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# Health Literacy Mediates the Relationship Between Educational Attainment and Health Behavior: A Danish Population-Based Study

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Individuals with a lower education level frequently have unhealthier behaviors than individuals with a higher education level, but the pathway is not fully understood. The aim of this study was to investigate whether health literacy mediates the association between educational attainment and health behavior (smoking, physical inactivity, poor diet) and obesity. The study included respondents ages 25 years or older drawn from a large population-based survey conducted in 2013 ( $N = 29,473$ ). Two scales from the Health Literacy Questionnaire were used: (a) Understanding health information well enough to know what to do and (b) Ability to actively engage with health care providers. Multiple mediation analyses were conducted using the Karlson-Holm-Breen method. The study showed that health literacy in general and the ability to understand health information in particular mediated the relationship between educational attainment and health behavior, especially in relation to being physically inactive (accounting for 20% of the variance), having a poor diet (accounting for 13% of the variance), and being obese (accounting for 16% of the variance). These findings suggest that strategies for improving health behavior and reducing health inequalities may benefit from adopting a stronger focus on health literacy within prevention, patient education, and other public health interventions.

The persistence of social inequality in health is a major concern in public health (Mackenbach, 2012). In general, individuals with low education levels have a poorer health status than well-educated individuals, which is indicated by worse self-reported health and physical functioning as well as by higher levels of morbidity and disability and a shorter life expectancy (Diderichsen et al., 2012; Gallo et al., 2012; Mackenbach, 2012; Ullits et al., 2015). It is frequently reported that people with low educational attainment have higher rates of unhealthy behaviors (such as smoking, physical inactivity, and poor diet) and obesity than people with higher levels of education (Buck & Frosini, 2012; Laaksonen et al., 2008; Lantz, Golberstein, House, & Morenoff, 2010; Marmot, 2005; McFadden, Luben, Wareham, Bingham, & Khaw, 2008; Nandi, Glymour, & Subramanian, 2014; Nordahl et al., 2014; Stringhini et al., 2010, 2011). In order to target these disparities, it is important to understand how educational attainment is related to health behavior. A number of competing mechanisms may mediate the relationship between education and health behavior. Such mechanisms include work and economic conditions as well as sociopsychological resources (Cutler & Lleras-Muney, 2010), but the

pathway is not fully understood. To reduce inequality in health and to facilitate the development of targeted and effective interventions, a clearer conceptualization and empirical investigation of the pathways between education and health behavior is needed.

*Health literacy* is defined by the World Health Organization as the cognitive and social skills that determine persons' motivation and ability to gain access to, understand, and use information in ways that promote and maintain good health (Nutbeam, 1986). Health literacy brings together many concepts that relate to what people need in order to make effective decisions about health for themselves and their families. It is well established that education level is associated with health literacy level (Barber et al., 2009; Beauchamp et al., 2015; Bo, Friis, Osborne, & Maindal, 2014; Paasche-Orlow, Parker, Gazmararian, Nielsen-Bohlman, & Rudd, 2005; Van Der Heide, Wang, et al., 2013). Some studies have shown that inadequate health literacy is associated with unhealthy behaviors such as smoking, physical inactivity, and poor diet (Adams et al., 2013; Geboers, De Winter, Luten, Jansen, & Reijneveld, 2014; Husson, Mols, Fransen, Van De Poll-Franse, & Ezendam, 2015; Speirs, Messina, Munger, & Grutzmacher, 2012; Von Wagner, Knight, Steptoe, & Wardle, 2007), although Wolf, Gazmararian, and Baker (2007) found that limited health literacy is not independently associated with some health behaviors.

Some authors have suggested that health literacy is a mediator between education level and health outcomes (Howard, Sentell, & Gazmararian, 2006; Lee, Tsai, Tsai, & Kuo, 2010; Nielsen-Bohman, Panzer, & Kinding, 2004; Paasche-Orlow et al., 2005; Schillinger, Barton, Karter, Wang, & Adler, 2006; Van Der Heide, Rademakers, et al., 2013). As poor health behaviors affect health outcomes directly, it is reasonable to assume that health literacy also mediates the relationship between education and health behavior. Yet to the best of our knowledge, this relationship has not been investigated in population-based studies. Health literacy may mediate the effects of education on health behavior through a number of mechanisms. Previous studies have shown that inadequate health literacy (measured in terms of health-related reading ability and numeracy) is associated with poor problem-solving ability, low self-efficacy, low motivation, and poor knowledge of how to perform self-care behaviors (Amalraj, Starkweather, Nguyen, & Naeim, 2009; Geboers et al., 2014; Husson et al., 2015; Kaminski & Good, 1998; Osborn, Paasche-Orlow, Bailey, & Wolf, 2011; Paasche-Orlow & Wolf, 2007; Schillinger et al., 2006; Torres & Marks, 2009; Verhoeven & Snow, 2001; Wolf et al., 2004). It is important to know whether health literacy does indeed mediate the relationship between education level and health behavior. If this is the case, adults with a lower formal education level may benefit from health literacy-informed interventions and from health services that are responsive to the needs of populations with limited health literacy.

