	1.3 (1.7)	0.2 (0.6)	< .001
3rd year	0.2 (0.4)	0.6 (0.8)	2.5 (1.8)	0.4 (0.8)	< .001
The number of IADL domains, mean (SD)					
1st year	0.2 (0.5)	1.7 (1.8)	4.4 (2.8)	0.7 (1.5)	< .001
3rd year	0.3 (0.6)	2.6 (1.8)	7.9 (1.9)	1.0 (2.1)	< .001
Geriatric conditions					
The number of comorbidities, mean (SD)					
1st year	1.1 (1.0)	1.6 (1.0)	2.0 (1.2)	1.3 (1.0)	< .001
3rd year	1.6 (1.1)	2.1 (1.1)	2.4 (1.2)	1.7 (1.2)	< .001
SPPB score, mean (SD)					
1st year	9.5 (2.2)	6.8 (2.9)	3.3 (2.4)	8.8 (2.8)	< .001

* The P value given in the table uses a chi-square test and the other variables used within the one-way ANOVA

Variable	Relatively-stable group (n = 617)	Gradually-aggravated group (n = 126)	Rapidly-deteriorated group (n = 43)	Total (n = 786)	P value*
3rd year	10.2 (2.0)	7.4 (3.2)	3.1 (2.2)	9.3 (2.9)	< .001
MMSE-DS score, mean (SD)					
1st year	26.5 (3.4)	23.6 (4.0)	20.4 (4.7)	25.7 (3.9)	< .001
3rd year	26.1 (3.3)	21.9 (5.1)	18.1 (5.0)	25.0 (4.4)	< .001
CES-D score, mean (SD)					
1st year	5.4 (7.0)	11.8 (11)	13.4 (12.6)	6.8 (8.6)	< .001
3rd year	4.9 (6.8)	12.7 (12.5)	17.5 (12.1)	6.8 (9.1)	< .001
MNA-SF score, mean (SD)					
1st year	12.3 (1.8)	11.2 (2.2)	10.6 (2.0)	12 (1.9)	< .001
3rd year	12.5 (1.7)	11.5 (2.0)	10.5 (2.5)	12.2 (1.9)	< .001
The number of regular medications, mean (SD)					
1st year	2.2 (2.4)	3.5 (2.9)	4.4 (3.8)	2.6 (2.6)	< .001
3rd year	2.4 (2.3)	3.0 (2.5)	4.4 (3.8)	2.6 (2.5)	0.001
FRAIL scale, mean (SD)					
1st year	0.9 (1.0)	2.1 (1.1)	2.5 (1.0)	1.2 (1.2)	< .001
3rd year	1.0 (1.1)	2.2 (1.1)	2.7 (0.8)	1.3 (1.2)	< .001
The number of falls (for 12 months), mean (SD)					
1st year	0.1 (0.6)	0.3 (0.7)	0.8 (2.0)	0.2 (0.8)	0.047
3rd year	0.3 (1.7)	1.6 (8.4)	3 (12.9)	0.7 (4.8)	0.097
* The P value given in the table uses a chi-square test and the other variables used within the one-way ANOVA					

Geriatric measurements differed significantly in the three groups except for living alone and the number of falls in the 3rd year. In the 1st year, the relatively-stable group had a mean age of 72.1 years, 45.1% were women, the mean

number of comorbidities was 1.1, the number of medications was 2.2, and the mean number of falls in the previous year was 0.1. In the rapidly-deteriorated group, mean age at 1st year was 81.1 years (which is almost nine years higher than the relatively-stable group), and 76.7% of the participants were women. This group had a mean number of 2.0 for comorbidities, 4.4 for those receiving regular medications, and 0.8 for the number of falls in the previous year.

In terms of physical performance, the SPPB score was 9.5 points in the relatively-stable group and 3.3 points in the rapidly-deteriorated group. In the 3rd year, the difference between the relatively-stable group and rapidly-deteriorated group was larger than that of the 1st year, increasing from 6.1 to 7.2, respectively.

Table 1. Demographic characteristics and geriatric conditions by trajectory group (417 lines).

