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Trajectories of mobility limitations over 24 years and their characterization by shift work and leisure time physical activity in midlife

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Abstract:

Background: We aimed to investigate trajectories of mobility limitations (MLs) over a period of 24 years. In addition, we aimed to study how shift work and leisure-time physical activity (LTPA) in midlife predict assignment to MLs trajectories separately for those retired on statutory pensions (SP) and on disability pensions (DP).

Methods: Subjects who responded MLs questionnaires (1985-2009, N=3048) in Finnish Longitudinal Study on Aging Municipal Employees (FLAME) were included in this prospective cohort study. LTPA and shift work was measured during baseline. International Classification of Functioning was used to code MLs. Growth mixture modeling was used to identify the trajectories of MLs. Odds ratio (OR) and their 95% Confidence Interval (CI) were assessed by using multinomial logistic regression.

Results: We identified four trajectories of MLs, namely low persistent, low increasing, high decreasing and high persistent. Among the SP recipients, shift work with night shifts was associated with an increased risk (adjusted OR 1.49; 95% CI 1.03–2.14) of belonging to the high persistent MLs trajectory. The inactive LTPA (SP: OR 5.99, 95% CI 3.39-10.58, DP: OR 6.81, 95% CI 2.52-18.43) was similarly associated with high persistent MLs trajectory.

Conclusions: Nearly two-thirds of the people retired due to disability belonged to high MLs trajectory. High persistent MLs trajectory was associated with physical inactivity in midlife among those retired on SP and on DP. Shift work with night shift predicted high persistent MLs in SP strata. Active involvement in LTPA during midlife could be beneficial to spend MLs free later life.

Keywords: Prospective study; Work Schedule; Physical activity; Mobility disability; Epidemiology

INTRODUCTION

Among people in old age, mobility limitations (MLs) are the most common cause of physical disablement [1, 2], which emerges due to the loss in equilibrium between demands of physical surroundings and physical competences of an individual [2–4]. MLs are associated with disruption of quality of life among older adults and predict all-cause mortality [5]. In this era of population aging, MLs are becoming a major public health issue due to their higher impact on elevating dependency ratio and the proportion of health care use [1, 5, 6].

Numerous risk factors of MLs in later life start to accumulate early from midlife. These include behavioral, environmental, lifestyle-related and socio-economic factors [2, 6–8], but little is known about the link between work history, work-related exposures in midlife and their association with MLs in later life. The study of the role of work-related factors in midlife in the progression of MLs in later life is fundamental due to the significant role of the work history in the disablement process [9]. Physically demanding work with vigorous occupational physical activity in midlife increases the risk of MLs in later life [10], whereas, lower level of work-related stress [11] and better workability [12] in midlife were found to be protective to MLs in later life.

Furthermore, shift work is gradually being documented as a risk factor for sleep disturbances and several chronic diseases [13-15], as well as all-cause mortality [16]. Shift workers have mostly similar leisure-time physical activity patterns as day workers, but findings on occupational physical activity differ [17]. Lack of leisure-time physical activity (LTPA) is a potential risk factor of MLs [10] and later life physical disabilities [18, 19]. The declining LTPA or persistent inactivity significantly contributed as one of the factors of trajectories of unhealthy behavior that predicted the high risk of disability in Whitehall-II cohort study [20]. Shift work [21-23] and sleep disturbances [24] predict musculoskeletal disorders and pain in different body sites, but we are not aware of earlier longitudinal studies examining the link between shift work and MLs. Here, we investigated the trajectories of development of MLs using a longitudinal study of Finnish municipal employees separately for those retired in statutory pension (SP) and disability pension (DP). In addition, we aimed to describe the association of LTPA and Shift work with different trajectories of MLs over the time.