Using a large population-based survey, this study aimed to investigate whether health literacy mediates the association between education level and health behavior (smoking, physical inactivity, poor diet) and obesity. Figure 1 illustrates the model used for the mediation analyses. Two distinct health literacy dimensions from the 9-dimension Health Literacy Questionnaire (HLQ) were used: (a) Understanding health information well enough to know what to do and (b) Actively engage with health care providers (Osborne, Batterham, Elsworth, Hawkins, & Buchbinder, 2013).

## Methods

### Study Design and Data Collection

The study was based on data from respondents ages 25 years or older. The data were drawn from the 2013 Danish health and

morbidity survey called “How Are You?” Geographically speaking, Denmark is divided into five administrative regions. The present study comprised data from one of these regions—the Central Denmark Region—where approximately 22% of the Danish population resides. The population of the Central Denmark Region has a similar demographic composition (gender, age, and marital status) and similar health and social factors as the total Danish population (Christensen, Davidsen, Ekholm, Pedersen, & Juel, 2014).

The survey consisted of a county-stratified random sample of 46,354 persons who were drawn from the Danish Civil Registration System using as a key the unique personal identification number given to each Danish citizen. People were invited to complete a postal or a Web-based questionnaire. Three reminders were issued. Data were collected by the Central Denmark Region between February and April 2013. A total of 29,473 people (63.6%) completed and returned the questionnaire. The personal identification number was used by Statistics Denmark to link both respondents and nonrespondents to the Danish national registers. Weights were used to account for differences in selection probabilities and response rates. These weights were constructed using a model-based calibration approach based on register information from Statistics Denmark. Data were weighted to represent the population of the Central Denmark Region.

### Measures

#### Health Literacy

The HLQ (Osborne et al., 2013) is a widely used measure of health literacy that has been translated into many European and Asian languages. It was developed using a validity-driven approach including in-depth grounded consultations, psychometric analyses, and cognitive interviews. The HLQ consists of nine scales. The translation and cultural adaption of the questions from English into Danish followed a rigorous forward-backward translation procedure and cognitive testing to ensure cross-cultural validity.

In the present study, two of the nine HLQ scales were included: Understanding health information well enough to know what to do and Actively engage with health care providers. Given that population surveys have limited space for survey questions, only these two scales were selected that covered two distinct elements of health literacy that we hypothesized would provide valuable perspectives within a larger general population health and morbidity survey. Each scale comprised five items for which participants indicated their response on a 4-point scale: 1 = *very difficult*, 2 = *difficult*, 3 = *easy*, and 4 = *very easy*. Scale scores were calculated as the mean of the five item scores and then standardized to range from 1 (lowest ability) to 4 (highest ability) to ensure consistency with the response options. If responses to more than two items in a scale were missing for an individual, the scale score for that individual was regarded as missing. As a result of this, 1,962 observations (6.7%) were excluded from the Understanding health information scale and 1,925 observations (6.5%) were excluded from the Actively engage with health care providers scale. Cronbach's alpha coefficients indicated that the internal consistency of both scales was high: Understanding health information ( $\alpha = .87$ ) and Actively engage with health care providers ( $\alpha = .91$ ).

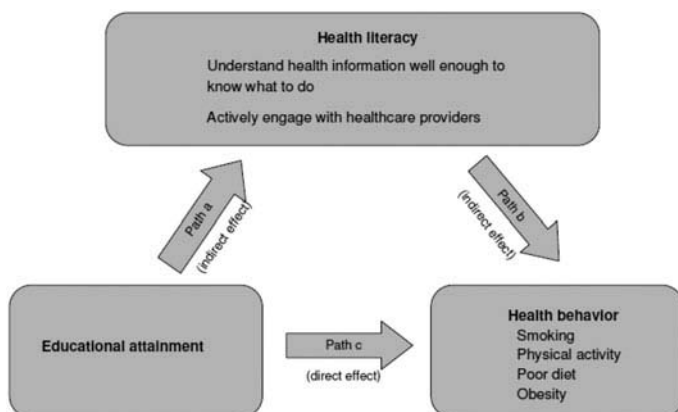


Fig. 1. Model of mediation analysis.

