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Polypharmacy including falls risk-increasing medications and subsequent falls in community-dwelling middle-aged and older adults

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Abstract

Background: polypharmacy is an important risk factor for falls, but recent studies suggest only when including medications associated with increasing the risk of falls.
Design: a prospective, population-based cohort study.
Subjects: 6,666 adults aged ≥50 years from The Irish Longitudinal study on Ageing.
Methods: participants reported regular medication use at baseline. Any subsequent falls, any injurious falls and the number of falls were reported 2 years later. The association between polypharmacy (>4 medications) or fall risk-increasing medications and subsequent falls or injurious falls was assessed using modified Poisson regression. The association with the number of falls was assessed using negative binomial regression.
Results: during follow-up, 231 falls per 1,000 person-years were reported. Polypharmacy including antidepressants was associated with a greater risk of any fall (adjusted relative risk (aRR) 1.28, 95% CI 1.06–1.54), of injurious falls (aRR 1.51, 95% CI 1.10–2.07) and a greater number of falls (adjusted incident rate ratio (aIRR) 1.60, 95% CI 1.19–2.15), but antidepressant use without polypharmacy and polypharmacy without antidepressants were not. The use of benzodiazepines was associated with injurious falls when coupled with polypharmacy (aRR 1.40, 95% CI 1.04–1.87), but was associated with a greater number of falls (aIRR 1.32, 95% CI 1.05–1.65), independent of polypharmacy. Other medications assessed, including antihypertensives, diuretics and antipsychotics, were not associated with outcomes.
Conclusion: in middle-aged and older adults, polypharmacy, including antidepressant or benzodiazepine use, was associated with injurious falls and a greater number of falls.

Keywords: *falls, older people, polypharmacy, drug therapy*

Introduction

Falls are common in the elderly with around 30% of community-dwelling older adults falling every year and around half of these experiencing multiple falls [1, 2]. Most falls in this age group result in injury ranging from more severe fractures and dislocations to less severe cuts and bruises [1, 3]. Falls are associated with increased rates of hospitalisation, institutionalisation, disability, fear of falling, decreased activity and poorer quality of life [4].

Risk factors for falling are complex and involve intrinsic and extrinsic factors [5]. Medications are modifiable extrinsic risk factors. Certain medication classes, including benzodiazepines, antidepressants, antipsychotics, antihypertensives and diuretics, have been consistently associated with increased falling risks in population-based studies [6, 7]. Polypharmacy is also an important risk factor for falling [8]. However, recent studies suggest that the association may not be significant when indications for the medicines are considered [9], and that polypharmacy

only poses a risk if it includes falls risk-increasing medications [10].

In a large, prospective cohort study of adults aged ≥50 years in Ireland, we investigated the interaction between polypharmacy and established medications associated with falling on the subsequent risk of any fall, of a greater number of falls and of injurious falls after adjusting for sociodemographics and co-morbidity.

Methods

Participants

Data were retrieved from the Irish Longitudinal study on Ageing (TILDA) which is representative of the community-dwelling older adults aged ≥50 years in Ireland. The sample and methods are described in detail elsewhere [11, 12]. In its first wave (September 2009–February 2011), TILDA recruited 8,175 individuals with participants completing an extensive in-home face-to-face computer-aided interview, self-completion questionnaire and nurse-conducted health assessment. Households were selected from a clustered sample of Irish residential addresses with an overall response rate of 62.0%. TILDA was approved by the Faculty of Health Sciences Research Ethics Committee of Trinity College Dublin. Participants with dementia or with a cognitive impairment severe enough to prevent consent (determined at the discretion of the interviewer) were not included in the study.

Fall outcomes

In TILDA's second wave (April–December 2012), 6,831 participants (201 had died and 1,111 dropped out) were re-interviewed and asked 'Have you fallen since your last interview?', 'How many times have you fallen since your last interview?' and 'Did you injure yourself seriously enough to need medical treatment?' (injurious fall). To improve falls data accuracy, we excluded participants with dementia ($n = 46$), institutionalised ($n = 20$), with missing baseline medication data ($n = 82$) or whose falls data were missing or provided by a proxy ($n = 49$), leaving 6,666 participants for analysis.