METHODS

Participants and design

This prospective cohort study is based on the Finnish Longitudinal Study on Aging Municipal Employees (FLAME). With a response rate of 85.2% altogether 6,257 public sector employees, aged 44-58 years responded the baseline survey in 1981. Follow up data were collected in 1985(n=5556), 1992(n=4534), 1997 (n=3815) and in 2009 (n=3093) [12]. We used four waves 1985-2009 in the present study due to lack of MLs related questionnaires in 1981 and regarded 1985 as baseline. We studied those who replied to the MLs items in baseline, the last follow-up and in at least one of the intervening follow-ups that finalized the inclusion of 3048 subjects in the present analysis. The follow-up process of respondents is described in detail in **Supplement Figure 1.** The FLAME data was linked to mortality register using the unique personal identification number to obtain mortality data. According to the linked data, 33.2% of the baseline respondents had died during the 28-year follow-up period. Those who were deceased during the follow-up were mostly men, blue-collar workers, regular smokers, high alcohol consumers, subjects with high BMI and were diagnosed with chronic diseases compared to the respondents with data on MLs trajectory. The ethics committee of the Finnish Institute of Occupational Health approved the FLAME study and the national Data Protection Ombudsman provided the ethical clearance for the register linkage.

Mobility Limitation

The assessment of Mobility Limitations (MLs) was done by using self-reported questionnaires distributed among the participants in 1985, 1992, 1997 and 2009. The 'mobility' domain (*d4*) on component *d* termed as 'activities and participation' of the International Classification of Functioning, Disability, and Health (ICF) was used to code nine items included in the outcome variable MLs [25]. The domain *d4* is comprised of four main categories, which are changing and maintaining body position (*d410–d429*), carrying moving, and handling objects (*d430–d449*), walking (*d450*) and moving around (*d455*). We used the nine items of the survey questionnaire on physical functioning to cover these categories of ICF, which are described in detail in **Supplement Table 1**. For the present analyses, all of the nine items were dichotomized (no difficulty "0" Vs. at least some difficulty "1"). Then the dichotomized items were summed up to get a summary score "0–9" (score '0' represented no limitations in carrying out any of the 9 tasks and those who had at least some limitations in carrying out one or more of the 9 tasks scored '1–9' depending on the number of tasks entailing limitations) [10–12].

Work Schedule (Shift work)

The work schedule was requested using the question "Which time do you carry out your main work?" with the following response alternatives: fixed day work, fixed evening work, fixed night work, 2-shift work (day and evening), 3-shift work (day, evening and night) and other work schedules. The six responses were then categorized into three groups: "*day work*", "*shift work without night shifts*" (those in 2-shift work or in fixed evening work) and "*shift work with night shifts*" (those in 3-shift work or in fixed night works) [17]. The information on work schedules was used from the baseline of this study in 1985. After those surveys, almost 3/4th of the respondents continued the same work until their retirement, due to which we believe that the exposure level did not vary largely.

Type of Pension

The data on the type of pensions, date of award, and primary diagnosis for disability pension (DP) were obtained from the Finnish Centre for Pensions. The obtained data were cross-linked to the survey using the unique personal identification number. The statutory retirement age of the municipal employees was 63 years and all of our respondents were retired by July 2000. In this study, we categorized retirement in two groups: Statutory pension (SP, i.e., old-age pension, part-time, early voluntary and others) and Disability pension (DP, i.e., retirement due to a medically confirmed illness before the statutory retirement age). [12]

Leisure-time Physical Activity (LTPA)

Information on LTPA was obtained from baseline using a self-reported questionnaire about the average involvement of respondents in LTPA during the previous year. LTPA was based on five responses ("0: brisk exercise at least twice a week", "1: brisk exercise at least once a week", "2: some form of exercise once a week", "3: some form of exercise less than once a week" or "4: not engaging in exercise"). In this study we categorized LTPA in three groups (vigorous: 0–1; moderate: 2–3; and inactive: 4) [10].

Covariates: Supplement Text 1

Statistical analysis

Growth Mixture Modeling (GMM) was used to detect the developmental pathways of MLs between the study waves during the follow-up. GMM is a method that identifies within the data, the multiple latent classes that tend to have a similar development over time [26]. We fitted the GMM with two to Six classes and selected the best-fitted model. The selection of the best-fitted model was based on numerous criteria namely: Bayesian Information Criterion (BIC), Akaike Information Criterion (AIC), substantive interpretability of classes, parsimony, entropy, posterior probability and relevance [26, 27]. The fit indices are presented in detail in **Supplement Table 2**. Although a five-class model had a lower BIC value, two different classes from the Five-class model displayed similar development patterns. Therefore, we favored the Four-class model that had the distinct development patterns of all the four classes, higher entropy, and higher average posterior probability. In addition, there was a sparse difference on BIC values of four and five class models. The four-class model gave us the latent classes that represent Low persistent MLs, Low increasing MLs, High decreasing MLs and High persistent MLs respectively.