### Health Behavior

Three measures of health behavior (smoking, physical inactivity, poor diet) were used. Respondents who smoked on a daily basis were classified as smokers. Furthermore, respondents were classified as physically inactive if during a typical week they were not physically active for a minimum of 30 minutes per day as recommended by the Danish Health and Medicines Authority (Kiens et al., 2007). Dietary habits were assessed using the Dietary Quality Score (Toft, Kristoffersen, Lau, Borch-Johnsen, & Jorgensen, 2007), which classifies the quality of the diet in relation to cardiovascular risk. The scale consists of 25 items, including questions about type of bread spread, fats used for cooking, and how often the participants consumed selected food items (including fish, meat, fruits, and vegetables). Poor diet was defined by a low amount of fruit, vegetables, and fish and a high amount of saturated fat.

### Obesity

Self-reported height and weight were used to calculate body mass index, and obesity was defined as a body mass index of 30 kg/m<sup>2</sup> or more.

### Educational Attainment

The participants were asked about their highest level of completed school education and any further higher level education. Participants were classified into two educational categories: (a) low level of education and (b) medium/high level of education. Low level of education included basic education (primary and lower secondary school). Medium/high level included education levels above the low level (vocational education; upper secondary school; and short-, medium-, and long-term higher education).

### Demographic and Socioeconomic Factors

Data on age, gender, ethnic background, and marital status were collected from national registers to avoid missing data. Respondents were defined as Danish if they had Danish citizenship or if at least one of their parents was a Danish citizen. Marital status referred to whether an individual was married or not.

### Ethics

The study was approved by the Danish Data Protection Agency (Reference No. 2007-58-0010) and was conducted in accordance with the Helsinki Declaration. Information about the survey was provided to potential participants in writing and via the Web. The participants' voluntary completion and return of the survey questionnaires constituted implied consent.

### Statistical Analysis

Prior to the multiple mediation analyses, we used regression analyses to test (a) the association between education level and the two health literacy scales, (b) the association between the two health literacy scales and each of the four health behavior measures, and (c) the association between education level and each of the four health behavior measures (see Figure 1). All bivariate analyses identified significant associations (data not shown).

To determine the indirect effect of health literacy on the association between education and each of the four dependent

variables (smoking, physical inactivity, poor diet, obesity), we conducted multiple mediation analyses using the Karlson-Holm-Breen STATA command (Breen, Karlson, & Holm, 2013; Kohler, Karlson, & Holm, 2011). This command decomposes the total effect into the direct effect (the effect of the independent variable [education level] on the dependent variable [health behavior] while controlling for mediating variables [health literacy scales]) and the indirect effect (the effect of the independent variable on the dependent variable through mediating variables; Breen et al., 2013). All mediation analyses were further adjusted for age, gender, ethnic background, and marital status. Significance was set at  $p < .05$ . Statistical analyses were performed using STATA 13.

### Results

A total of 18.6% of the respondents had low levels of education (see Table 1). In total, 17.6% were daily smokers, 18.9% were physically inactive, 12.3% had a poor diet, and 15.6% were obese.

Low educational attainment significantly predicted daily smoking (total effect; see Table 2), even when the two health literacy scales were included as mediating factors (direct effect). Both health literacy scales were significant mediators in the association between educational attainment and daily smoking (see Table 3), but the contributing factor was relatively small (Understanding health information: 6.6%, Actively engage with health care providers: 4.5%).

Low educational attainment was a significant predictor of physical inactivity (total effect; see Table 2), even when the two health literacy scales were included as mediating factors (direct effect). Moreover, both health literacy scales were significant mediators in the association between educational attainment and physical inactivity (see Table 3). The Understanding health information scale accounted for 20.1% of the variance between educational attainment and physical inactivity, whereas the Actively engage with health care providers scale accounted for only 5.4% of the variance. Hence, Understanding health information had the strongest indirect effect on physical inactivity (78.8%).

Low educational attainment was also a significant predictor of having an unhealthy diet (total effect), even when the health literacy scales were included as mediating factors (direct effect; see Table 2). The understanding health information scale mediated the association between education and having an unhealthy diet (accounting for 13.3% of the variance), whereas the Actively engage with health care providers scale did not contribute significantly to the total effect of the association between educational attainment and healthy diet (see Table 3).

Finally, Table 2 shows that low educational attainment was also a significant predictor of obesity (total effect), even when the two health literacy scales were used as mediating factors (direct effect). Both health literacy scales were significant mediators in the association between education and obesity (see Table 3). The Understanding health information scale accounted for 16.2% of the total variance, whereas the Actively engage with health care providers scale accounted for only 4.2% of the variance. Of the two scales, Understanding health information had the strongest indirect effect on obesity (79.6%).



