

BMJ Open Low health literacy and multiple medications in community-dwelling older adults: a population-based cohort study

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ABSTRACT

Objectives Adequate health literacy is important for patients to manage chronic diseases and medications. We examined the association between health literacy and multiple medications in community-dwelling adults aged 50 years and older in England.

Design, settings and participants We included 6368 community-dwelling people of median age 66 years from the English Longitudinal Study of Ageing. Health literacy was assessed at wave 5 (2010/11) with 4 questions concerning a medication label. Four correct answers were categorised as adequate health literacy, otherwise low. Data on medications were collected at wave 6 (2012/13). To examine the difference in the number of medications between low and adequate health literacy, we used zero-inflated negative binomial regression, estimating odds ratio (OR) for zero medication and incidence rate ratios (IRR) for the number of medications, with 95% CIs. Associations were adjusted for demographic, socioeconomic and health characteristics, smoking and cognitive function. We also stratified the analysis by sex, and age (50–64 and ≥65 years). To be comparable with preceding studies, multinomial regression was fitted using commonly used thresholds of polypharmacy (0 vs 1–4, 5–9, ≥10 medications).

Results Although low health literacy was associated with a lower likelihood of being medication-free (OR=0.64, 95% CI: 0.45 to 0.91), health literacy was not associated with the number of medications among those at risk for medication (IRR=1.01, 95% CI: 0.96 to 1.05), and this finding did not differ among younger and older age groups or women. Among men, low health literacy showed a weak association (IRR=1.06, 95% CI: 0.99 to 1.14). Multinomial regression models showed graded risks of polypharmacy for low health literacy.

Conclusions Although there was no overall association between health literacy and the number of medications, this study does not support the assertion that low health literacy is associated with a notably higher number of medications in men.

INTRODUCTION

Most high-income countries are experiencing an ever-growing ageing population. In Europe, the proportion of people aged ≥65

Strengths and limitations of this study

- Strengths of this study include the use of longitudinal study design based on a large representative sample of older adults in England.
- Qualified nurses checked self-reported medication use; thus, medication misreporting was reduced.
- To reduce the impact of confounding, statistical adjustment included a wide range of potential confounders such as age, sex, income, education, cognitive function and pre-existing and concurrent morbidity and self-rated health.
- Although health literacy in English Longitudinal Study of Ageing was measured with a validated instrument with good face validity, it mainly focuses on basic document literacy skills and does not account for other skills such as prose and health navigation literacy.
- As residual and unmeasured confounding cannot be ruled out and the effect size of the association was weak, the results need to be interpreted with caution.

years is expected to increase and reach 27% by 2050.¹ Although there are older people who remains healthy, a considerable share of older adults has multiple chronic diseases and uses multiple medications, polypharmacy. There is no consensus on the definition of polypharmacy, but the most commonly used cut-offs are ≥5 or ≥10 medications.²

Relationships between polypharmacy and health in the ageing process are complex and multidirectional. Polypharmacy may be due to multimorbidity; however, polypharmacy can cause negative consequences, such as poor medication adherence, declines in cognition and quality of life and increased risk of side effects such as fall injuries, frailty, hospitalisations and even death.³ Therefore, reducing the risk of inappropriate polypharmacy has been a priority among clinicians, public health scientists and policymakers.⁴



Health literacy has recently gained much attention as a factor that can reduce the risk of polypharmacy.⁵ Health literacy is an individual's ability to access, understand, appraise and apply health information to make decisions that prevent disease and excessive medications, promote good health and improve quality of life throughout the life-course.⁶ An estimated 60% of the European older population has low health literacy.⁶ Patient-centred interventions have suggested that improving health literacy can reduce polypharmacy risk, medication non-adherence and healthcare costs.^{5,7,8} However, despite that low health literacy was associated with incorrect medication use^{9,10} and reduced willingness to reduce the number of medications,¹¹ low health literacy has not been shown to associate with polypharmacy.^{12,13} The lack of association may be because the majority of these studies were cross-sectional with relatively small sample size¹⁴⁻¹⁶ and low statistical power.