Baseline medications

Interviewers recorded all medications taken on a regular basis by viewing medication packages. Medications were assigned WHO Anatomic Therapeutic Chemical (ATC) classification codes [13]. Polypharmacy was defined as a regular use of five or more medicines (excluding dietary supplements) [14]. Falls risk-increasing medications were identified from previous systematic reviews and meta-analysis as antihypertensives (ATC C02, C07A, C08, C09A or C09C), diuretics (C03), antipsychotics (N05A), benzodiazepines (N05BA, N05CD or N05CF) and antidepressants (N06A) [6, 7].

Baseline health status

History of a diagnosis was reported for hypertension, angina, heart attack, heart failure, diabetes, transient ischaemic attack, high cholesterol, heart murmur, arrhythmia, stroke, other cardiovascular disease, cataracts, glaucoma, age-related macular degeneration, chronic lung disease, asthma, osteoporosis, cancer, arthritis, stomach ulcer, liver disease, varicose ulcer, Parkinson's disease, anxiety, depression or other psychological disorder (emotional problem, mood swings, hallucinations, schizophrenia or other). The number of health conditions reported from this list was recorded.

Disability was reported as any limitations in instrumental activities of daily living or activities of daily living. Participants self-reported pain (none, mild, moderate or severe), urinary incontinence in the past 12 months, sleep problems (trouble falling asleep most of the time), vision and hearing (excellent, very good, good, fair or poor) and any hospital admission in the last year. Falls-related history included falls in the last year, fractures (hip or wrist), blackouts or fainting. Cognition was assessed using the animal naming test, where participants were asked to name as many different animals as possible in 1 min. Depressive symptoms were assessed using the Centre for Epidemiologic Studies Depression Scale [15].

Approximately 40% of the Irish population are entitled to free health care through the public General Medical Services scheme. Eligibility is means tested and is available to those for whom medical expenses would cause undue hardship. Most of those aged over 70 years are eligible. The remaining population purchase private insurance plans, while many remain uninsured but caps exist on medical expenses.

Statistical analysis

We aimed to estimate the effect of (i) each falls risk-increasing medication class, (ii) polypharmacy and (iii) polypharmacy including each falls risk-increasing medication class, on each fall-rated outcome (faller, injurious falls and number of falls). We used separate regression models for each of these aims.

To estimate relative risks for both binary faller and injurious fall outcomes, which are more appropriate than odds ratios as the outcomes are not rare, we used modified Poisson regression which estimates robust standard errors for the 95% confidence intervals (CIs) [16]. We used negative binomial regression to calculate incident rate ratios and 95% CIs for the number of falls. The number of falls was capped at 5 due to concerns on the accuracy of reporting beyond this. Associations are provided unadjusted and adjusted for sociodemographics, days between interviews, self-reported co-morbidities and health-related variables, and fall-related variables.

For each of the regression models above, the interaction between polypharmacy and the falls risk-increasing medication class was tested. For medication classes with a statistically significant interaction for any falls outcome, the results of this interaction were reported for all falls outcomes. We also

estimated the adjusted falls risks for polypharmacy including all statistically significant falls risk-increasing medication classes.

To examine differential attrition, we used modified Poisson regression to estimate both the association between baseline polypharmacy and falls risk-increasing medication use and loss to follow-up (i.e. study dropout or proxy-reported or no falls data) and mortality by Wave 2 after adjusting for the potential covariates. Analyses were performed using Stata version 12.0. Significance at $P < 0.05$ is assumed.

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Results

Of the 6,666 eligible participants completing the falls questions at follow-up, 1,140 (17%) participants reported polypharmacy at baseline. The mean (SD) time between the baseline and second interview was 24.3 (2.8) months, range 15.9–36.8 months. A total of 1,455 (22%) participants reported falling during follow-up, reporting 3,113 falls in total (rate of 231 falls per 1,000 person-years) and 642 (10%) reported an injurious fall. Those who fell were more likely to be female, older, have more chronic diseases, disability, report moderate/severe chronic pain and a history of falls and/or fractures (Table 1). For example, 36% of those falling during follow-up had also fallen in the previous year.