**Table 1.** Characteristics of individuals who participated in the 2013 health and morbidity survey ( $N = 29,473$ ).

Characteristic	<i>n</i>	% <sup>a</sup>	<i>M</i>	<i>SD</i>
Demographic and socioeconomic factors				
Age			52.1	16.3
Gender				
Male	14,045	49.4		
Female	15,448	50.6		
Ethnicity				
Danish	28,400	93.6		
Not Danish	1,073	6.4		
Educational attainment				
Low	5,507	18.6		
Medium/high	23,037	81.4		
Marital status				
Married	19,828	58.9		
Not married		41.1		
Health literacy				
Understanding health information well enough to know what to do			3.1	0.6
Actively engage with health care providers			3.1	0.6
Health behavior				
Smoking				
Daily smoking	4,856	17.6		
Not daily smoking	23,971	82.4		
Physical activity				
Physically inactive	5,253	18.9		
Not physically inactive	23,484	81.1		
Diet				
Poor diet	3,268	12.3		
Not poor diet	24,872	87.7		
Obesity				
Obese (BMI $\geq 30$ )	4,602	15.6		
Not obese (BMI $< 30$ )	24,057	84.4		

Note. BMI = body mass index.

<sup>a</sup>All percentages are weighted on register data to represent the population of the Central Denmark Region, 2013.

## Discussion

To our knowledge, this is the first population-based study examining whether components of health literacy mediate the often-reported associations between education and a number of important health behaviors. We found that pertinent elements of health literacy do indeed act as mediators in the relationship between education and health behavior. Specifically, among people reporting that they are physically inactive, have a poor diet, and/or are obese, the ability to understand health information accounted for a substantial percentage of the total association with educational attainment. Of the two health literacy scales, Understanding health information was clearly the stronger mediating factor. A reason for this may be that this scale reflects a basic set of competencies needed for people to become equipped with knowledge through reading and comprehension of information and

**Table 2.** Direct effect of education on health behaviors and indirect effect of health literacy on the association between education and health behaviors.

Dependent variable and effect <sup>a</sup>	OR [CI]	<i>SE</i>	<i>Z</i>	<i>p</i>
Smoking				
Total effect	1.86 [1.68, 2.05]	0.09	12.23	.000
Direct effect	1.73 [1.57, 1.92]	0.09	10.65	.000
Indirect effect	1.07 [1.05, 1.10]	0.01	5.88	.000
Physical inactivity				
Total effect	1.57 [1.43, 1.72]	0.07	9.46	.000
Direct effect	1.40 [1.27, 1.54]	0.07	6.95	.000
Indirect effect	1.12 [1.10, 1.15]	0.01	9.40	.000
Unhealthy diet				
Total effect	2.37 [2.12, 2.65]	0.13	15.16	.000
Direct effect	2.10 [1.88, 2.36]	0.12	12.83	.000
Indirect effect	1.13 [1.10, 1.16]	0.02	8.25	.000
Obesity				
Total effect	1.72 [1.56, 1.90]	0.09	10.67	.000
Direct effect	1.54 [1.39, 1.71]	0.08	8.28	.000
Indirect effect	1.12 [1.09, 1.15]	0.01	8.67	.000

Note. All estimates are adjusted for age, gender, ethnic background, and marital status. OR = odds ratio; CI = confidence interval.

<sup>a</sup>Total effect: The effect of the independent variable (education) on the dependent variable (specific health behaviors) when not controlling for mediating variables (health literacy). Direct effect: The effect of the independent variable (education) on the dependent variable (specific health behaviors) when controlling for mediating variables (health literacy). Indirect effect: The effect of the independent variable (education) on the dependent variable (specific health behaviors) through mediating variables (health literacy).

instructions about health. The other scale, Actively engage with health care providers, may have a less direct or a downstream impact on health behaviors. People whose skills do not allow them to properly understand health information may be less exposed to common health information, and they may not have the skills needed to comprehend and act on health-promoting communication (Nutbeam, 2008; Roberts, 2015).

Our study shows that compared with the other health behaviors explored, health literacy plays only a small part in mediating the relationship between education and smoking. The underlying causes for this may relate to the fact that in Denmark policy regulations and mass media campaigns relating to tobacco use have been in place for more than two decades. Regardless of their health literacy levels, most persons are therefore aware of the health-related consequences of smoking. Instead, certain cultural factors and normative beliefs in people with a low educational attainment may in part explain the strong social gradient in smoking status (Mackenbach, 2012).

