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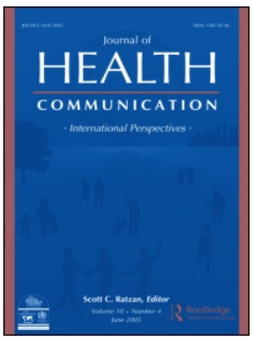

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Health Literacy Is Associated With Health Behaviors and Social Factors Among Older Adults: Results from the LifeLines Cohort Study

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This study assesses the associations between health literacy and various health behaviors and social factors among older adults, and whether social factors moderate the other associations. Data from 3,241 participants in the LifeLines Cohort Study were analyzed (mean baseline age = 68.9 years). Data on health literacy, health behaviors (physical activity, fruit and vegetable consumption, smoking, breakfast consumption, alcohol consumption, and body mass index (BMI), and social factors (loneliness, social support, social activities, social contacts, and living situation) were collected in three waves. Logistic regression analyses were used, adjusted for age and gender. Low health literacy was associated with insufficient physical activity, insufficient fruit and vegetable consumption, lack of regular breakfast consumption, obesity (odds ratios (ORs) > 1.31, *p*-values < .005) and low alcohol use (OR = 0.81, $p = .013$), but not with smoking. Low health literacy was also associated with greater loneliness, engaging in fewer social activities, and having fewer social contacts (ORs > 1.48, *p*-values < .005), but not with social support or living situation. Only the association between health literacy and smoking was moderated by social contacts, but this finding needs confirmation in future studies. In conclusion, low health literacy is negatively associated with health behaviors and social factors in older adults, but social factors seldom moderate the associations between health literacy and health behaviors.

Many people in developed countries have low health literacy, which is associated with various undesirable outcomes, such as poorer self-rated health (Bennett, Chen, Soroui, & White, 2009), higher rates of hospitalization (Cho, Lee, Arozullah, & Crittenden, 2008), and higher rates of mortality (Baker, Wolf, Feinglass, & Thompson, 2008). A common definition of health literacy is "the degree to which people are able to access, understand, appraise and communicate information to engage with the demands of different health contexts in order to promote and maintain good health across the life-course" (Kwan et al., 2006). Large-scale studies in developed countries show low health literacy rates to be as high as 36% in the United States (Kutner, Greenburg, Jin, & Paulsen, 2006) and 47% in Europe (HLS-EU Consortium, 2012), with both studies using different instruments to measure health literacy. Low health literacy is most prevalent among older adults (Kobayashi, Wardle, Wolf, & von Wagner, 2014). Greater understanding of how health literacy impacts health outcomes makes it possible to focus interventions on intermediate outcomes, in order to mitigate the detrimental effects of low health literacy.

One pathway between health literacy and health outcomes could be via health behaviors like physical activity, fruit and vegetable consumption, smoking behavior, breakfast consumption, alcohol consumption, and body mass index (BMI), all of which are known to be linked to health status and health outcomes (Blow et al., 2000; Huang, Hu, Fan, Liao, & Tsai, 2010; Kaplan et al., 2012; Södergren, McNaughton, Salmon, Ball, & Crawford, 2012). Older adults with low health literacy may be less aware of the importance of health behaviors. Additionally, having an adequate level of health literacy is often needed in order to make appropriate decisions with regard to health behaviors. For example, people with low health literacy have poorer comprehension of food labels (Rothman et al., 2006). However, while studies tend to find associations between health literacy and health behaviors, not all studies do find such relations. Various studies have established an association between low health literacy and low physical activity in older adults, for example, among survivors of colorectal cancer (Husson, Mols, Fransen, van de Poll-Franse, & Ezendam, 2015), and among community-dwelling people (Bennett, Boyle, James, & Bennett, 2012; Geboers, de Winter, Luten, Jansen, & Reijneveld, 2014; Suka et al., 2015), but some studies did not find associations of health literacy with other health behaviors like fruit and vegetable consumption (Geboers et al., 2014), smoking behavior (Reisi et al., 2014), and BMI (Kennen et al., 2005). Additional research on these associations could improve our understanding of how low health literacy affects the health outcomes of older adults.