The difference in descriptive characteristics of the subjects in different categories were tabulated according to trajectories of MLs with a significance level of $p<0.05$. Multinomial logistic regression was used to calculate the odds ratios (OR) and their 95% confidence intervals (CI) for trajectory group memberships according to the categories of shift work and LTPA. Two models were fitted; model I: adjusted for age and model II: further adjusted for gender, occupational groups, smoking status, alcohol intake, BMI and chronic diseases (CVD, MSD, COPD and neurological disease). The selections of the models were based on maximum likelihood. In order to account for potential bias due to dropout, we conducted a GMM for overall respondents (as a sensitivity analysis), from 1985-2009 (N=5536) which gave us similar trajectory shapes, so the results for selected respondents are presented (N=3048). GMM was done in Mplus version 7.11(Muthen & Muthen, 3463 Stoner Ave., Los Angeles, CA) and other analyses were done in STATA 14.0 (StataCorp LP, College Station, Texas 77845, USA).

RESULTS

The baseline characteristics stratified by type of retirement and their proportions in each of the four trajectories of MLs are described in detail in **Table 1.** Of the 3048 participants, 65% were retired on SP and 35% on DP. The mean age at baseline was 53.6 years (SD 3.4) and 63% of the respondents were women. The proportion of day work, shift work without night shifts and shift work with night shifts was 68%, 15%, and 17% respectively. Likewise, 37% of the respondents were vigorously involved in LTPA, 47% were moderately involved and 16% were physically inactive. The four trajectories for development of MLs over the follow-up period are shown in shown in **Figure 1** (SP) and **Figure 2** (DP) and for overall respondents in **Supplement Figure 2**. Among the respondents on SP, one third belonged to the high persistent, nearly another third to the low increasing (31%), almost one fourth to the low persistent (24%) and 12% to the high decreasing trajectory of MLs. Among the respondents on DP, the largest proportion (65%) of participants belonged to the high persistent followed by the low increasing (16%), high decreasing (12%) and low persistent trajectory (7%) of MLs.

(Table 1, Figure 1 and Figure 2 about here)

The association of shift work and LTPA with MLs trajectory membership separately for SP and DP are presented in **Table 2**. In case of smaller sample sizes, especially in DP strata, the effect size was taken into consideration instead of observed power. Among the respondents on SP, in a fully adjusted model, adjusted for gender, smoking status, alcohol intake, BMI, occupational status and chronic diseases (model II), moderate LTPA characterized the increased risk of belonging to the low increasing and inactive LTPA characterized high persistent MLs trajectory relative to low persistent MLs trajectory. Furthermore, the risk of belonging to the high persistent MLs trajectory was higher among those in shift work with night shifts (OR 1.49; 95% CI 1.03–2.14) and those who were physically inactive (5.99; 3.39–10.58).

Among the respondents on DP, in the fully adjusted model (model II), those with moderate LTPA (2.29; 1.29–4.08) and the physically inactive (6.81; 2.52–18.43) in midlife had an increased risk of belonging to the high persistent MLs trajectory.

(Table 2 about here)

DISCUSSION

In this prospective study, we found that most of the people on SP belonged to low persistent MLs trajectory. The proportion of high persistent MLs trajectory was higher among those retired on DP. However, we observed an equal proportion of people who had a rapidly decreasing MLs trajectory alleviating towards null during their old age in both groups (SP and DP). The robust predictors of high persistent MLs were shift work with night shift in the SP group and being physically inactive in midlife in both groups.

The comparison with the existing literature suggests that most of our results and findings are plausible. We found that there was a slight decrease in MLs among those in both DP and SP strata from 1992 to 1997, which could be the temporary effect of the relief from the shift work and increase in LTPA, as it was the phase of transition to retirement [28]. We found that shift work without night shifts was not associated with high persistent MLs trajectory, which could be explained by the selection. Since, among workers in the health and social care sector, changing from shift work with night shifts to day work and shift work without night shifts is common [29]. However, we are not aware regarding the flexibility of our subjects to choose their work-shifts during the study period. We found that shift work with night shifts possess a high risk for all classes of MLs including a substantial prediction of high persistent MLs trajectory, which is apparently in line with some of the previous studies that have reported shift work as a predictor of musculoskeletal disorders and pain in different body sites [21-23, 30]. This could be plausible because one could consider MLs as a late phase of musculoskeletal disorders and diseases in different body sites [3, 4]. Epidemiological evidence on the association of shift work with adverse chronic health outcomes are inconsistent [31, 32] with fluctuating trends in findings. Nonetheless, different shift work effects are reported across most of the occupational sectors [33], which is generalizable to our respondents who were public sector employees actively involved in different occupations.