Our study also shows that even though the association between educational attainment and health behavior is partly mediated by health literacy, educational attainment remains associated with all four health behavior factors when two indicators of health literacy are taken into account. This association remains even after adjustment for age, gender, ethnic background, and marital status. Hence, the present study suggests that the two indicators of health literacy measured contribute to the link between education and

**Table 3.** Contribution of each health literacy mediator on the association between education and health behaviors

Dependent variable and health literacy mediating variable	Coefficient	SE	p	Contribution to the indirect effect (%)	Contribution to the total effect (%)
Smoking					
Understanding health information well enough to know what to do	−0.14	0.06	.015	59.5	6.6
Actively engage with health care providers	−0.14	0.05	.008	40.5	4.5
Physical inactivity					
Understanding health information well enough to know what to do	−0.31	0.06	.000	78.8	20.1
Actively engage with health care providers	−0.12	0.08	.015	21.3	5.4
Unhealthy diet					
Understanding health information well enough to know what to do	−0.41	0.07	.000	96.3	13.3
Actively engage with health care providers	−0.02	0.07	.739	3.7	0.5
Obesity					
Understanding health information well enough to know what to do	−0.30	0.06	.000	79.6	16.2
Actively engage with health care providers	−0.11	0.06	.042	20.4	4.2

health behavior. Still, the measures do not offer a complete explanation of the pathway. The full construct of health literacy, as defined by the HLQ, includes seven other independent scales that may also be strong determinants. Other variables, such as social norms, workplace environments, knowledge, stressors/resources, and work status/income, that differ between educational groups could also be part of the mechanisms explaining the association between education and health behavior, as found in other studies (Cutler & Lleras-Muney, 2010; Godin et al., 2010; Layte & Whelan, 2009; Matsuyama et al., 2011; Mulder, De Bruin, Schreurs, Van Ameijden, & Van Woerkum, 2011). For instance, individuals with low educational attainment may have poorer health behaviors because they face different constraints, have different beliefs about the impact of their behavior, or have different norms than individuals with higher levels of education (Cutler & Lleras-Muney, 2010).

To date, most research on the association between health literacy and health behavior has used available measures of functional health literacy (Adams et al., 2013; Geboers et al., 2014; Husson et al., 2015; Speirs et al., 2012; Von Wagner et al., 2007; Wolf et al., 2007). With the development of new health literacy measures, a much broader range of the health literacy concept can now be measured. In this study we sought to measure difficulties people have in understanding health information and also difficulties they have in interacting with health care providers. The two different measures of health literacy are self-reported and capture a dynamic state depending on how the individual person perceives his or her current situation. It is important to note that the way in which persons respond to questions about their ability to understand health information and actively engage with health care providers varies depending on the presence or absence of demands related to their specific health conditions and the complexity of the immediate health care system with which they engage (Batterham, Hawkins, Collins, Buchbinder, & Osborne, 2016; Edwards, Wood, Davies, & Edwards, 2012).

This study has some limitations. First, it is important to note that our findings are based on cross-sectional data, and therefore no conclusions about temporality or causation can be made. Second, the ability and motivation to fill out a health survey

may be viewed as a health literacy competency in itself; thus, the most vulnerable groups may have been excluded from our study. The study is also limited because it included only two of the nine defined scales of the HLQ. Thus, it suffers from construct underrepresentation (Buchbinder et al., 2011). We can therefore draw conclusions only about the two scales we measured and not about health literacy overall. Application of the complete tool in this large population survey was not possible for practical reasons. Future research may be strengthened through the measurement of the full range of health literacy indicators and may therefore generate a more complete understanding of any health literacy strengths and limitations that individual persons have independent of their educational attainment and how these strengths and limitations determine their health behavior and health status.

## Conclusion

Health literacy, particularly the ability to understand health information, is a mediator in the relationship between educational attainment and health behavior, especially in relation to being physically inactive, having a poor diet, and being obese. The findings of the present study indicate that strategies for improving public health and reducing health inequalities may be improved through a stronger focus on health literacy. Health literacy is very closely linked to education and health inequalities. Interventions aimed at improving health behavior and health status have the potential to become more targeted and effective when informed by robust data on the health literacy of the target populations.