A more novel pathway between health literacy and health outcomes concerns social factors like degree of loneliness, social support, and engagement in social activities. Health literacy is linked with general literacy (World Health Organization, 2013), which is associated with social outcomes from an early age (Glogowska, Roulstone, Peters, & Enderby, 2006). However, the

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associations between health literacy and social factors have received little attention so far. One study showed a link between low health literacy and poorer communication skills among older adults (Hester, 2009). Another study showed that people with low health literacy often feel ashamed about this limitation (Baker et al., 1996; Parikh, Parker, Nurss, Baker, & Williams, 1996), and many of them hide their low health literacy from their relatives, friends, and even their spouses (Parikh et al., 1996). Such feelings may make older adults with low health literacy unwilling or unable to maintain a social network or make use of social resources. However, there are few studies on the association between health literacy and social factors (e.g., Bennett et al., 2012). Studies on the association between health literacy and social support among older adults show mixed results (Johnson, Jacobson, Gazmararian, & Blake, 2010; Lee, Arozullah, Cho, Crittenden, & Vicencio, 2009; Lee, Gazmararian, & Arozullah, 2006). Moreover, the associations between health literacy and other social factors in older adults, such as a persons' number of social contacts, have not yet been studied.

Social factors may also play a moderating role in the associations between health literacy and outcomes. For example, one study showed that people with a larger social network are more likely to use interpersonal communication to seek health information than are people with a smaller social network (Askelson, Campo, & Carter, 2011). Qualitative studies suggest that people with a long-term health condition often draw on the health literacy skills of members of their social network (Edwards, Wood, Davies, & Edwards, 2015), and that people with high health literacy tend to pass on health information to others in their social network (Ellis, Mullan, Worsley, & Pai, 2012). Just as social support has been shown to buffer the effects of financial strain on life satisfaction among older adults (Krause, 2005), it has been suggested that such support could also buffer the negative effects of low health literacy (Lee, Arozullah, & Cho, 2004). Thus, whereas social factors like having many social contacts and engaging in social activities may buffer the negative impacts of low health literacy, other factors, like loneliness, may strengthen these impacts.

Our study, therefore, focuses on the associations of health literacy with health behaviors and social factors among older adults. We also examine the potentially moderating role of social factors in the associations between health literacy and health behaviors. We expect high health literacy to be associated with favorable health behaviors and social factors in older adults. We furthermore expect social factors to moderate the associations between health literacy and health behaviors. As both low health literacy (Kobayashi et al., 2014) and negative social factors like loneliness (Theeke, 2009) and social isolation (Iliffe et al., 2007) are especially common among older adults, we focus specifically on adults above the age of 65.

Method

Lifelines Cohort Study

For our research, we used data from the ongoing LifeLines Cohort Study. Lifelines is a multidisciplinary prospective population-based cohort study examining in a unique three-generation design the health and health-related behaviors of 167,729 persons living in the north of The Netherlands. It employs a broad range of investigative procedures in assessing the biomedical, sociodemographic, behavioral, physical, and psychological factors which contribute to the health and disease of the general population, with a special focus on multimorbidity and complex genetics (Klijs et al., 2015; Scholtens et al., 2015; Stolk et al., 2008). The LifeLines Cohort Study is conducted in accordance with the principles of the Declaration of Helsinki and the research code of the University Medical Center Groningen. Approval by the medical ethical committee of the University of Groningen was obtained for LifeLines. LifeLines is a facility that is open for all researchers. Information on application and data access procedure is summarized on www.lifelines.net.

Recruitment and Data Collection

Participants were recruited via their general practitioners (GPs) (49%), via participating family members (38%), or via self-registration (13%). All participants gave written informed consent before taking part in LifeLines. Baseline data collection was performed at the research site between November 2006 and December 2013. The complete baseline cohort consisted of 167,729 participants between the ages of 6 months and 93 years. For our analyses, we included the subset of participants aged 65 and over at baseline (n = 12,612) for whom health literacy data were collected (n = 3,241). Data from this group at the first follow-up measurement (follow-up rate: 76.8%) and at the second follow-up measurement (follow-up rate compared to baseline: 63.4%) were collected after an average of 17 and 31 months, respectively.