Therefore, using a large sample of longitudinal data, we aimed to examine the association between health literacy and multiple medications in community-dwelling older adults. We further examined whether this association differed by sex, age and morbidity because sex may modify the association health literacy and medication given differences in health behaviour between men and women,^{17,18} and the risk of low health literacy and use of multiple medications differ in by age,^{17,18} and morbidity burden.^{18,19}

METHODS

Study design and sample

This population-based cohort study used data from the English Longitudinal Study of Ageing (ELSA),²⁰ an ongoing study of a large representative cohort of people living in England aged ≥ 50 years. The first cohort of ELSA (wave 1) was collected in 2002 from participants of the Health Survey of England (HSE), an annual cross-sectional household survey of a randomly selected sample representative of the English population living in private homes.²⁰ ELSA participants have been followed up biennially. New participants have been recruited from HSE to maintain the representativeness of the general English older adult population. At each wave, trained interviewers visited participants (including members who were identified from HSE and their cohabiting partners) at their homes to carry out a survey comprising personal face-to-face computer-assisted interviews and a paper-and-pen self-completion questionnaire. At every other wave, a qualified nurse visits a subset of participants assessed in the survey (nurse visit), carries out interviews, performs a physical examination and collects blood samples.²⁰

In this study, we included participants who had completed the health literacy assessment in wave 5 (2010/11) and had data on medication use recorded at nurse visit in wave 6 (2012/13). There were partners who were younger than 50 years, and they were excluded. Of all 6837 participants assessed at wave 5 and with nurse

visit at wave 6, we excluded 7% ($n=469$) who had incomplete data in relevant variables, leaving a total sample of 6368 participants included in our analyses.²⁰

Variables

Exposure: health literacy

In wave 5, trained interviewers assessed participants' health literacy using a realistic but fictitious medicine label, the method that is used in the International Adult Literacy Survey.²¹ Participants were asked four questions to examine how well they understood the instructions on the label. Response to each of the four questions was scored 1 if correct and otherwise 0. Using the sum of correct responses (range 0–4), we categorised health literacy as adequate if participants scored 4/4, otherwise as low. This cut-off has been previously used.²¹

Outcome: number of medications

In wave 6 nurse visit, participants were asked to name the medications they were taking in the last 7 days. The nurses checked medication containers to ascertain self-reported medication use. Devices that do not deliver drugs, such as stoma or urinary catheters and vaccines, were excluded.²⁰

Adjustment variables: sociodemographic, cognitive function and health-related characteristics

Factors that have been reported in the literature to be associated with health literacy¹⁷ and polypharmacy^{2,22} have been considered for adjustment. These factors include *age* (≥ 90 years collapsed in ELSA dataset), *sex* (male/female), *highest education qualification* (no qualification/up to secondary education/degree or higher education), *wealth* (quintiles of household-level net total non-pension wealth), *smoking status* (never smoked/ex-smoker/current smoker), *self-rated health* (excellent/very good/good/fair/poor), *Charlson Comorbidity Index (CCI)*, *depression* and *cognitive function*.

CCI was derived using the weights of self-reported conditions based on the New Jersey Medicare weights.²³ Identified self-reported conditions were myocardial infarction, heart failure, stroke or cerebrovascular disease, dementia, chronic lung disease including asthma, diabetes mellitus or high blood sugar, diabetes mellitus with end-organ damage defined as diabetes with eye disease, diabetes with protein in urine or kidney trouble told by a doctor, any cancer including any solid cancer, leukaemia, lymphoma and some other blood disorder. The sum of CCI weights (range 0–8) was categorised into three levels: 0, 1–2 and 3–8.

Depression was assessed using the dichotomous 8-item Centre for Epidemiological Studies Depression Scale. Of a score ranging 0–8, a score ≥ 3 was defined as depression, otherwise no depression.²⁴

Cognitive memory function was assessed by testing verbal learning, immediate and delayed recall of 10 words, and a score (range 0–20) was provided. *Cognitive executive function* was assessed by testing verbal fluency based on the total number of animals named in 1 min, and a score (range

0–51) was provided. A binary variable for any observed or reported *factor that could impair cognitive test* was created based on at least one positive answer to the following being one otherwise zero: poor sight, poor hearing, tiredness, illness or physical impairment, impaired concentration, nervousness, external interaction or distraction (eg, phone call or visit), noisy environment, distressed (eg, from bereavement), memory problems, the influence of alcohol or difficulty in understanding English.