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## References

- Adams, R. J., Piantadosi, C., Ettridge, K., Miller, C., Wilson, C., Tucker, G., & Hill, C. L. (2013). Functional health literacy mediates the relationship between socio-economic status, perceptions and lifestyle behaviors related to cancer risk in an Australian population. *Patient Education and Counseling*, 91(2), 206–212. doi:10.1016/j.pec.2012.12.001
- Amalraj, S., Starkweather, C., Nguyen, C., & Naeim, A. (2009). Health literacy, communication, and treatment decision-making in older cancer patients. *Oncology*, 23(4), 369–375.
- Barber, M. N., Staples, M., Osborne, R. H., Clerehan, R., Elder, C., & Buchbinder, R. (2009). Up to a quarter of the Australian population may have suboptimal health literacy depending upon the measurement tool: Results from a population-based survey. *Health Promotion International*, 24(3), 252–261. doi:10.1093/heapro/dap022
- Batterham, R., Hawkins, M., Collins, P., Buchbinder, R., & Osborne, R. (2016). Health literacy: Applying current concepts to improve health services and reduce health inequalities. *Public Health*, 132, 3–12. doi:10.1016/j.puhe.2016.01.001
- Beauchamp, A., Buchbinder, R., Dodson, S., Batterham, R. W., Elsworth, G. R., McPhee, C., & Osborne, R. H. (2015). Distribution of health literacy strengths and weaknesses across socio-demographic groups: A cross-sectional survey using the Health Literacy Questionnaire (HLQ). *BMC Public Health*, 15, 678. doi:10.1186/s12889-015-2056-z
- Bo, A., Friis, K., Osborne, R. H., & Maindal, H. T. (2014). National indicators of health literacy: Ability to understand health information and to engage actively with healthcare providers—A population-based survey among Danish adults. *BMC Public Health*, 14, 1095. doi:10.1186/1471-2458-14-1095
- Breen, R., Karlson, K. B., & Holm, A. (2013). Total, direct, and indirect effects in logit and probit models. *Sociological Methods & Research*, 42, 164–191. doi:10.1177/0049124113494572
- Buchbinder, R., Batterham, R., Elsworth, G., Dionne, C. E., Irvin, E., & Osborne, R. H. (2011). A validity-driven approach to the understanding of the personal and societal burden of low back pain: Development of a conceptual and measurement model. *Arthritis Research & Therapy*, 13(5), R152. doi:10.1186/ar3468
- Buck, D., & Frosini, F. (2012). *Clustering of unhealthy behaviours over time: Implications for policy and practice*. London, UK: The King's Fund.
- Christensen, A. I., Davidsen, M., Ekholm, O., Pedersen, P. V., & Juel, K. (2014). *Danskernes sundhed – den nationale sundhedsprofil 2013* [The health of the Danes—The national public health survey 2013]. Copenhagen, Denmark: Sundhedsstyrelsen.
- Cutler, D. M., & Lleras-Muney, A. (2010). Understanding differences in health behaviors by education. *Journal of Health Economics*, 29(1), 1–28. doi:10.1016/j.jhealeco.2009.10.003
- Diderichsen, F., Andersen, I., Manuel, C., Andersen, A. M., Bach, E., Baadsgaard, M., ... Søgaard, J. (2012). Health inequality—Determinants and policies. *Scandinavian Journal of Public Health*, 40(8 Suppl.), 12–105. doi:10.1177/1403494812457734
- Edwards, M., Wood, F., Davies, M., & Edwards, A. (2012). The development of health literacy in patients with a long-term health condition: The health literacy pathway model. *BMC Public Health*, 12(1), 130. doi:10.1186/1471-2458-12-130
- Gallo, V., Mackenbach, J. P., Ezzati, M., Menzies, G., Kunst, A. E., Rohrmann, S., & Vineis, P. (2012). Social inequalities and mortality in Europe—Results from a large multi-national cohort. *PLoS ONE*, 7(7), e39013. doi:10.1371/journal.pone.0039013
- Geboers, B., De Winter, A. F., Luten, K. A., Jansen, C. J., & Reijneveld, S. A. (2014). The association of health literacy with physical activity and nutritional behavior in older adults, and its social cognitive mediators. *Journal of Health Communication*, 19(Suppl. 2), 61–76. doi:10.1080/10810730.2014.934933
- Godin, G., Sheeran, P., Conner, M., Belanger-Gravel, A., Gallani, M. C., & Nolin, B. (2010). Social structure, social cognition, and physical activity: A test of four models. *British Journal of Health Psychology*, 15(Pt. 1), 79–95. doi:10.1348/135910709X429901