Measures

For our analyses we used data on health literacy, health behaviors (physical activity, fruit consumption, vegetable consumption, smoking behavior, breakfast consumption, alcohol consumption, and BMI), and social factors (loneliness, social support, engaging in social activities, number of social contacts, and living situation).

Health Literacy

Health literacy was measured during the second follow-up, using three self-report screening questions. These questions form a validated health literacy instrument (Chew, Bradley, & Boyko, 2004; Chew et al., 2008).

1. "How often do you have someone help you read hospital materials?"
2. "How confident are you filling out medical forms by yourself?"
3. "How often do you have problems learning about your medical condition because of difficulty understanding written information?"

Participants answered these questions on a 5-point scale. We reversed the scores on the first and third questions and then added up the scores on all questions; this led to a continuous scale (3–15) in which a higher score indicates a higher level of health literacy. Because of the strongly skewed distribution, we then split participants into a group with high health literacy

(score 13 or higher, 66.6%) and a group with low health literacy (score 12 or lower, 33.4%; Geboers et al., 2014). This cut-off point was selected because comparable percentages of low health literacy were found in large-scale health literacy surveys in the Netherlands (29%; HLS-EU Consortium, 2012) and in the United States (36%; Kutner et al., 2006).

Health Behaviors

For most health behaviors, we used data from the first follow-up measurement. For alcohol consumption and BMI, we used baseline data, as data on these behaviors were only collected at baseline. We dichotomized the data on health behaviors according to commonly used recommendations.

Physical activity was assessed with the question, "On average how many days per week do you cycle, do odd jobs, garden, or exercise for a total of at least half an hour?" According to commonly used guidelines, we classified physical activity as insufficient when participants reported being active for at least half an hour on fewer than five days per week (Wendel-Vos, Schuit, Saris, & Kromhout, 2003).

Fruit and vegetable consumption were assessed with the questions, "How often in the past month did you eat (fresh) fruit?" and "How often in the past month did you eat boiled or stir-fried vegetables?" Both questions had seven response categories (6–7 days per week, 4–5 days per week, 2–3 days per week, one day per week, 2–3 days per month, one day per month, not during the preceding month). We classified fruit and vegetable consumption as insufficient for participants who reported consuming fruits or vegetables on fewer than six days per week.

Smoking behavior was assessed with the question, "Do you smoke, or have you smoked in the past month?" and scored as yes (smoker) vs. no (nonsmoker).

Breakfast consumption was assessed with the question, "How often in the past month did you have breakfast?" There were seven response categories (range: 6–7 days per week—not during preceding month). We classified participants who reported having breakfast on fewer than six days per week as not having regular breakfast consumption.

Alcohol consumption was assessed with two questions, "How often in the past month did you drink alcoholic drinks?" and "On days when you drank alcohol, how many drinks did you have, on average?" In accordance with international guidelines (U.S. Department of Agriculture and U.S. Department of Health and Human Services, 2010), we classified alcohol consumption as high for men who reported drinking more than two drinks per occasion and for women who reported drinking more than one drink per occasion.

BMI was calculated using the length and weight of the participants as objectively measured at the research site. BMI was dichotomized as obese (BMI over 30) or nonobese (World Health Organization, 2015). We checked whether dichotomizing BMI as overweight (BMI over 25) or not overweight would lead to different results. This was not the case.

To reduce the time needed to fill out the questionnaires during the follow-up measurements, the food frequency questionnaire (FFQ) was divided into three parts. These three parts were presented to participants in a randomized order over the course of the first three follow-up measurements. As a result, percentages of missing data were relatively high for fruit consumption (n = 1,089, 33.6%) and vegetable consumption (n = 1,096, 33.8%). We found no significant differences regarding age (p-values > .62), gender (p-values > .39), and health literacy (p-values > .22) between participants who filled out these questions and participants whose data on these questions were missing. Percentages of missing data for all other health behaviors were low (all percentages <3.8%).