Medication class and falls

Neither polypharmacy, nor the use of antihypertensives, diuretics or antipsychotics was associated with any falls outcomes after adjusting for the covariates (Table 2). Benzodiazepine use was associated with a greater number of falls in the next 2 years (adjusted incidence rate ratio (aIRR) 1.32, 95% CI 1.05–1.65), but the association did not reach statistical significance for the 'any falls' or 'injurious falls' outcomes. Antidepressant use was associated with a greater number of falls (aIRR 1.28, 95% CI 1.03–1.60) and risk of an injurious fall (adjusted rate ratio (aRR) 1.37, 95% CI 1.06–1.75). There was evidence of an association with the

Table 1. Baseline characteristics of participants reporting a fall by the second interview ($N = 6,666$)

Baseline characteristics	No falls ($n = 5,211$)		At least one fall ($n = 1,455$)		P[a]
	n	%	*n*	%	
Sociodemographics					
Age, mean (SD)	62.7	9.2	65.0	9.6	<0.001
Sex—women	2,732	52.4	884	60.8	<0.001
Higher education	1,602	30.7	473	32.5	0.18
Employed	2,099	40.3	450	30.9	<0.001
Household income <€20,000[b]	1,388	28.9	452	34.2	0.002
Lives alone	1,024	19.7	378	26.0	<0.001
Current smoker	892	17.1	243	16.7	0.71
Chronic disease					
Number of health conditions					<0.001
0	1,083	20.8	210	14.4	
1	1,446	27.7	292	20.1	
2	1,134	21.8	331	22.7	
3	739	14.2	231	15.9	
4	432	8.3	164	11.3	
5+	377	7.2	227	15.6	
Moderate/severe chronic pain	1,148	22.0	512	35.2	<0.001
Urinary incontinence	579	11.1	246	16.9	<0.001
Trouble falling asleep	1,715	32.9	610	41.9	<0.001
Depressive symptoms, median (IQR)[b]	3	1–7	4	1–10	<0.001
Disability (ADL or IADL)	447	8.6	262	18.0	<0.001
Fair/poor self-rated vision	425	8.2	157	10.8	0.002
Fair/poor self-rated hearing	694	13.3	238	16.4	0.003
Cognition, animal naming mean (SD)[a]	21.0	7.0	20.4	7.1	0.008
Health-care utilisation					
Public health-care coverage	2,341	44.9	780	53.6	<0.001
Hospital admission in past year	589	11.3	237	16.3	<0.001
Fall-related history					
Fall in the last year	752	14.4	520	35.7	<0.001
History of hip or wrist fracture	636	12.2	269	18.5	<0.001
History of fainting/blackouts	889	17.1	348	23.9	<0.001

ADL, activity of daily living; IADL, instrumental activity of daily living.

[a]χ^2 test for binary and ordinal variables, *t*-test for continuous variables, Mann–Whitney *U*-test for depressive symptoms.

[b]Missing data (number of participants): income (529), depressive symptoms (89) and cognition (26).

Table 2. Associations (with 95% CI) between polypharmacy, the regular use of high-risk medications and incident falls ($N = 6,666$)

Medication class	N	Any fall		Number of falls		Injurious fall	
		Crude RR	Adjusted RR[a]	Crude IRR	Adjusted IRR[a]	Crude RR	Adjusted RR[a]
Polypharmacy	1,140	1.54 (1.39–1.71)	1.01 (0.90–1.14)	1.94 (1.69–2.23)	1.10 (0.93–1.30)	1.70 (1.45–2.01)	1.02 (0.84–1.24)
Antihypertensives	2,112	1.16 (1.06–1.28)	0.91 (0.81–1.02)	1.24 (1.09–1.40)	0.92 (0.78–1.08)	1.19 (1.02–1.38)	0.89 (0.73–1.07)
Diuretics	538	1.40 (1.22–1.61)	1.06 (0.92–1.23)	1.45 (1.19–1.77)	1.07 (0.87–1.31)	1.42 (1.12–1.78)	0.96 (0.75–1.23)
Antipsychotics	81	1.02 (0.68–1.53)	0.71 (0.49–1.02)	1.15 (0.69–1.94)	0.58 (0.34–1.01)	1.42 (0.81–2.47)	0.88 (0.51–1.47)
Benzodiazepines	366	1.72 (1.49–1.98)	1.14 (0.98–1.34)	2.10 (1.68–2.64)	1.32 (1.05–1.65)	2.01 (1.59–2.52)	1.24 (0.97–1.58)
Antidepressants	422	1.66 (1.45–1.91)	1.16 (0.99–1.35)	2.18 (1.77–2.69)	1.28 (1.03–1.60)	1.96 (1.57–2.44)	1.37 (1.06–1.75)

RR, relative risk; IRR, incident rate ratio.