- Howard, D. H., Sentell, T., & Gazmararian, J. A. (2006). Impact of health literacy on socioeconomic and racial differences in health in an elderly population. *Journal of General Internal Medicine*, 21(8), 857–861. doi:10.1111/j.1525-1497.2006.00530.x
- Husson, O., Mols, F., Fransen, M. P., Van De Poll-Franse, L. V., & Ezendam, N. P. (2015). Low subjective health literacy is associated with adverse health behaviors and worse health-related quality of life among colorectal cancer survivors: Results from the profiles registry. *Psycho-Oncology*, 24(4), 478–486. doi:10.1002/pon.3678
- Kaminski, R. A., & Good, R. H. (1998). Assessing early literacy skills in a problem-solving model: Dynamic indicators of basic early literacy skills. In M. R. Shinn (Ed.), *Advanced applications of curriculum-based measurement: The Guilford school practitioner series* (pp. 113–144). New York, NY: Guilford Press.
- Kiens, B., Beyer, N., Brage, S., Hyldstrup, L., Ottesen, L. S., Overgaard, K., & Puggaard, L. (2007). *Fysisk inaktivitet – konsekvenser og sammenhænge* [Physical inactivity—Consequences and associations]. Copenhagen, Denmark: Motions og Ernæringsrådet.
- Kohler, U., Karlson, K. B., & Holm, A. (2011). Comparing coefficients of nested nonlinear probability models. *The Stata Journal*, 11, 420–438.
- Laaksonen, M., Talala, K., Martelin, T., Rahkonen, O., Roos, E., Helakorpi, S., & Prattala, R. (2008). Health behaviours as explanations for educational level differences in cardiovascular and all-cause mortality: A follow-up of 60 000 men and women over 23 years. *European Journal of Public Health*, 18(1), 38–43. doi:ckm051[pil]
- Lantz, P. M., Golberstein, E., House, J. S., & Morenoff, J. (2010). Socioeconomic and behavioral risk factors for mortality in a national 19-year prospective study of U.S. adults. *Social Science & Medicine*, 70(10), 1558–1566. doi:10.1016/j.socscimed.2010.02.003
- Layte, R., & Whelan, C. T. (2009). Explaining social class inequalities in smoking: The role of education, self-efficacy, and deprivation. *European Sociological Review*, 25, 399–410. doi:10.1093/esr/jcn022
- Lee, S. Y., Tsai, T. I., Tsai, Y. W., & Kuo, K. N. (2010). Health literacy, health status, and healthcare utilization of Taiwanese adults: Results from a national survey. *BMC Public Health*, 10, 614. doi:10.1186/1471-2458-10-614
- Mackenbach, J. P. (2012). The persistence of health inequalities in modern welfare states: The explanation of a paradox. *Social Science & Medicine*, 75(4), 761–769. doi:10.1016/j.socscimed.2012.02.031
- Marmot, M. (2005). Social determinants of health inequalities. *The Lancet*, 365(9464), 1099–1104. doi:10.1016/S0140-6736(05)74234-3
- Matsuyama, R. K., Wilson-Genderson, M., Kuhn, L., Moghanaki, D., Vachhani, H., & Paasche-Orlow, M. (2011). Education level, not health literacy, associated with information needs for patients with cancer. *Patient Education and Counseling*, 85(3), e229–e236. doi:10.1016/j.pec.2011.03.022
- McFadden, E., Luben, R., Wareham, N., Bingham, S., & Khaw, K.-T. (2008). Occupational social class, educational level, smoking and body mass index, and cause-specific mortality in men and women: A prospective study in the European Prospective Investigation of Cancer and Nutrition in Norfolk (EPIC-Norfolk) cohort. *European Journal of Epidemiology*, 23(8), 511–522. doi:10.1007/s10654-008-9267-x
- Mulder, B. C., De Bruin, M., Schreurs, H., Van Ameijden, E. J., & Van Woerkum, C. M. (2011). Stressors and resources mediate the association of socioeconomic position with health behaviours. *BMC Public Health*, 11(1), 798. doi:10.1186/1471-2458-11-798
- Nandi, A., Glymour, M. M., & Subramanian, S. V. (2014). Association among socioeconomic status, health behaviors, and all-cause mortality in the United States. *Epidemiology*, 25(2), 170–177. doi:10.1097/EDE.0000000000000038
- Nielsen-Bohman, L., Panzer, A. M., & Kinding, D. A. (2004). *Health literacy: A prescription to end confusion*. Washington, DC: National Academies Press.
- Nordahl, H., Lange, T., Osler, M., Diderichsen, F., Andersen, I., Prescott, E., & Rod, N. H. (2014). Education and cause-specific mortality: The mediating role of differential exposure and vulnerability to behavioral risk factors. *Epidemiology*, 25(3), 389–396. doi:10.1097/EDE.0000000000000080