Social Factors

Degree of loneliness, social support, and living situation (living alone vs. living with others) were assessed during the first follow-up. Engagement in social activities and the number of social contacts were assessed at baseline, as no data on these social factors were collected during the follow-up measurements. We dichotomized all social factors because of the highly skewed distribution of the ordinal variables. For all social factors, we chose cut-off points in such a way that the group scoring unfavorably encompassed a proportion of the sample as close as possible to 10%; we did this in order to identify the most unfavorably scoring group. Splitting data based on percentiles is a common practice in various fields of research (Fei & Olsen, 2011; Mulsant et al., 2003).

Degree of loneliness was assessed with three questions from the validated Groningen Frailty Indicator (Peters, Boter, Burgerhof, Slaets, & Buskens, 2015): "Do you ever feel let down?", "Do you ever experience emptiness around you?", and "Do you ever miss people around you?" and had three response categories (1 = No, 2 = Sometimes, 3 = Yes). The scores on all three questions were added up, leading to scores of 3–9, with a higher score indicating greater loneliness. Participants with a score of 6 or higher were classified as lonely.

Social support was measured with two questions. The first question was, "What do you think of the support given by your spouse, family, co-workers or friends?" Response categories were, "I receive sufficient support", "I need a little more support", "I need more support", and "I receive far too little support." The second question was, "When necessary, is support given by your spouse, family, co-workers or friends available at any time?" The response categories were, "Support is always available", "Support is available most of the time", "Support is sometimes available", and "Support is (almost) never available." We considered social support to be low if participants reported either that they needed more support or that support was only available sometimes or (almost) never.

Social activities were measured with four statements: "I am engaged in several activities per week, during which I meet many people", "I am engaged in a different activity every week, during which I meet quite a few people", "I am usually engaged in the same activity, during which I always meet the same people", and "I am engaged in (almost) no activities during which I meet people." Participants were to select the statement that applied to them. We classified participants as socially inactive if they reported engaging in (almost) no social activities.

The number of social contacts was measured with one question, "With on average how many different people do you have contact over a period of two weeks?" We considered people to

have few social contacts if they reported having contact with four or fewer people during an average 2-week period.

Living situation was measured with the question, "How many people live in your home, including yourself?" and dichotomized into "live alone" and "live with others."

The percentage of missing data on social factors was low (percentages <1.7%), except for social activities (n = 470, 14.5%). Participants who filled out this question and participants for whom data were missing did not significantly differ regarding age (p = .26), gender (p = .52), and health literacy (p = .21).

Statistical Analyses

First we explored the health behaviors and characteristics of the sample and the associations of these characteristics with health literacy; we tested differences by using chi-square tests. Second, using logistic regression analyses, we assessed the associations between health literacy and all health behaviors, crudely and adjusted for age and gender. Third, to assess the main associations of health literacy with the social factors, we repeated the analyses using these variables as outcomes. Fourth, we conducted sensitivity analyses to check whether choices in our analyses might have influenced the results. Finally, we assessed how social factors potentially moderated the associations between health literacy and health behaviors by adding the various separate social factors and their interactions with health literacy to a model with health literacy, age, and gender. We repeated this procedure for all health behaviors. We performed all analyses using SPSS 22.0 for Windows. We considered results to be statistically significant if $p < 0.05$.

Sensitivity Analyses

We conducted sensitivity analyses with two alternative cut-off points for low health literacy: 11 or lower, leading to a lower percentage of low health literacy (18.7%), and 13 or lower, leading to a higher percentage of low health literacy (51.7%). As the first question of our health literacy instrument might partially overlap with some social factors, we also conducted a sensitivity analysis using only the other two health literacy questions. This led to a continuous scale (2–10) in which a score of 7 or lower was considered to indicate low health literacy (29.5%).

Educational level and cognitive functioning are associated with health literacy (Yost, DeWalt, Lindquist, & Hahn, 2013) and might confound the analyses. We therefore repeated the analyses with adjustments for these variables. Educational level was measured at baseline and was split into three categories: Low (lower vocational education or less; 25.9%), medium (lower general secondary education or intermediate vocational education; 42.9%), and high (higher secondary general or vocational education or more; 31.2%). Cognitive functioning was measured at baseline by the Ruff Figural Fluency Test (Ruff, 1988) and was used as a continuous variable.