[a]Adjusted for baseline covariates: age, sex, living alone, education, employment status, income, smoking status, time between interviews, co-morbidities (listed in text), incontinence, pain, sleep problems, depressive symptoms, cognition, self-rated vision, self-rated hearing, disability, public health-care coverage, history of falls, fracture, fainting and hospitalisation.

Table 3. Multivariate[a] associations (95% CI) between polypharmacy, including and excluding benzodiazepines or antidepressants, and incident falls ($N = 6,666$)

Medications	n	Any fall RR (95% CI)	Number of falls IRR (95% CI)	Injurious fall RR (95% CI)
No BZD, no polypharmacy	5,368	1.00	1.00	1.00
No BZD, polypharmacy	932	1.00 (0.88–1.14)	1.09 (0.91–1.30)	0.91 (0.73–1.13)
BZD, no polypharmacy	158	1.22 (0.96–1.55)	1.43 (1.03–1.99)	0.84 (0.53–1.35)
BZD, polypharmacy	208	1.11 (0.91–1.35)	1.30 (0.97–1.75)	1.40 (1.04–1.87)
P for interaction[b]		0.52	0.43	0.03
No AD, no polypharmacy	5,295	1.00	1.00	1.00
No AD, polypharmacy	949	0.95 (0.83–1.08)	0.99 (0.82–1.18)	0.92 (0.74–1.14)
AD, no polypharmacy	231	0.98 (0.78–1.24)	0.97 (0.71–1.32)	1.13 (0.79–1.63)
AD, polypharmacy	191	1.28 (1.06–1.54)	1.60 (1.19–2.15)	1.51 (1.10–2.07)
P for interaction[b]		0.03	0.02	0.12

RR, relative risk; IRR, incident rate ratio; BZD, benzodiazepine; AD, antidepressant.

[a]Adjusted for baseline covariates: age, sex, living alone, education, employment status, income, smoking status, time between interviews, co-morbidities (listed in text), incontinence, pain, sleep problems, depressive symptoms, cognition, self-rated vision, self-rated hearing, disability, public health-care coverage, history of falls, fracture, fainting and hospitalisation.

[b]P value for the interaction between polypharmacy and use of the specific medication class.

risk of any fall, but this did not quite reach statistical significance (aRR 1.16, 95% CI 0.99–1.35).

Polypharmacy including and excluding falls risk-increasing medications

There was a significant interaction effect between antidepressant use and polypharmacy with respect to any fall ($P = 0.03$) and the number of falls ($P = 0.02$). There was also a significant interaction between benzodiazepine use and polypharmacy with respect to injurious falls ($P = 0.03$). Polypharmacy including antidepressant use was associated with a greater risk of any fall (aRR 1.28, 95% CI 1.06–1.54) and a greater number of falls (aIRR 1.60, 95% CI 1.19–2.15) compared with those without polypharmacy or using antidepressants, but both antidepressant use without polypharmacy and polypharmacy without antidepressants were not (Table 3). In addition, there was an elevated risk of an injurious fall for those with polypharmacy including benzodiazepines (aRR 1.40, 95% CI 1.04–1.87). Seventy participants reported polypharmacy and both antidepressant and benzodiazepine use. This was associated with a greater risk of an injurious fall (aRR 2.02, 95% CI 1.32–3.08) and a greater number of falls (aIRR 1.70, 95% CI 1.08–2.67), but not any fall (aRR 1.25, 95% CI 0.94–1.65).

Attrition

In total, 1,160 participants dropped out during follow-up, or had no or proxy-reported falls data. They were more likely to be smokers and have less education and lower cognition than those assessed at follow-up (results not shown). However, they were not more likely to have fallen at baseline nor report greater use of any medication class studied once adjusted for the other factors. Those taking antidepressants, antipsychotics and diuretics at baseline had an aRR of mortality during follow-up of 1.70 (95% CI 1.09–2.65), 3.58 (95% CI 1.74–7.39) and 1.46 (95% CI 1.03–2.06), respectively. The associations among polypharmacy, benzodiazepine use,

antihypertensive use and mortality did not reach statistical significance.