3.3. Comparison of Home Time Between the Conventional Versus Trajectory-based Group

Home time decreased by an incremental degree in both the conventional and trajectory-based disability groups (Table 2). Compared to the 1st year, the trend of decreasing home time took place continuously in the 2nd and 3rd year.

In the 1st year, the home time of the severe group was shorter by 8.9 days (352.2 days-343.3 days) compared to the no dependency group by conventional grouping. In contrast, the rapidly-deteriorated group had 11.7 days less (351.6 days-339.9 days) home time than the relatively-stable group by trajectory-based grouping in the 1st year.

In the 3rd year, the home time of the severe group was shorter by 5.5 days (350.3 days-344.8 days) compared to the no dependency group by conventional grouping. By trajectory-based grouping, the rapidly-deteriorated group stayed 8.5 days less in their home than in the relatively-stable group (350.3 days-341.8 days, decrease 2.43%).

Table 2

Home time difference according to conventional versus trajectory-based grouping of disability.

Year	Conventional Disability Group				Trajectory-based Group			
	No dependency group (n = 518)	Mild-dependent group (n = 154)	Severe-dependent group (n = 114)	p value*	Relatively-stable group (n = 617)	Gradually-aggravated group (n = 126)	Rapidly-deteriorated group (n = 43)	p value*
Home time (days)**, mean (SD)								
1st year	352.2 (14.3)	348.0 (22.3)	343.3 (23.1)	< .001	351.6 (14.9)	346.0 (19.7)	339.9 (37.0)	0.003
2nd year	352.0 (14.1)	347.7 (22.2)	342.9 (22.8)	< .001	351.4 (14.7)	345.7 (19.5)	339.5 (36.4)	0.002
3rd year	350.3 (17.6)	348.2 (22.2)	344.8 (20.4)	0.025	350.3 (17.6)	345.5 (17.5)	341.8 (34.6)	0.009
* The p value given in the table uses the one-way ANOVA.								

3.4. Incidence Risk Ratio for Home Time According to Conventional Versus Trajectory-based Grouping of Disability

After recognizing the differences in home time decrements by definitions of disability phenotype (Table 2), regression models were employed to adjust for demographic factors including age and gender in these observations. Additionally, the year of measurement was adjusted in the conventional group since the trajectory-based definition already took into account time sequence. In the statistical model with the adjusted variables, significant differences of home time between the conventional based and trajectory-based definitions were observed in the univariate analysis (see Table S2 on Additional file 1).

The incidence risk ratio (IRR) for home time in the conventional groups and trajectory groups is shown in Fig. 3. Home time in the mild dependent group (IRR = 0.993; 95% CI, 0.987–0.998) was shorter than the reference group (no dependency group) by conventional grouping. Similarly, the severe-dependent group had shorter home time (IRR = 0.985; 95% CI, 0.978–0.992) compared with the no dependency group.

In the trajectory-based group, the home time of the gradually-aggravated group was shorter (IRR = 0.991; 95% CI, 0.985–0.998) compared to the relatively-stable group. Similarly, the rapidly-deteriorated group had shorter home time (IRR = 0.978; 95% CI, 0.967–0.988) compared to the relatively-stable group.

*The analysis of the trajectory group was adjusted for gender and age. The conventional group was additionally adjusted for the year of measurement.

** The reference value of the conventional group is the 'no dependency group' and the reference value of the trajectory group is the 'relatively-stable group'

4. Discussion

Disability is a major determinant of quality of life in older adults. In the present study, different trajectory groups were categorized according to the severity of disability over time. The conventional method of identifying disability shows only a snapshot of disability status and individual disability components. Therefore, the trajectory groups of disability that we identified demonstrated a more integrated approach toward defining disability.

The major finding of this study is that three trajectory groups with different severities of disability were confirmed in community-dwelling older adults. The three trajectory groups were divided into the following: a relatively-stable group (78.5%), a gradually-aggravated group (16.0%), and a rapidly-deteriorated group (5.5%). Previous studies had shown trajectory grouping using the number of disabilities in patients with underlying diseases such as cancer. In a study with cancer patients, the percentage of the severe trajectory group was 21.2% prior to receiving cancer treatment [41]. Our study is unique in that we show the percentage of the severe disability group (rapidly-deteriorated group) to be around 5.5% in relatively healthy older adults living in rural communities. Our data may serve as a basis for future reference in disability studies of the general older populations.