Results

The sample consisted of 3,241 participants (51.4% male). The participants had a mean age of 68.9 years at baseline (range 65–89), 70.4 at the first follow-up (range 66–90), and 71.3 at the second follow-up (range 66–91). Table 1 presents an overview of the health behaviors and social factors and of all associations of these factors with health literacy.

Health Literacy and Health Behaviors

Table 2 shows a significant association between low health literacy and most of the studied health behaviors. The crude models show statistically significant associations of low health literacy with insufficient physical activity, insufficient fruit consumption, insufficient vegetable consumption, lack of regular breakfast consumption, and obesity (odds ratios (ORs) > 1.31, p-values < .01). Low health literacy was negatively associated with alcohol consumption (OR = 0.84, p = .033), indicating that participants with high health literacy more often exceeded the recommendations for moderate alcohol consumption. We found no significant association between health literacy and smoking

Table 1. Prevalence of health behaviors and social factors of the participants by level of health literacy.

	Health literacy			
	Low (n = 1081, 33.4%)	High (n = 2160, 66.6%)	Total (n = 3241)	P
Health behaviors				
Insufficient physical activity	33.5	27.6	29.5	<.001
Insufficient fruit consumption	35.5	29.2	31.3	.003
Insufficient vegetable consumption	68.8	60.6	63.4	<.001
Smoker	6.3	5.7	5.9	.50
No regular breakfast consumption	6.1	4.0	4.7	.007
High alcohol consumption	30.8	34.6	33.3	.033
Obesity	19.4	15.0	16.4	.001
Social factors				
Lonely	12.7	7.5	9.2	<.001
Low social support	5.0	4.2	4.5	.27
Few social activities	10.8	7.6	8.7	.004
Few social contacts	12.9	9.1	10.3	<.001
Living alone	17.1	17.0	17.1	.96

Note. All p-values are based on χ^2 tests.

Table 2. Associations between health literacy (low vs. high) and health behaviors, crude and adjusted for gender and baseline age.

	Low (vs. high) health literacy			
	Crude OR (95% CI)	*p*	Adjusted OR (95% CI)	*p*
Insufficient (vs. sufficient) physical activity *(n = 3121)*	**1.32 (1.13–1.55)**	<.001	**1.31 (1.11–1.54)**	<.001
Insufficient (vs. sufficient) fruit consumption *(n = 2152)*	**1.34 (1.11–1.62)**	.003	**1.41 (1.16–1.70)**	<.001
Insufficient (vs. sufficient) vegetable consumption *(n = 2145)*	**1.43 (1.19–1.73)**	<.001	**1.51 (1.24–1.83)**	<.001
Smoker (vs. no smoker) *(n = 3146)*	1.11 (0.82–1.52)	.50	1.19 (0.87–1.63)	.26
Lack of regular (vs. regular) breakfast consumption *(n = 3222)*	**1.57 (1.13–2.18)**	.008	**1.66 (1.19–2.32)**	.003
High (vs. low) alcohol consumption *(n = 3180)*	**0.84 (0.72–0.99)**	.033	**0.81 (0.69–0.96)**	.013
Obesity (vs. non-obesity) *(n = 3241)*	**1.37 (1.13–1.66)**	.001	**1.35 (1.11–1.63)**	.002

Note. Bold ORs indicate that $p < .05$. OR = Odds ratio, CI = Confidence interval.

behavior. Adjusting for age and gender did not substantially change any of the associations.

Health Literacy and Social Factors

Table 3 shows statistically significant associations of low health literacy with loneliness, engaging in few social activities, and having few social contacts (ORs > 1.47, *p*-values < .01). We found no statistically significant associations between health literacy and social support or living situation. None of the studied associations changed substantially after adjusting for gender and age.