Statistical analyses

We summarised participants' characteristics using means, SD, median, IQR (lower quartile to upper quartile) and proportions. To test differences between groups, we used χ^2 test, Student's t-test or Mann-Whitney U test. To examine the association between health literacy and the number of medications, we used zero-inflated negative binomial models because the proportion of participants with zero medication was 22%, the variability of data on medication was high (range=0–27, mean=3.4, variance=11.7) and Akaike and Bayesian Information Criteria as well as the Vuong statistic favoured zero-inflated negative binomial model over negative binomial model. Zero-inflated negative binomial models account for excess zeros by combining two separate models; a logistic model for estimating likelihood of being certain zeros (not at risk of medication, possibly because of absence of diseases) and a negative binomial model for modelling the number of medications for those who are not certain zeros (at risk of medication).²⁵ The former computes odds ratios (OR) and 95% CI, and the latter computes incidence rate ratios (IRR) and 95% CI. Initially, we fitted three models; a model not adjusting for any variable (model 1), a model adjusting for factors assessed at wave 5, including age, sex, education qualification, wealth, smoking, CCI, self-rated health, depression and cognitive function (model 2), and finally a model additionally including CCI, self-rated health and depression assessed at wave 6 to account for the influence of concurrent health status on medications (model 3). Since the models 2 and 3 did not differ notably, we present unadjusted estimates and estimates adjusting for all variables. We included all covariates in both the logistic part and the negative binomial part.

For all following stratified and secondary analyses, we used the full adjusted model. First, we stratified analyses by sex and age (50–64 and ≥ 65 years). Second, to reduce the possible influence of morbidity to conceal the association between health literacy and the number of medications, we conducted an analysis restricting participants to those with the lowest morbidity (CCI=0), no depression and 'good' or higher self-rated health at both waves 5 and 6. Third, to be comparable with preceding studies that used a certain number of medications to define polypharmacy, we conducted a secondary analysis using multinomial regression models. The association between health literacy and polypharmacy was estimated with relative risk ratios (RRR) and 95% CI. In these analyses, polypharmacy was classified into four levels: no polypharmacy

(0) as referent, minor polypharmacy (1–4), major polypharmacy (5–9) and excessive polypharmacy (≥ 10 medications).²

In all regression models, complex survey design and household clustering were accounted for by estimating robust SEs, and estimates were weighted to adjust for non-response. All analyses were conducted in Stata V.16 SE.

Patient and public involvement

There was no patient or public involvement in this study. ELSA participants were given a newsletter with recent findings from previous surveys.

RESULTS

A total of 6368 participants of median age 66 years (range 52–90 years, IQR=60–73 years) were included in our analyses. The number of reported medications was ranged 0–27, with 22% reporting zero medication and a median of 3 medications (IQR=1–5). The number of medications was higher among those with low health literacy (median 4) than those with adequate health literacy (median 2) (table 1). Approximately three-quarters of participants had adequate health literacy, but 25% showed low health literacy. Both in men and women, the proportion of low health literacy was similar whereas low health literacy was more prevalent among those aged ≥ 65 years, with lower education qualification, lower wealth, current smoking, depression, higher morbidity and poorer self-rated health and lower cognitive performance.

Health literacy and number of medications

Compared with participants with adequate health literacy, the unadjusted odds of reporting zero medication were 61% lower for those with low health literacy (OR=0.39, 95% CI: 0.27 to 0.57). Among those at risk of medications, the unadjusted rate of the number of medications was 20% higher for participants with low health literacy compared with those with adequate health literacy (IRR=1.20, 95% CI: 1.13 to 1.27) (table 2, online supplemental appendix 1). Furthermore, the probability of reporting zero medication was low for females than males, but there was no difference between men and women in the number of medications among those who are at risk of medication (online supplemental appendix 1). Higher age and current or past smoking was associated with higher number of medications but not consistently with likelihood of zero medication. Disadvantageous socioeconomic position, indicated by lower education and wealth, was linked to a lower probability of zero medication as well as to a higher number of medications among those at risk of medication. On the other hand, ORs for zero medication declined as health status, indicated by self-rated health and morbidity, declined while the rate of medications among those at risk increased and the highest morbidity score and the poorest self-rated health were associated with up to a 2 and 4 times higher number