- Nutbeam, D. (1986). Health promotion glossary. *Health Promotion International*, 1(1), 113–127. doi:10.1093/heapro/1.1.113
- Nutbeam, D. (2008). The evolving concept of health literacy. *Social Science & Medicine*, 67(12), 2072–2078. doi:10.1016/j.socscimed.2008.09.050
- Osborn, C. Y., Paasche-Orlow, M. K., Bailey, S. C., & Wolf, M. S. (2011). The mechanisms linking health literacy to behavior and health status. *American Journal of Health Behavior*, 35(1), 118–128. doi:10.5555/ajhb.2011.35.1.118[pil]
- Osborne, R. H., Batterham, R. W., Elsworth, G. R., Hawkins, M., & Buchbinder, R. (2013). The grounded psychometric development and initial validation of the Health Literacy Questionnaire (HLQ). *BMC Public Health*, 13(1), 658. doi:10.1186/1471-2458-13-658
- Paasche-Orlow, M. K., Parker, R. M., Gazmararian, J. A., Nielsen-Bohman, L. T., & Rudd, R. R. (2005). The prevalence of limited health literacy. *Journal of General Internal Medicine*, 20(2), 175–184. doi:10.1111/j.1525-1497.2005.40245.x
- Paasche-Orlow, M. K., & Wolf, M. S. (2007). The causal pathways linking health literacy to health outcomes. *American Journal of Health Behavior*, 31(Suppl. 1), S19–S26. doi:10.5993/AJHB.31.s1.4
- Roberts, J. (2015). *Local action on health inequalities: Improving health literacy to reduce health inequalities*. London, UK: Public Health England.
- Schillinger, D., Barton, L. R., Karter, A. J., Wang, F., & Adler, N. (2006). Does literacy mediate the relationship between education and health outcomes? A study of a low-income population with diabetes. *Public Health Reports*, 121(3), 245–254.
- Speirs, K. E., Messina, L. A., Munger, A. L., & Grutzmacher, S. K. (2012). Health literacy and nutrition behaviors among low-income adults. *Journal of Health Care for the Poor and Underserved*, 23(3), 1082–1091. doi:10.1353/hpu.2012.0113
- Stringhini, S., Dugravot, A., Shipley, M., Goldberg, M., Zins, M., Kivimaki, M., & Singh-Manoux, A. (2011). Health behaviours, socioeconomic status, and mortality: Further analyses of the British Whitehall II and the French GAZEL prospective cohorts. *PLoS Medicine*, 8(2), e1000419. doi:10.1371/journal.pmed.1000419
- Stringhini, S., Sabia, S., Shipley, M., Brunner, E., Nabi, H., Kivimaki, M., & Singh-Manoux, A. (2010). Association of socioeconomic position with health behaviors and mortality. *Journal of the American Medical Association*, 303(12), 1159–1166. doi:10.1001/jama.2010.297
- Toft, U., Kristoffersen, L. H., Lau, C., Borch-Johnsen, K., & Jorgensen, T. (2007). The Dietary Quality Score: Validation and association with cardiovascular risk factors: The Inter99 study. *European Journal of Clinical Nutrition*, 61(2), 270–278. doi:10.1002/ejcn.20070
- Torres, R. Y., & Marks, R. (2009). Relationships among health literacy, knowledge about hormone therapy, self-efficacy, and decision-making among postmenopausal health. *Journal of Health Communication*, 14(1), 43–55. doi:10.1080/10810730802592247
- Ullits, L. R., Ejlskov, L., Mortensen, R. N., Hansen, S. M., Kraemer, S. R., Vardinghus-Nielsen, H., & Overgaard, C. (2015). Socioeconomic inequality and mortality—A regional Danish cohort study. *BMC Public Health*, 15, 490. doi:10.1186/s12889-015-1813-3
- Van Der Heide, I., Rademakers, J., Schipper, M., Droomers, M., Sørensen, K., & Ueters, E. (2013). Health literacy of Dutch adults: A cross sectional survey. *BMC Public Health*, 13(1), 179. doi:10.1186/1471-2458-13-179
- Van Der Heide, I., Wang, J., Droomers, M., Spreeuwenberg, P., Rademakers, J., & Ueters, E. (2013). The relationship between health, education, and health literacy: Results from the Dutch Adult Literacy and Life Skills Survey. *Journal of Health Communication*, 18(Suppl. 1), 172–184. doi:10.1080/10810730.2013.825668
- Verhoeven, L., & Snow, C. (2001). *Literacy and motivation: Reading engagement in individuals and groups* (7th ed.). Mahwah, NJ: Erlbaum.
- Von Wagner, C., Knight, K., Steptoe, A., & Wardle, J. (2007). Functional health literacy and health-promoting behaviour in a national sample of British adults. *Journal of Epidemiology & Community Health*, 61(12), 1086–1090. doi:10.1136/jech.2006.053967
- Wolf, M. S., Davis, T. C., Cross, J. T., Marin, E., Green, K., & Bennett, C. L. (2004). Health literacy and patient knowledge in a southern US HIV clinic. *International Journal of STD & AIDS*, 15(11), 747–752. doi:10.1258/0956462042395131
- Wolf, M. S., Gazmararian, J. A., & Baker, D. W. (2007). Health literacy and health risk behaviors among older adults. *American Journal of Preventive Medicine*, 32(1), 19–24. doi:10.1016/j.amepre.2006.08.024