Moderation Analyses

Table 4 shows that, among older adults, social factors seldom moderated the associations between health literacy and health behaviors. The associations of health literacy with physical activity, fruit consumption, vegetable consumption, breakfast consumption, alcohol consumption, and obesity were not significantly moderated by any of the studied social factors. The association between health literacy and smoking behavior was only significantly moderated by the number of social contacts. Stratified logistic regression analyses revealed that having a low level of health literacy was associated with more smoking among older adults with many social contacts (OR = 1.38, 95% confidence interval (CI) = 0.99–1.92, $p = .055$), and with less smoking among those with few social contacts (OR = 0.35, 95% CI = 0.11–1.08, $p = .07$, results not tabulated). However, neither of these associations reached significance.

Sensitivity Analyses

The sensitivity analyses in which 18.7% of the sample were classified as having low health literacy (compared to 33.4% in the primary analyses) yielded results that were similar to the primary analyses. Most significant associations were stable (all ORs > 1.29, all *p*-values < .05), except the associations of health literacy with alcohol consumption (OR = 0.83, 95% CI = 0.68–1.01, $p = .063$) and obesity (OR = 1.19, 95% CI = 0.94–1.49, $p = .15$), which were no longer significant. The sensitivity analyses in which 51.7% of the sample were classified as having low health literacy revealed similar results, with only the association between health literacy and alcohol consumption losing significance (OR = 0.91, 95% CI = 0.78–1.06, $p = .22$) and the other significant results being stable (all ORs > 1.23, all *p*-values < .05). Restriction of our health literacy instrument to only the questions with definitely no overlap with social factors did not change any of our findings (results not shown).

Adjusting the analyses for education level changed the associations of health literacy with alcohol consumption (OR = 0.89, 95% CI = 0.74–1.06, $p = .18$), obesity (OR = 1.06, 95% CI = 0.86–1.31, $p = .58$), and social activities (OR = 1.33, 95% CI = 0.99–1.78, $p = .060$). The other significant associations did not change (all ORs > 1.30, all *p*-values < .05).

Adjustment for cognitive functioning did not change the results (all ORs > 1.25, all *p*-values < .05), except that the association

Table 3. Associations between health literacy (low vs. high) and social factors, crude and adjusted for gender and baseline age.

	Low (vs. high) health literacy			
	Crude OR (95% CI)	*p*	Adjusted OR (95% CI)	*p*
Lonely (vs. not lonely) *(n = 3194)*	**1.78 (1.39–2.26)**	<.001	**1.69 (1.32–2.16)**	<.001
Low (vs. high) social support *(n = 3189)*	1.22 (0.86–1.72)	.27	1.15 (0.81–1.64)	.43
Few (vs. many) social activities *(n = 2771)*	**1.48 (1.13–1.93)**	.005	**1.52 (1.16–2.00)**	.002
Few (vs. many) social contacts *(n = 3199)*	**1.48 (1.17–1.87)**	.001	**1.48 (1.17–1.87)**	.001
Living alone (vs. living with others) *(n = 3210)*	1.01 (0.83–1.22)	.96	0.87 (0.71–1.07)	.18

Note. Bold ORs indicate that $p < .05$. OR = Odds ratio, CI = Confidence interval.

Table 4. Moderation of the associations between health literacy (low vs. high) and health behaviors by social factors, adjusted for gender and baseline age, in odds ratios (with 95% confidence intervals).

	Loneliness	Social support	Social activities	Social contacts	Living situation
Insufficient physical activity	1.06 (0.63–1.80)	0.68 (0.31–1.50)	0.87 (0.49–1.53)	1.35 (0.82–2.22)	1.50 (0.98–2.29)
Insufficient fruit consumption	0.66 (0.35–1.23)	1.87 (0.74–4.73)	0.77 (0.38–1.55)	1.09 (0.60–1.97)	0.83 (0.50–1.38)
Insufficient vegetable consumption	0.74 (0.39–1.38)	0.82 (0.33–2.03)	0.93 (0.45–1.92)	1.24 (0.67–2.29)	0.78 (0.47–1.31)
Smoking	0.73 (0.29–1.85)	0.62 (0.17–2.24)	0.60 (0.20–1.76)	**0.25* (0.08–0.81)**	0.89 (0.41–1.91)
Lack of regular breakfast consumption	1.02 (0.33–3.20)	0.81 (0.17–3.93)	0.91 (0.31–2.72)	0.36 (0.13–1.04)	1.80 (0.76–4.30)
High alcohol consumption	0.80 (0.47–1.34)	0.42 (0.18–1.01)	0.60 (0.31–1.14)	1.23 (0.74–2.06)	0.86 (0.56–1.30)
Obesity	1.15 (0.62–2.13)	0.84 (0.37–1.91)	0.91 (0.47–1.78)	0.76 (0.41–1.42)	0.98 (0.60–1.58)