We found that being physically inactive in midlife was highly predictive of high persistent MLs in later life among the subjects in both strata. This finding is in line with an earlier finding from the same cohort by Hinrichs, et al. (2014) that reported protective effects of vigorous LTPA [10] and the findings by Leino-Arjas et al. (2004) that reported being involved in higher LTPA assures better walkability [34]. Earlier findings from the Whitehall II cohort study reported high disability risk among inactive study subjects [20]. Furthermore, sustained physical activity from moderate to active level in midlife was significantly associated with decreased disability among a cohort followed for 20 years [18] and another followed up for 2 years [19], which is in line with our findings among the people on SP, but there was a minor dissimilarity in the construction of outcome variable. Findings from our study reveal the same level of risk of high persistent MLs characterized by inactive and moderate LTPA among the people in both pension schemes, but being physically inactive in leisure time was significantly associated with low increasing and high decreasing MLs among people on SP only. These findings support the idea that after retiring in DP, there is a chance of constantly higher MLs rather than increasing and decreasing and we could see that around one-third of our subjects in DP fall under high persistent trajectory of MLs.

Although LTPA and shift work was associated with MLs, various other factors play the role in limiting the physical functions in old age [35, 36]. For instance, there was a chance that disability pension determining diagnoses were likely to drive the higher MLs. In order to minimize this bias demographic, socio-economic, lifestyle and health-related characteristics have been used as explanatory factors in our study, which attenuated the associations marginally. In addition, the assumption was that those with high MLs scores tend to have more attrition and lost to follow up.

Long prospective follow-up along with being representative of largest municipal occupations illustrates the major strength of our study. According to our awareness of literature, our study is the first to examine the trajectories of MLs and their association with LTPA and shift work separately and jointly. The constantly high response rate in all waves by those who were alive added a significant strength to our study. One can consider some of the limitations of this study while inferring the findings. LTPA and items used in MLs were self-reported and thus possibly subject to the information and recall bias, and could have led to over-estimated LTPA levels [10, 37]. Future studies using an objective measure of LTPA are recommended to validate and replicate these findings. In addition, another shortcoming of our study is not to have included non-LTPA or other recreational physical activities. However, adjustment for occupational class possibly covers most of the non-LTPA. In order to construct MLs, we have used the classic ICF classification approach that has been validated and frequently used [10, 11], instead of refined ICF linking rules [38]. We recommend the use of refined ICF linking rules in the future studies. Likewise, lack of complete information on sleep quality is other potential limitation of this study. Therefore, use of the sleep-related variable is warranted in future studies considering shift work as the exposure variable. The generalizability of the results to today's shift workers may suffer from the long follow-up time, due to the probable changes in the nature of some jobs with the advancement of technology. Nonetheless, most of our study subjects continued in the same occupations from the baseline until their retirement with no evident major changes [28]. The information on shift work was limited due to the lack of comprehensive information on working hour characteristics and their changes, so the inclusion of those along with the sleep insufficiency in further studies is warranted.

Conclusions

We found four trajectories of MLs in this longitudinal study of municipal employees namely, low persistent, low increasing, high decreasing and high persistent. Assignment to the high persistent MLs trajectory was predicted by moderate LTPA and physical inactivity among those retired on SP and on DP. Shift work with night shift predicted high persistent MLs in SP strata. Active involvement in LTPA during midlife could be beneficial to spend MLs free later life.

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CONFLICT OF INTEREST: The authors declare that they have no conflict of interest.