Discussion

In this prospective, population-based study of community-dwelling adults aged 50 years and older, polypharmacy was not associated with an increased risk of falls after adjustment for co-morbidity. However, polypharmacy including antidepressant use was associated with a greater number of falls and of injurious falls. The use of benzodiazepines was also associated only with an increased risk of injurious falls when combined with polypharmacy. However, the use of benzodiazepines was associated with a greater number of falls irrespective of polypharmacy.

Our findings are consistent with another population-based study of Dutch adults aged ≥55 years, who also found polypharmacy only associated with a greater risk of falling if including falls risk-increasing medications [10]. However, this study was cross-sectional, and although its definition of falls risk-increasing medications included a broader range of classes dominated by benzodiazepines, it did not include antidepressants. As studies differ in medication classes they find associated with falls, we examined only established fall risk-increasing medications identified from systematic reviews [6, 7].

Polypharmacy entails frequent changes in medications, which could lead to confusion and a greater chance of drug interactions [17]. The identified falling risks may be attributed to potential drug interactions between antidepressants and other medications, or the concomitant use of other psychotropic medications, as, for example, 67% of those with polypharmacy including antidepressants were also taking another psychotropic medication (benzodiazepine for 37%). For community-dwelling older men, studies have found that multiple central nervous system (CNS)-active medications have further increased the risk of falls [18] and fractures [19]. They suggest that the effects of concomitant use of several CNS-active medications on postural balance may be additive [19]. Multiple underlying diseases causing the concomitant use of these medications may also have negative effects on physical functioning [19].

The association between antidepressant use and falls has been replicated many times [6] and effects attributed to sedation and postural hypotension [20]. Unfortunately, we had insufficient power to examine the effects of specific antidepressant subclasses. Selective serotonin reuptake inhibitors negatively affect bone metabolism [21], whereas syncope can occur with tri-cyclic antidepressant use [22]. All classes of antidepressants can cause cardiovascular depressant effects by inhibiting cardiovascular ion channels [23].

The use of benzodiazepines has also commonly been implicated with increased falls risks [6] and attributed to dizziness, sedation, impaired motor coordination and postural disturbances [20]. Our findings for injurious falls are in line with recent studies examining concomitant benzodiazepine use with injury and hip fracture risk [24, 25], which suggest that pharmacodynamic drug interactions (e.g. with CNS-active medications, muscle relaxants, opioids and H1-antihistamines) with benzodiazepines contribute to the excess risk.

Our findings of no association for polypharmacy, antihypertensives and diuretics further highlight the importance of thorough adjustment for confounders [9]. However, we do not believe that our findings reflect over-adjusting, as, although each of these exposures was significantly related to falls outcomes, this was not so when adjusted for age, sex and only the self-reported health conditions. The exclusion of those institutionalised or with dementia from our cohort could be responsible for our lack of association for antipsychotics and may lead to underestimation of the association with benzodiazepines, antidepressants and falling.

Our study has a number of strengths. The use of a large, randomly sampled, population-representative cohort with longitudinal follow-up ensured medication exposure preceded the falls outcomes. Participants underwent a detailed assessment of their socioeconomic characteristics, cognitive and physical health, allowing us to examine potential confounders usually unavailable to pharmacoepidemiological studies. It was important to fully adjust for co-morbidity [9]. We modelled all health conditions simultaneously allowing each condition to exert its own weight for predicting falls, rather than using a pre-weighted co-morbidity index which provides only limited confounding control [26]. Most health variables were self-reported, but results were unchanged when additionally adjusted for objectively measured health status and frailty for a subset of participants who attended a health assessment (results not shown). Nevertheless, despite this extensive adjustment for health-related major risk factors for falling, the possibility of some residual confounding by indication cannot be excluded.

Medication reporting based on self-report was improved by interviewers viewing medication packages. Self-report allows the collection of non-prescription medication use and potentially better reflects adherence than prescribing or dispensing records [27]. We previously compared the self-reported medications to pharmacy dispensing claims for public patients and good agreement was generally found [27]. Although falling was recorded subsequent to medication exposure, we lack the ability to observe the full temporal relationship between the use of medications and the falls. However, medication use remained fairly constant with 66–87% of those taking each medication class at baseline continued to at follow-up (data not shown). We also considered only established falls risk-increasing medication classes; hence, we may be missing more specific drug classes that are risk factors for falling. We were also unable to examine the effect of dose or duration.