Note. ORs indicating increase in risk of low health literacy due to unfavorable social factors. All analyses adjusted for age and gender.
*Bold indicates that $p < .05$.

between health literacy and alcohol consumption dropped out of significance (OR = 0.84, 95% CI = 0.70–1.01, $p = .067$).

Discussion

Main Findings

As far as we know, this study is the first to examine the associations between health literacy and a large range of health behaviors and social factors, as well as the possible moderating role of social factors, among older adults. We found low health literacy in older adults to be associated with insufficient physical activity, insufficient fruit consumption, insufficient vegetable consumption, lack of regular breakfast consumption, low alcohol consumption, and more obesity, but not with smoking behavior. We also found low health literacy to be associated with loneliness, having few social contacts, and being engaged in few social activities, but not with social support and living situation (living alone vs. living with others). Results suggest that the associations between health literacy and health behaviors were generally not moderated by social factors. One exception was smoking, which was moderated by the number of social contacts.

In accordance with our expectations, we found associations between health literacy and health behaviors. These results are in line with results of other studies among older adults that found associations between health literacy and physical activity (Reisi et al., 2014), fruit and vegetable consumption (von Wagner, Knight, Steptoe, & Wardle, 2007), and BMI (Husson et al., 2015). However, some studies did not find associations between health literacy and some of the health behaviors that we studied (Geboers et al., 2014; von Wagner et al., 2007; Wolf, Gazmararian, & Baker, 2007). In contrast with the general pattern of results in our study, we found health literacy to be positively associated with alcohol consumption. An earlier study also suggested an association between low health literacy and low alcohol consumption (Husson et al., 2015). The higher alcohol consumption among older adults with high health literacy may reflect a kind of lifestyle in this group which is associated with having a high educational level. High health literacy is associated with being highly educated (Yost et al., 2013), and some studies suggest that highly educated people are more likely to exceed the guidelines for alcohol consumption (Merrick et al., 2008; Platt, Sloan, & Costanzo, 2010). This aligns with our finding that the association disappeared after adjusting for educational level. Future studies should aim to identify the factors behind the mixed results of studies on associations between health literacy and health behaviors.

As for social factors, we found associations between low health literacy and loneliness, being engaged in few social activities, and having few regular social contacts, which is in accordance with our expectations. One other cross-sectional study found an association of health literacy with engagement in social activities among older adults (Bennett et al., 2012). However, other than in our study, in this study no association between health literacy and loneliness was found, which might be explained by differences in the study characteristics, such as the population studied or the instruments used. Our results may reflect poorer communication skills in older adults with low health literacy, which limits their willingness and ability to maintain a large social network (Hester, 2009). These associations could also be the result of the link between health literacy and general literacy (World Health Organization, 2013), with literacy being associated with social outcomes from an early age (Glogowska et al., 2006). Our results do not allow for definitive conclusions about the direction of associations between health literacy and social factors. Having a small social network may thus lead to lower levels of health literacy, and decreasing cognitive capacities among older adults may lead to both lower health literacy and increased loneliness.

We found no associations between health literacy and social support and living situation (living alone vs. living with others). An explanation may be that although social skills generally decrease due to aging (Simon, Chang, Zhang, Ruan, & Dong, 2014), this decrease affects the living situation less than it affects the undertaking of social activities and maintenance of a social network.