Table 1 The characteristics of ELSA participants by health literacy

	Health literacy			P value†
	Total n (%)*	Low N=1581 (24.8%)*	Adequate N=4787 (75.2%)*	
Number of medications, median (IQR)	3 (1–5)	4 (1–6)	2 (1–5)	<0.001
Sex, n (%)				0.084
Male	2837 (44.6)	734 (25.9)	2103 (74.1)	
Female	3531 (55.4)	847 (24.0)	2684 (76.0)	
Age group, n (%)				<0.001
50–64 years	2929 (46.0)	577 (19.7)	2352 (80.3)	
65 years and older	3439 (54.0)	1004 (29.2)	2435 (70.8)	
Highest education qualification, n (%)				<0.001
No qualification or equivalent	2553 (40.1)	933 (36.6)	1620 (63.5)	
Up to secondary education	1723 (27.1)	330 (19.2)	1393 (80.9)	
Degree or higher education	2092 (32.9)	318 (15.2)	1774 (84.8)	
Wealth quintiles, n (%)				<0.001
1 (least wealthy)	960 (15.1)	361 (37.6)	599 (62.4)	
2	1266 (19.9)	364 (28.8)	902 (71.3)	
3	1254 (19.7)	343 (27.4)	911 (72.7)	
4	1410 (22.1)	284 (20.1)	1126 (79.9)	
5 (most wealthy)	1478 (23.2)	229 (15.5)	1249 (84.5)	
Smoking status, n (%)				<0.001
Never smoked	2440 (38.3)	558 (22.9)	1882 (77.1)	
Ex-smoker	3188 (50.1)	777 (24.4)	2411 (75.6)	
Current smoker	740 (11.6)	246 (33.2)	494 (66.8)	
Charlson Comorbidity Index, n (%)				<0.001
0	4338 (68.1)	978 (22.5)	3360 (77.5)	
1–2	1676 (26.3)	474 (28.3)	1202 (71.7)	
3–8	354 (5.6)	129 (36.4)	225 (63.6)	
Self-rated health, n (%)				<0.001
Excellent	819 (12.9)	136 (16.6)	683 (83.4)	
Very good	1998 (31.4)	387 (19.4)	1611 (80.6)	
Good	2095 (32.9)	540 (25.8)	1555 (74.2)	
Fair	1099 (17.3)	372 (33.9)	727 (66.2)	
Poor	357 (5.6)	146 (40.9)	211 (59.1)	
Depression, n (%)				<0.001
No	5102 (80.1)	1172 (23.0)	3930 (77.0)	
Yes	1266 (19.9)	409 (32.3)	857 (67.7)	
Cognitive function				
Memory score, mean (SD)	10.8 (3.4)	9.16 (3.3)	11.3 (3.2)	<0.001
Executive score, mean (SD)	21.4 (6.5)	18.8 (6.1)	22.3 (6.4)	<0.001
Factor could impair cognitive test, n (%)				<0.001
No	5962 (93.6)	1408 (23.6)	4554 (76.4)	
Yes	406 (6.4)	173 (42.6)	233 (57.4)	
Charlson Comorbidity Index at wave 6‡, n (%)				<0.001
0	4222 (66.3)	930 (22.0)	3292 (78.0)	
1–2	1763 (27.7)	514 (29.2)	1249 (70.9)	

Continued

Table 1 Continued

	Health literacy			P value†
	Total	Low	Adequate	
	n (%)*	N=1581 (24.8%)*	N=4787 (75.2%)*	
3–8	383 (6.0)	137 (35.8)	246 (64.2)	
Self-rated health at wave 6‡, n (%)				<0.001
Excellent	709 (11.1)	120 (16.9)	589 (83.1)	
Very good	1902 (29.9)	361 (19.0)	1541 (81.0)	
Good	2055 (32.3)	491 (23.9)	1564 (76.1)	
Fair	1264 (19.8)	450 (35.6)	814 (64.4)	
Poor	438 (6.9)	159 (36.3)	279 (63.7)	
Depression at wave 6‡, n (%)				<0.001
No	5190 (81.5)	1206 (23.2)	3984 (76.8)	
Yes	100 (1.6)	375 (31.8)	803 (68.2)	

Mean (SD) is displayed for cognitive function scores, median (IQR) for number of medications and sample size *n* and (% of sample size *N*) for all other variables.