Another finding is that there were differences in the demographic characteristics and geriatric conditions among the different trajectory groups. Most of the variables of the demographic and geriatric conditions were significantly different among the groups except for the number of falls and living alone status. We confirm that the age increased, and the years of education decreased from the relatively-stable to deteriorated group. What stands out

most from this study, is the change of SPPB. It is well known that SPPB is an important variable for older adults in addition to the FRAIL scale and MMSE-DS score [42]. Our results show that at the 3rd year, the SPPB score was 10.2 points (SD: 2.0) in the relatively-stable group and 3.1 points (SD: 2.2) in the rapidly-deteriorated (more severe) group. In addition to a statistical difference, the numerical difference shows that there was a difference of more than three times between the relatively-stable group and the rapidly-deteriorated group. From this result, we recommend that a comprehensive geriatric assessment in clinical settings, if available, should be performed in order to measure physical performance such as SPPB.

Furthermore, our study contributes to the literature by showing that the trajectory method can maximize the difference in home time compared to the conventional method. We showed that home time decreased more over time, as the disability type was severe at initial diagnosis and as the increasing levels of disability were rapid. In the 2nd and 3rd year follow-up, the decrease in home time was smaller than in the 1st year, but the home time of the trajectory groups were still reduced compared to the conventional groups, and this difference was statistically significant. We found that the trajectory method decreased 3.33% in the rapidly-deteriorated group compared to the stable group. In the conventional case, the severe-dependent group decreased by 2.53% compared to the non-dependent group.

The strengths of this study are that the enrollment rate was 90% and based on an aging cohort derived from an academic-public health collaborative model. We obtained consistent data based on internationally validated geriatric assessment tools and, therefore, reflect real world data. Although our data is based on rural communities where some proportions of individuals have low education and are engaged in agriculture, it is a population-based cohort and the sociodemographic characteristics were similar to those of the representative Korean national data.

This study has several limitations. Among the 1,122 eligible participants, 166 people (15%) were lost to follow-up. This may be a limitation in constructing the trajectory model; however, this 15% follow-up loss was over the three years of analysis. Therefore, loss to follow-up occurred around 5% per year, which is less than the general percentage of population migration. Second, there may be a recall bias in home time. The participants may not fully recall their hospital or emergency visits in the previous years. In order to overcome this limitation, we obtained information from Community Health Posts in Pyeonchang run by the National Healthcare Service for information if the participants were not fully aware of their hospital use in the past. Therefore, we attempted to minimize recall bias. Third, there was a relatively short term of follow-up. The cohort was a three-year follow-up study and, therefore, there is a need for individuals to be examined over longer periods of time.

5. Conclusions

A longitudinal trajectory method was used to apply the time trend of disability to community-dwelling older adults. We verify that the demographical and clinical indexes are different according to the trajectory grouping, and the significant effect of the trajectory method on home time was also examined. Our observations provide public health professionals and policy makers with valuable information in order to set priorities for policy making and interventions.

Abbreviations

ANOVA

Analysis of Variance; BIC:Bayesian information criterion; SPPB:Short Physical Performance Battery; ADL:Activity of Daily Living; IADL:Instrumental Activity of Daily Living; MMSE-DS:Mini Mental State Examination-Dementia Screening; CES-D:center for Epidemiological Studies Depression scale; MNA-SF:Mini Nutritional Assessment-Short Form; ASPRA:Aging Study of Pyeongchang Rural Area

Declarations

Acknowledgments: We are indebted to the public health professionals and nurses of PyeongChang County Hospital, Public Health Center, and Community Health Posts for their administrative support and efforts in enrollment and measurements.