Contrary to our expectations, we found that social factors generally do not moderate the associations between health literacy and health behaviors. The negative impacts of low health literacy on health behaviors are apparently not limited to older adults who are lonely, have low social support, have few social contacts, engage in few social activities, or are living alone. We

found only one significant interaction effect: the association between health literacy and smoking behavior is moderated by the number of social contacts. More specifically, our results suggest that a low level of health literacy is associated with more smoking among older adults with many social contacts, and with less smoking among those with few social contacts, but neither of these relations reached significance. Social pressure could partially explain this moderation. Having many social contacts may imply many exposures to social pressure to smoke. People with low health literacy may be relatively sensitive to give in to this social pressure. However, this does not explain why high health literacy is associated with more smoking among those with few regular social contacts. Moreover, it should be noted that we assessed a large number of associations, which increased the chance of spuriously finding statistical significance.

Strengths and Limitations

The main strengths of our study are the use of a relatively large sample of community-dwelling older adults and a large set of health related behaviors. The power of our study to detect relevant differences was high. The power was 79% for the difference in prevalence of few social activities between older adults with low and high health literacy (i.e. 10.8% vs. 7.6%) and higher for almost all larger differences. The stability of most associations in various sensitivity analyses shows that our results were not substantially influenced by methodological choices regarding the measures.

Limitations of our study should also be taken into account. First, we used a subjective instrument to measure health literacy, which might have led to the underestimation of some associations as people may sometimes not be fully aware of their own health literacy limitations. However, our instrument has been validated (Chew et al., 2004, 2008) and has been used in various other studies (Aikens & Piette, 2009; Bayliss, Ellis, & Steiner, 2007; Geboers et al., 2014; Halverson et al., 2015). Second, data on health literacy were collected at a later point in time than the other data. As health literacy has shown to gradually decline in older adults (Kobayashi, Wardle, Wolf, & von Wagner, 2015; Morris, Maclean, & Littenberg, 2013), our findings may underestimate the actual associations of health literacy with health behaviors and social factors. Third, most health behaviors and social factors were only measured by a few questions. This may have led to measurement error, possibly resulting in an underestimation of actual effect sizes. However, many of these measures are part of routine instruments with extensive documentation of validity and reliability. Fourth, our findings need confirmation as we studied a rather large number of associations.

Implications

Low health literacy was associated with poor health behaviors and an unfavorable social situation, which may partially explain the associations between health literacy and health outcomes such as general health status (Bennett et al., 2009), rates of hospitalization (Cho et al., 2008), and mortality (Baker et al., 2008). This has important implications for research and practice. An explanation for the association between health literacy and health behaviors might be that people with low health literacy may be less aware of the importance of health behaviors. Interventions to mitigate the negative effects of low health literacy in older adults could then focus on improving the knowledge of this group regarding the benefits of health behaviors such as physical activity and fruit and vegetable consumption. Low health literacy was also associated with loneliness, engaging in fewer social activities, and a lower number of social contacts. Interventions among older adults could therefore also focus on social aspects, for example by including social activities (Luten, Reijneveld, Dijkstra, & de Winter, 2016) or by directly addressing loneliness (Kremers, Steverink, Albersnagel, & Slaets, 2006).

Our research has identified associations between health literacy, health behaviors, and social factors, but pinpointed no strong moderating effects of social factors on the association between health literacy and health behaviors. Future studies should further assess pathways between health literacy, health behaviors, and social factors, for example by focusing on social factors that may mediate the associations between health literacy and health behaviors.

As the majority of participants in our analyses were between 65 and 70 years at baseline, further research should test the studied associations in those above the age of 75, to assess the generalizability of our findings.

Conclusions

We have found that a large range of unfavorable health behaviors are likely to be greater among older adults with low health literacy. This could partially explain the associations between low health literacy and negative health outcomes. Low health literacy is also associated with loneliness, engaging in few social activities, and having few social contacts. However, the associations between health literacy and health behaviors are not primarily moderated by social factors. The negative impacts of low health literacy on health behaviors among older adults are apparently not limited to those who are lonely, have low social support, have few social contacts, engage in few social activities, or are living alone. Much health can be gained by better addressing this group.

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