KEY POINTS:

- Four developmental pathways of mobility limitations (namely low persistent, low increasing, high decreasing and high persistent) were identified during a 24-year follow up
- Among the respondents retired on disability pensions around two third had high persistent mobility limitations
- Night shift workers in midlife can be at higher risk of persistent mobility limitations in old age compared to non-shifters
- Physical inactivity in leisure time during midlife predicted high mobility limitations in later life
- Identification and minimization of factors associated with mobility limitations could help to prevent early exit of workforce from labour market and induce better mobility in old age

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Table 1: Distribution of basic characteristics and exposures in four different trajectories of mobility limitations (MLs) stratified according to type of pensions, FLAME, 1985-2009

Basic-characteristics	N (3048)	Membership of trajectory of mobility limitations							
		Statutory Pension (SP) (%), n=1987				Disability Pension (DP) (%), n=1061			
		Low persistent (473)	Low increasing (612)	High decreasing (237)	High persistent (665)	Low persistent (71)	Low increasing (172)	High decreasing (129)	High persistent (689)
Age[a]	53.6±3.4	53.0±3.3	54.2±3.4	53.0±3.0	55.0±3.4	52.7±3.5	53.0±3.3	52.6±2.9	53.3±3.3
BMI[a]	25.3±3.2	24.2±2.6	24.9±2.8	24.9±3.2	26.1±3.3	24.1±3.2	24.9±2.9	25.1±2.8	26.1±3.5
Gender									
Women	1918	47	67	65	77	45	54	41	64
Men	1130	53	33	35	30	55	46	59	36
Occupational class									
White-collar	1747	66	67	59	58	62	64	43	42
Blue-collar	1301	34	33	41	42	38	36	57	58
Smoking- status									
None	1945	62	65	70	69	59	56	66	60
Former smokers	754	31	23	24	19	30	28	29	25
Current smokers	349	7	12	6	12	11	16	5	15
Alcohol intake									
None	2233	69	76	74	79	72	68	62	73
<2 drinks/months	570	22	17	20	15	21	20	26	20
≥1drink/week	227	9	7	6	6	7	12	12	7
Chronic diseases									
MSD	952	13	21	30	40	11	22	35	49
CVD	523	4	14	12	21	15	16	17	28
COPD	313	4	7	8	14	4	10	12	16
Neurological	342	4	9	12	11	14	15	17	16
Major-Exposures									
Shift work									
Day work	2076	66	65	63	58	81	84	81	76
SW without night shifts	461	19	15	15	18	13	7	7	14
SW with night shifts	511	15	20	22	24	6	9	12	10

LTPA									
Vigorous	1134	57	44	42	28	52	42	36	22
Moderate	1446	39	49	46	53	41	46	49	48
Inactive	468	4	7	12	19	7	12	15	30

Note FLAME, Finnish Longitudinal Study on Aging Municipal Employees; BMI, Body Mass Index; MSD, Musculoskeletal Diseases; CVD, Cardiovascular Diseases; COPD, Chronic Obstructive Pulmonary Disease; LTPA, Leisure Time Physical Activities; SW, Shift Work; [a]expressed as mean and SD (Standard Deviation)

Table 2: Odds ratio (OR) and their 95% confidence intervals (CI) for association of shift work and LTPA with mobility limitations (MLs) trajectories among the respondents retired on statutory pension (SP) and on disability pension (DP), FLAME, 1985-2009