Funding: The Aging Study of PyeongChang Rural Area was supported by PyeongChang County Hospital, Gangwon Province. This study was supported by the Foundational Technology Development Program (NRF - 2019M3E5D4064682) the Ministry of Science and ICT, Republic of Korea. This study was also supported by the Social Service R&D Project funded by the Ministry of Health and Welfare, Republic of Korea through the Korea Health Industry Institute (Grant number: HI18C2400). This study was also supported by a philanthropic fund donated by The Herald through Asan Institute for Life Sciences and Corporate Relations of Asan Medical Center, Seoul, Korea.

Author Contributions: IY Jang, YR Park, HR Kim, HY Lee: study concept and design, data analysis, data interpretation, drafting, revision of manuscript; YJ Seong: study concept and design, data analysis, data interpretation; HW Jung, E Lee: data interpretation, revision of manuscript. All of the authors contributed to and approved the final manuscript.

Conflicts of Interest: The authors have no potential conflicts of interest to disclose.

Availability of data and materials: The datasets used are available from the corresponding author on reasonable request.

Sponsor's Role: Public health professionals and nurses of PyeongChang County Hospital participated in data collection. Otherwise, sponsors did not have any role in study design; analysis and interpretation of data; in the writing of the article; and in the decision to submit the article for publication.