*Per cent of total population size *n*=6368.

†P value by χ^2 test for categorical variables, Student's *t*-test for cognitive function and Mann-Whitney U test for number of medications.

‡Charlson Comorbidity Index score, self-rated health reported and depression at wave 6 (2012/13). All other factors analysed are baseline factors reported at wave 5 (2010/11).

ELSA, English Longitudinal Study of Ageing.

of medications compared with the lowest morbidity score and excellent self-rated health, respectively.

When the model was adjusted for covariates measured at waves 5 and 6, participants with low health literacy had still a lower probability of zero medication compared with those with adequate health literacy (OR=0.64, 95% CI: 0.45 to 0.91) (table 2, online supplemental appendix 1). However, among those at risk of medication, there was no evidence of a difference in the number of medications between those with low and those with adequate health literacy (IRR=1.01, 95% CI: 0.96 to 1.05). Among covariates, IRRs associated with more disadvantaged socioeconomic characteristics were no longer consistently statistically significant (online supplemental appendix 1).

However, IRRs for age, morbidity and self-rated health assessed at waves 5 and 6 remained statistically significantly associated with a higher number of medications and notably accounted for diminishing the association between health literacy and the number of medications among those at risk of medication.

There was little evidence that associations were different by age and sex, with Wald test for the interaction terms for sex ($p=0.096$) and age ($p=0.106$). Nevertheless, when the analysis was stratified by sex, in men, health literacy was not associated the likelihood of zero medication; but among those at risk of medication there was an indication of a weak association between low health literacy and number of medications (IRR=1.06, 95% CI: 0.99 to 1.14, $p=0.095$) (table 3).

Table 2 Unadjusted and adjusted ORs and IRRs based on zero-inflated negative binomial models for the association between literacy at wave 5 and the number of medications at wave 6

	Unadjusted		Adjusted*	
	Logistic part†	Negative binomial part†	Logistic part†	Negative binomial part†
	OR (95% CI)	IRR (95% CI)	OR (95% CI)	IRR (95% CI)
Health literacy				
Low (score <4)	0.39 (0.27 to 0.57)	1.20 (1.13 to 1.27)	0.64 (0.45 to 0.91)	1.01 (0.96 to 1.05)
Adequate (score=4)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)

95% CI with robust SEs.

Estimates for covariates are reported in online supplemental appendix 1.

Bold values are statistically significant.

*Full adjustment for baseline factors at wave 5 (2010/11) and Charlson Comorbidity Index, self-rated health and depression at wave 6 (2012/13).

†The logistic part estimates the probability (ORs) of being certain zero medication whereas the negative binomial part estimates the number of medications (IRRs) among those at risk of medication.

IRR, incidence rate ratio; OR, odds ratio; ref, reference.

Table 3 Adjusted ORs and IRRs based on zero-inflated negative binomial models for the association between literacy at wave 5 and the number of medications at wave 6, stratified by sex and age group

		Health literacy	Logistic part*	Negative binomial part*
			OR (95% CI)	IRR (95% CI)
Sex†	Male	Low (score <4)	0.62 (0.37 to 1.04)	1.06 (0.99 to 1.14)
		Adequate (score=4)	1.00 (ref)	1.00 (ref)
	Female	Low (score <4)	0.59 (0.35 to 0.98)	0.96 (0.90 to 1.02)
		Adequate (score=4)	1.00 (ref)	1.00 (ref)
Age (years)‡	50–64	Low (score <4)	0.45 (0.24 to 0.83)	1.02 (0.92 to 1.12)
		Adequate (score=4)	1.00 (ref)	1.00 (ref)
	≥65	Low (score <4)	1.16 (0.75 to 1.81)	1.01 (0.96 to 1.06)
		Adequate (score=4)	1.00 (ref)	1.00 (ref)

95% CI with robust SEs.

All estimates are full-adjusted for baseline factors at wave 5 (2010/11) and Charlson Comorbidity Index, self-rated health and depression at wave 6 (2012/13), equivalent to adjusted model in table 2.

*The logistic part estimates the probability (ORs) of being certain zero medication, whereas the negative binomial part estimates the number of medications (IRRs) among those at risk of medication.

†Wald test for the interaction term for sex was $p=0.096$.