The data were mostly complete. Only 1% of participants were excluded from the main analysis due to missing falls or medication data. Study attrition was not associated with either a baseline falls history, or use of any medication class studied. Refusal at baseline was associated with lower education [11]. Use of study inverse probability weights to weight the analysis for differential refusal at baseline or loss to follow-up led to very similar findings (results not shown).

The association between medication class and baseline falls also did not vary by completion at Wave 2 (results not shown); hence, we have no reason to believe that the associations with incident falls would be differential.

There may be misclassification of the falling outcomes. Our lack of associations for the faller outcome could be due to the lack of a standard falls definition. Concerns over the accuracy of falls recall in the elderly have been discussed extensively; however, studies find that injurious falls are recalled more accurately [28]. We also have no reason to believe that the recall would be differential, and the rate of falling among our sample was comparable with that found in similar populations [9, 29]. Moreover, the effect of under reporting of falls was minimised by excluding institutionalised participants and those with apparent cognitive impairment and dementia.

In this prospective study of community-dwelling middle-aged and older adults, polypharmacy was associated with increased falls risks if including regular antidepressant or benzodiazepine use. Medication reviews have been shown to be successful at reducing falls in the older population [30], and these findings give more specific medication classes to target interventions towards. The risks and benefits need to be fully considered when initiating these medications in those at risk of falls. The findings also further support the idea that it is the type of polypharmacy that is important for adverse events [7, 10].

Key points

- Polypharmacy including antidepressant use increased the risk of subsequent falls and injurious falls.
- Polypharmacy including benzodiazepine use increased the risk of injurious falls.
- A greater number of falls occurred with benzodiazepine use irrespective of polypharmacy.
- Antihypertensives, diuretics and antipsychotics were not associated with falling outcomes after adjustment for co-morbidity.

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Conflicts of interest

None declared.

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References

1. O'Loughlin JL, Robitaille Y, Boivin J-F, Suissa S. Incidence of and risk factors for falls and injurious falls among the community-dwelling elderly. Am J Epidemiol 1993; 137: 342–54.
2. Tinetti ME, Speechley M, Ginter SF. Risk factors for falls among elderly persons living in the community. N Engl J Med 1988; 319: 1701–7.
3. Bergland A, Wyller TB. Risk factors for serious fall related injury in elderly women living at home. Inj Prev 2004; 10: 308–13.
4. Kannus P, Sievänen H, Palvanen M, Järvinen T, Parkkari J. Prevention of falls and consequent injuries in elderly people. Lancet 2005; 366: 1885–93.
5. Deandrea S, Lucenteforte E, Bravi F, Foschi R, La Vecchia C, Negri E. Risk factors for falls in community-dwelling older people. Epidemiology 2010; 21: 658–68.
6. Woolcott JC, Richardson KJ, Wiens MO *et al*. Meta-analysis of the impact of 9 medication classes on falls in elderly persons. Arch Intern Med 2009; 169: 1952–60.
7. Hartikainen S, Lönnroos E, Louhivuori K. Medication as a risk factor for falls: critical systematic review. J Gerontol A Biol Sci Med Sci 2007; 62: 1172–81.
8. Hilmer SN, Gnjidic D. The effects of polypharmacy in older adults. Clin Pharmacol Ther 2008; 85: 86–8.
9. Lawlor DA. Association between falls in elderly women and chronic diseases and drug use: cross sectional study. BMJ 2003; 327: 712–7.
10. Ziere G, Dieleman JP, Hofman A, Pols HA, Van Der Cammen TJM, Stricker BHC. Polypharmacy and falls in the middle age and elderly population. Br J Clin Pharmacol 2006; 61: 218–23.
11. Barrett A, Savva G, Timonen V, Kenny RA, eds. Fifty Plus in Ireland 2011. First Results From The Irish Longitudinal Study on Ageing. Dublin: TILDA, 2011.
12. Whelan BJ, Savva GM. Design and methodology of The Irish Longitudinal Study on Ageing. J Am Geriatr Soc 2013; 61: S265–8.
13. WHO Collaborating Centre for Drug Statistics Methodology. Guidelines for ATC Classification and DDD Assignment 2011. Oslo: WHO Collaborating Centre for Drug Statistics Methodology, 2010.
14. Gnjidic D, Hilmer SN, Blyth FM *et al*. Polypharmacy cutoff and outcomes: five or more medicines were used to identify community-dwelling older men at risk of different adverse outcomes. J Clin Epidemiol 2012; 65: 989–95.
15. Radloff LS. The CES-D scale: a self-report depression scale for research in the general population. Appl Psychol Meas 1977; 1: 385–401.
16. Zou G. A modified Poisson regression approach to prospective studies with binary data. Am J Epidemiol 2004; 159: 702–6.
17. Neutel CI, Perry S, Maxwell C. Medication use and risk of falls. Pharmacoepidemiol Drug Saf 2002; 11: 97–104.
18. Weiner DK, Hanlon JT, Studenski SA. Effects of central nervous system polypharmacy on falls liability in community-dwelling elderly. Gerontology 1998; 44: 217–21.