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Figures

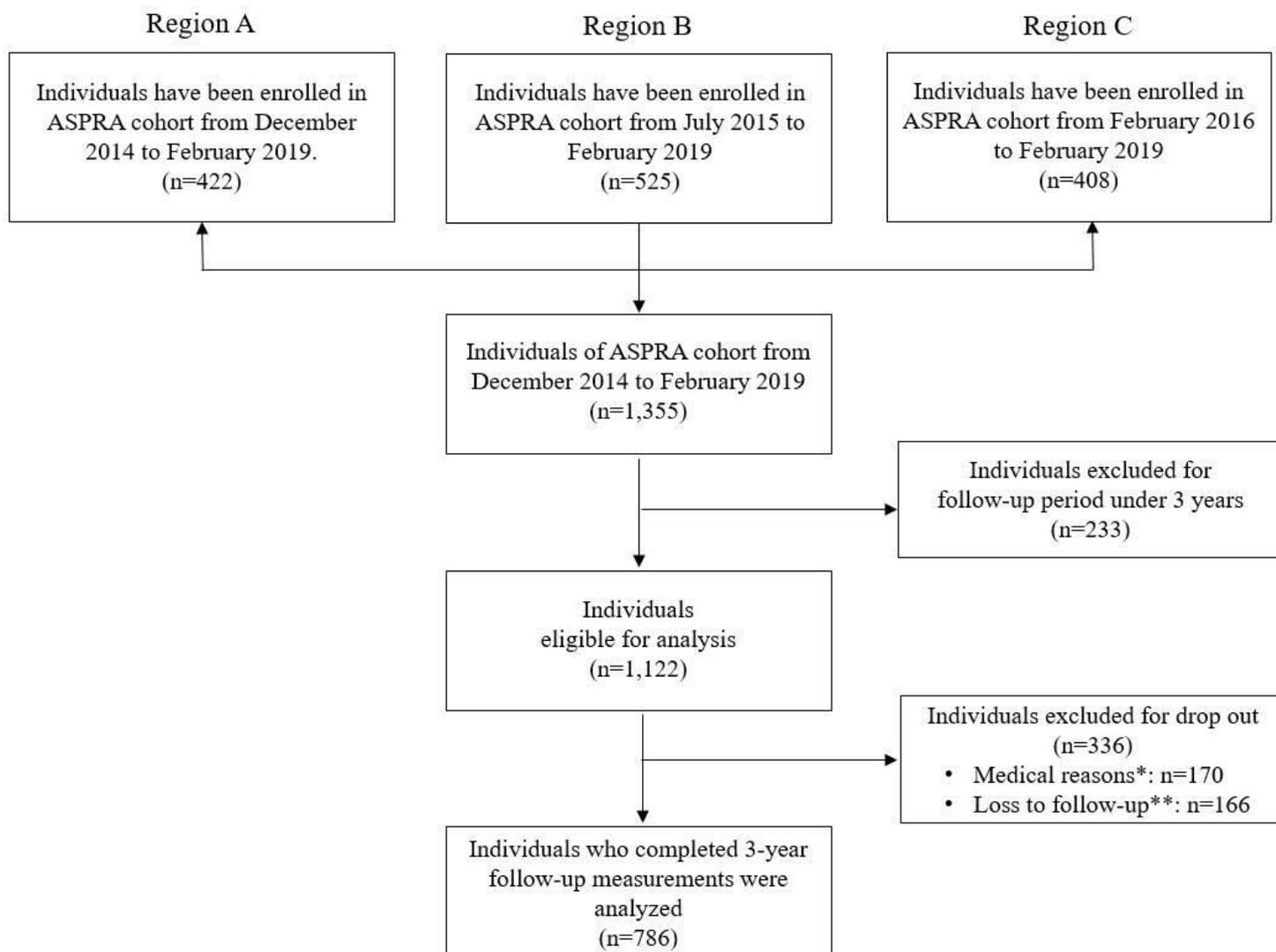


Figure 1

Patient selection flow.