‡Wald test for the interaction term for age was $p=0.106$.

IRR, incidence rate ratio; OR, odds ratio; ref, reference.

In women, low health literacy was associated with a lower likelihood of no medication (OR=0.59, 95% CI: 0.35 to 0.98), but not with the number of medications. While low health literacy was associated with a lower probability of reporting no medication among those aged 50–64 years (OR=0.45, 95% CI: 0.24 to 0.83), there was no statistically significant association between health literacy and the number of medications in those at risk of medication in either age group.

When we restricted the analysis on 898 individuals who reported the lowest morbidity (CCI=0), good or higher self-rated health and no depression at both waves 5 and 6, the finding was largely similar to that observed above; low health literacy was not associated with either the

probability of zero medication or the number of medications (online supplemental appendix 2).

Secondary analysis: health literacy and polypharmacy

Among the participants, 22% of individuals used no medication (no polypharmacy), 47% used 1–4 (minor), 25% used 5–9 (major) and 6% used ≥10 medications (excessive polypharmacy). Multinomial regression of polypharmacy showed that, compared with adequate health literacy, unadjusted RRR for low health literacy showed a gradient increased risk of up to 2.6 times for excessive polypharmacy (table 4). This association diminished after full adjustment but an adjusted

Table 4 Secondary analysis using multinomial regression models: relative risk ratios (RRR) for the association between health literacy at wave 5 and polypharmacy at wave 6

	Unadjusted	Adjusted*
	RRR (95% CI)	RRR (95% CI)
No medication (reference)		
1–4 medications		
Low health literacy	1.63 (1.35 to 1.96)	1.32 (1.06 to 1.63)
Adequate health literacy	1.00 (ref)	1.00 (ref)
5–9 medications		
Low health literacy	2.39 (1.96 to 2.91)	1.37 (1.07 to 1.77)
Adequate health literacy	1.00 (ref)	1.00 (ref)
10 or more medications		
Low health literacy	2.98 (2.28 to 3.90)	1.44 (1.02 to 2.04)
Adequate health literacy	1.00 (ref)	1.00 (ref)

95% CI with robust SEs.

*Full adjustment for baseline factors at wave 5 (2010/11) and Charlson Comorbidity Index, self-rated health and depression at wave 6 (2012/13).

ref, reference.

risk of up to 1.44 times for excessive polypharmacy compared with no polypharmacy remained after full adjustment.

DISCUSSION

This cohort study aimed to examine the association between health literacy and the number of medications and polypharmacy in community-dwelling older people. There was no evidence of an association between health literacy and the number of medications among those at risk of medication, although low health literacy was associated with a low likelihood of being medication-free. In unadjusted estimates, low health literacy was associated with increased number of medications among those at risk of medication, but adjustment for morbidity and poorer self-rated health diminished the association. In men, however, there was weak indication that low health literacy was associated with a 6% higher number of medications, equivalent to 0.3 excess medication, after adjustment.

In line with previous studies that found no association between health literacy and the number of medications among community-dwelling older people,¹⁹ older primary care patients^{12 26} as well as in younger population,¹³ this study found no association between health literacy and polypharmacy when both sexes were combined. The unadjusted positive associations between low health literacy and polypharmacy diminished when socioeconomic characteristics, morbidity and self-rated health were accounted for. The association was observed when polypharmacy was analysed using multinomial regression models; however, this is considered to be because the model does not differentiate certain zeros (those not at risk of medication, possibly because of absence of diseases) and those at risk of medication. Given that health literacy was strongly associated with at risk of medication or not (logistic part), but not with the number of medications (negative binomial part), the results from multinomial regression would be much driven by association observed in logistic part. Health literacy is a construct that formulates from early adolescence and develops across the life-course.¹⁷ It relates to poor health-related behaviour,²⁷ inappropriate health-information seeking behaviour,²⁸ delayed healthcare visit and forgone treatment.²⁹ Therefore, by the late middle age, as is our participants, low health literacy may have already resulted in poorer health in some individuals. Furthermore, socioeconomic disadvantages across the life-course are associated with both low health literacy and accumulated poor health.¹⁵ Therefore, logistic part focusing on at risk of medication showed strong association, and adjustment for health and socioeconomic characteristics diminished effect size for logistic part and explained away the association for negative binomial part.