19. Nurminen J, Puustinen J, Piirtola M, Vahlberg T, Kivelä S-L. Psychotropic drugs and the risk of fractures in old age: a prospective population-based study. BMC Public Health 2010; 10: 396.
20. Ray WA. Psychotropic drugs and injuries among the elderly: a review. J Clin Psychopharmacol 1992; 12: 386–96.
21. Diem SJ, Blackwell TL, Stone KL *et al*. Use of antidepressants and rates of hip bone loss in older women: the study of osteoporotic fractures. Arch Intern Med 2007; 167: 1240–5.
22. Bhangu J, King-Kallimanis B, Cunningham C, Kenny RA. Prevalence of syncope in older adults with depression: a population based study. Age Ageing 2013; 42(Suppl. 2): ii20–2.
23. Pacher P, Ungvari Z. Selective serotonin-reuptake inhibitor antidepressants increase the risk of falls and hip fractures in elderly people by inhibiting cardiovascular ion channels. Med Hypotheses 2001; 57: 469–71.
24. French DDD, Chirikos TN, Spehar A, Campbell R, Means H, Bulat T. Effect of concomitant use of benzodiazepines and other drugs on the risk of injury in a Veterans population. Drug Saf 2005; 28: 1141–50.
25. Zint K, Haefeli WE, Glynn RJ, Mogun H, Avorn J, Stürmer T. Impact of drug interactions, dosage, and duration of therapy on the risk of hip fracture associated with benzodiazepine use in older adults. Pharmacoepidemiol Drug Saf 2010; 19: 1248–55.
26. Schneeweiss S, Maclure M. Use of comorbidity scores for control of confounding in studies using administrative databases. Int J Epidemiol 2000; 29: 891–8.
27. Richardson K, Kenny RA, Peklar J, Bennett K. Agreement between patient interview data on prescription medication use and pharmacy records in the over 50s varied by therapeutic group and reporting of indicated health condition. J Clin Epidemiol 2013; 66: 1308–16.
28. Ganz DA, Higashi T, Rubenstein LZ. Monitoring falls in cohort studies of community-dwelling older people: effect of the recall interval. J Am Geriatr Soc 2005; 53: 2190–4.
29. Chu LW, Chi I, Chiu AYY. Incidence and predictors of falls in the Chinese elderly. Ann Acad Med Singapore 2005; 34: 60–72.
30. Van der Velde N, Stricker BHC, Pols HAP, van der Cammen TJM. Withdrawal of fall-risk-increasing drugs in older persons: effect on mobility test outcomes. Drugs Aging 2007; 24: 691–9.

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Association of vegetables and fruits consumption with sarcopenia in older adults: the Fourth Korea National Health and Nutrition Examination Survey

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Abstract

Background: several studies have found nutrients, including antioxidants, to be associated with sarcopenia. However, whether specific foods, such as vegetables and fruits, are associated with sarcopenia has not been studied.
Objective: to examine the association of the frequency of vegetables and fruits consumption with sarcopenia in older people.
Methods: this study used cross-sectional data from the Fourth Korea National Health and Nutrition Examination Survey in 2008–09. Subjects were community-dwelling 823 men and 1,089 women aged ≥65 years. Frequency of food group