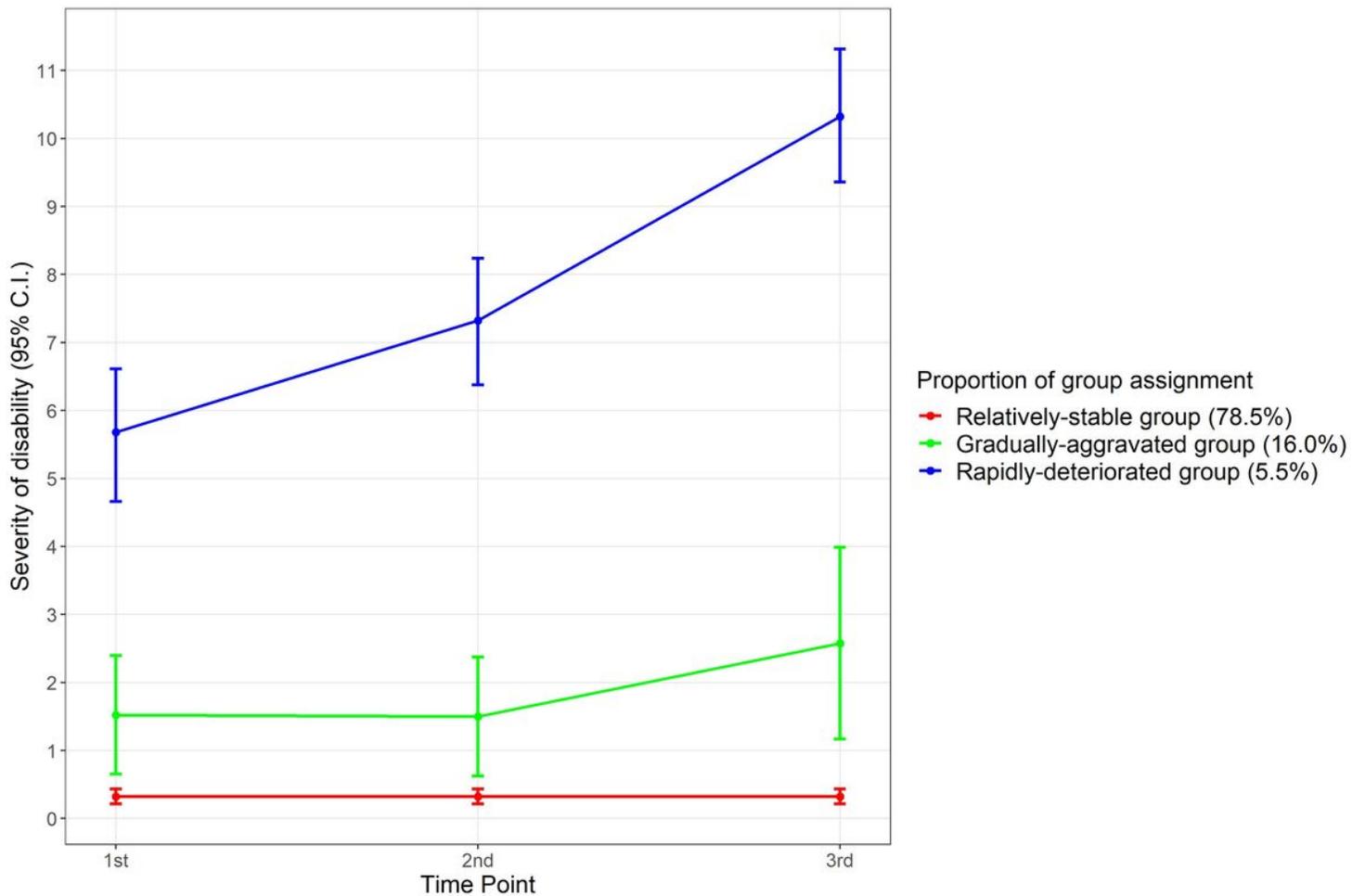


Figure 2

Trajectory group of disability over time (with 95% C.I., for 3-years).

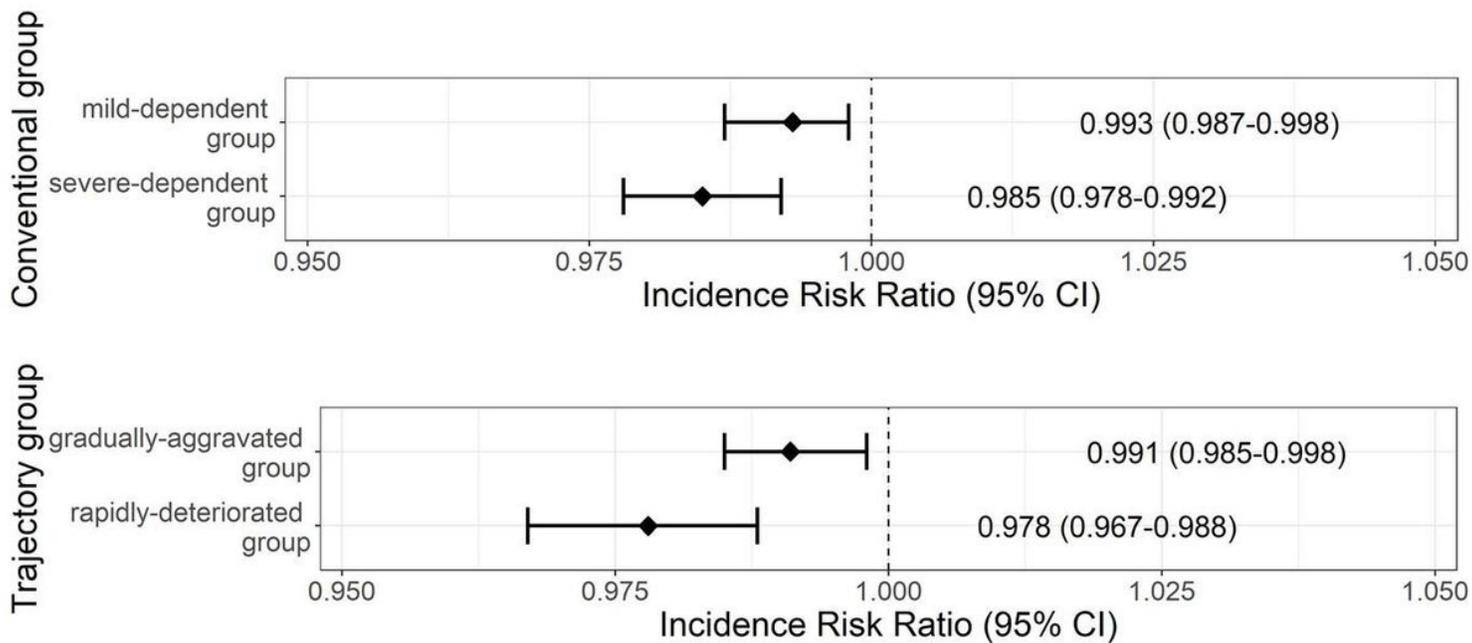


Figure 3

Forest plot of the incidence risk ratio for conventional versus trajectory group of disability.

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