Our results showed weak indication that low health literacy may be associated with polypharmacy in men. Given the lack of effect modification and the weak effect size, this finding may be a chance finding. Furthermore,

they can also be explained away even by a weak bias, although we adjusted for known confounding factors within the data available to us. For example, the reason the association remained in men may be because men tend to under-report morbidity and poor health to a greater extent,³⁰ and this may have been even more pronounced among low health literate men. Such differential under-reporting may have resulted in incomplete adjustment for the effect of morbidity among men. Therefore, these results should be interpreted with caution.

Nevertheless, the weak possible association in men can in part relate to gendered behaviours and attitudes to health. Research suggests men are more reluctant to seek healthcare and receive advice from peers, less likely to read healthcare instructions, and more likely to miss opportunities for medication reviews^{31–33} and stay longer on medications.³⁴ These characteristics may even be more so among low health literate men. Therefore, although in our cohort the difference in health literacy between men and women was small, men's overall health knowledge tends to be poorer³⁵; and this may relate to why there was some indication of association in men.

Identifying the magnitude of health risk associated with polypharmacy and its clinical implications is beyond the scope of our study, but an increased number of medications was associated with increased risk of fall, hospitalisation and mortality.^{3 36} A recent nation-wide cohort study and a meta-analysis found that one additional medication has been associated with a 3%–8% increased risk of death in people aged ≥ 65 years.^{37 38} Although these results do not necessarily imply causality,³⁷ they underline the need to identify risk groups and modifiable factors associated with polypharmacy. In this study, only in men there was a weak indication of association between low health literacy and higher number of medications. Therefore, men may benefit from improving health literacy to prevent poor health and possibly excessive medication. As our study focused on those aged over 50 years, and also prescribing and medication review practices may vary with healthcare system and country, our results may not be generalisable to younger people or other societal contexts.

Strengths and limitations

Our study has some potential limitations. First, we could not know whether the reported medications were complete. For example, if individuals with poorer health literacy or cognitive function have failed to present all medications, this would have resulted in underestimation of association. Furthermore, we were not able to distinguish necessary or inappropriate medications or account for preventive medications such as statins that may have been used more frequently among those with higher health literacy. Nevertheless, a higher number of medications has been associated with inappropriate prescribing and proposed as a marker of inappropriate medications.³⁹ Second, even though the method used in ELSA to measure health literacy only assesses basic document literacy skills and does not account for other

skills such as prose and health navigation literacy,²¹ it has been widely used, had good face validity and has been shown to associate with mortality.²¹ Third, although we have dichotomised health literacy by 4/4 correct answers or else²¹ other studies have used different cut-offs.⁴⁰ To examine whether different classification may change the conclusion, we conducted all main and stratified analyses using health literacy with three categories: low (score 0–2), intermediate (score 3) or adequate (score 4 correct answers); and we observed that the conclusion remained the same (online supplemental appendix 3). Fourth, the UK National Service Framework for Older People has recommended regular medication reviews for people with polypharmacy since 2001.⁴¹ Thus, it may be possible that medication reviews reduced likelihood of polypharmacy including among those with low health literacy. Fifth, we adjusted for morbidity assessed in wave 6 even though it is an intermediate factor linking health literacy and polypharmacy and may be in part a consequence of polypharmacy. We did so because multiple medications may be due to concurrent ill health. Also, if low health literate participants have rated their health poorer because of the fact that they received medications, adjustment for self-rated health may have weakened the association. However, when we restricted analyses to participants with the lowest morbidity, the conclusion remained unchanged. Sixth, the lack of significant association between health literacy and the number of medications in most of the stratified analyses, as well as interaction tests, should be interpreted with caution because these analyses may have lacked statistical power. Lastly, 7% of participants were excluded from analysis due to incomplete data, and this can lower precision of our estimates. It is also possible that this missingness introduced bias. However, to address non-response, we used survey weights in all analyses.

Our study has several strengths. We used a longitudinal design, included a large representative sample of an older population and adjusted for a wide range of potential confounding factors. Also, although some participants may miss presenting some medications, as nurses checked medication containers, the risk of medication under-reporting was reduced.

CONCLUSIONS

Although there was no overall association between health literacy and the number of medications, this study does not support the assertion that low health literacy is associated with a notably higher number of medications in men.

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