MLs Trajectories[a]	Statutory Pension (SP)				Disability Pension (DP)			
	Model I		Model II		Model I		Model II	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Low increasing Vs. Low persistent								
Shift work								
Day work	1.0	Reference	1.0	Reference	1.0	Reference	1.0	Reference
SW without night shifts	0.88	0.63-1.22	0.80	0.56-1.15	0.54	0.22-1.36	0.49	0.19-1.27
SW with night shifts	1.44	1.03-2.00	1.09	0.76-1.56	1.56	0.49-4.91	1.24	0.38-4.03
LTPA								
Vigorous	1.0	Reference	1.0	Reference	1.0	Reference	1.0	Reference
Moderate	1.64	1.28-2.11	1.39	1.07-1.82	1.36	0.76-2.44	1.39	0.75-2.56
Inactive	2.20	1.24-3.89	1.94	0.99-3.22	1.98	0.69-5.71	1.91	0.65-5.61
High decreasing Vs. Low persistent								
Shift work								
Day work	1.0	Reference	1.0	Reference	1.0	Reference	1.0	Reference
SW without night shifts	0.83	0.54-1.29	0.68	0.43-1.09	0.55	0.21-1.46	0.44	0.15-1.24
SW with night shifts	1.57	1.04-2.34	1.34	0.87-2.08	2.05	0.65-6.48	2.33	0.71-7.70
LTPA								
Vigorous	1.0	Reference	1.0	Reference	1.0	Reference	1.0	Reference
Moderate	1.60	1.15-2.22	1.36	0.96-1.93	1.77	0.95-3.28	1.83	0.95-3.53
Inactive	4.14	2.22-7.73	3.28	1.72-6.23	3.29	1.12-9.63	2.80	0.93-8.48
High persistent Vs. Low persistent								
Shift Work								
Day work	1.0	Reference	1.0	Reference	1.0	Reference	1.0	Reference
SW without night shifts	1.24	0.90-1.70	0.98	0.68-1.42	1.20	0.57-2.51	0.73	0.32-1.66
SW with night shifts	2.03	1.47-2.80	1.49	1.03-2.14	2.09	0.73-5.94	1.46	0.49-4.40
LTPA								
Vigorous	1.0	Reference	1.0	Reference	1.0	Reference	1.0	Reference
Moderate	2.81	2.16-3.65	2.22	1.65-2.98	2.68	1.59-4.53	2.29	1.29-4.08
Inactive	9.34	5.36-15.77	5.99	3.39-10.58	9.80	3.75-25.56	6.81	2.52-18.43

Note LTPA, Leisure Time Physical Activity; SW, Shift Work; OR, Odds Ratio; CI, Confidence Interval; [a]low persistent trajectory group serve as base (outcome); Model I: Age adjusted; Model II: Further adjusted for gender, occupational class, smoking status, alcohol intake, BMI (Body Mass Index) and chronic diseases

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Figure 1: Four different trajectories of mobility limitations (MLs) among the respondents retired on statutory pensions (SP), FLAME, 1985-2009

Figure 2: Four different trajectories of mobility limitations (MLs) among the respondents retired on disability pensions (DP), FLAME, 1985-2009

Figure 1.

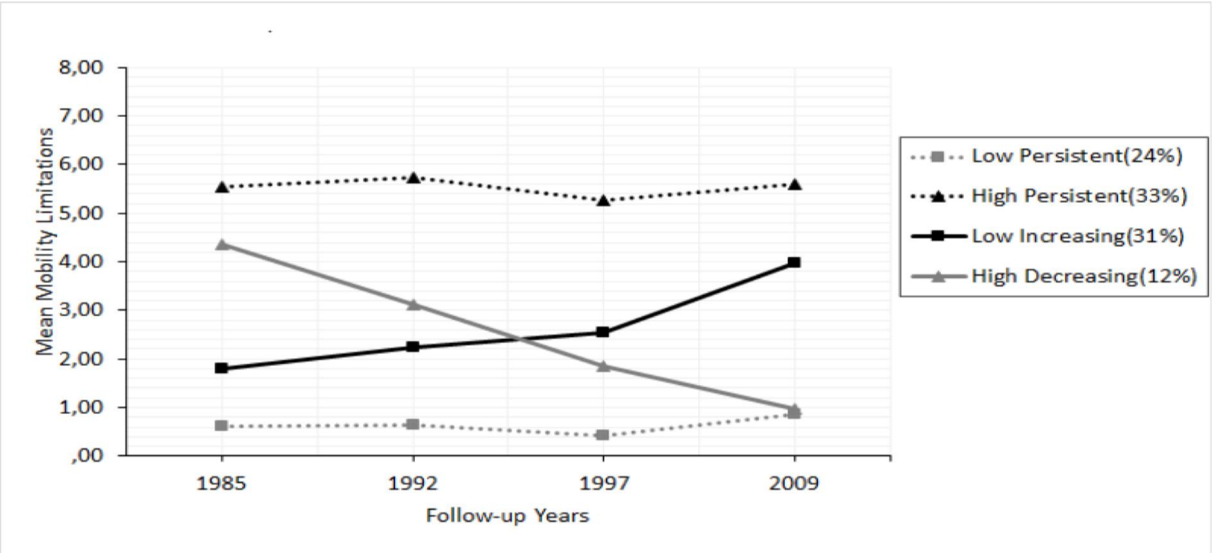

Figure 2.