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ORIGINAL PAPER

Association between chronic disease, socioeconomic position and digital health literacy: a danish population-based survey

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Abstract

Purpose There is social inequity in the distribution of digital health literacy (DHL), and patients with chronic disease have also been shown to have lower general health literacy. The study aimed to examine the associations between low socioeconomic status (SES) [measured by self-reported educational level], chronic disease and low DHL and whether chronic disease modifies the effect between SES and DHL.

Methods Cross-sectional study from the Danish HLS_{19} survey, a stratified random sample of 3,644 respondents from the Danish population. A questionnaire collected information on educational level and the prevalence of 13 specific chronic diseases. The number of self-reported chronic diseases were counted. DHL was measured using the HLS_{19} digital health literacy scale from the WHO-Action Network M-POHL. Linear regression models were used to estimate the association between chronic disease and DHL and between education level and DHL, adjusted for sex and age. The potential effect modification between SES, chronic disease and DHL was analyzed.

Results Having two or more chronic diseases was associated with a lower level of DHL (beta (95%CI)) (-3.88 (-5.68; -2.08)) compared to having no chronic disease. Both bachelor-level education (6.49 (4.68; 8.30)) and master-level or above (9.39 (7.43;11.36)) were associated with a higher DHL than respondents with vocational education. No statistically significant interaction was found between chronic diseases and education level on the level of DHL.

Conclusions SES and the presence of chronic diseases were independently associated with DHL but did not interact.

Keywords Digital health literary · Chronic disease · Socioeconomic position · Socioeconomic status · Education · Social inequity

1 Introduction

Globally, there has been a demographic shift with an increase in the number of older people [1]. Between 2015 and 2050, the worldwide proportion of people aged 60 years and older is expected to increase from 12% to 22% [1]. The same trend is seen across Europe, with an anticipated increase from 90.5 million people aged 65 or more in 2019 to 129.8 million in 2050 and especially among the oldest groups above 75 [2]. A similar trend occurs in Denmark, where the proportion of people over the age of 80 is expected to increase by 59% from 2020 to 2030 [3].

Ageing is associated with a higher prevalence of chronic disease [4]. Multimorbidity, the co-occurrence of several diseases has a higher prevalence among people aged 65 years or older [5, 6]. Both in Europe and the United States one-third of adults between 45 and 64 years old had at

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least two chronic conditions, which increased to two-thirds among adults aged 65 to 84 years and for those above 85 years old, more than 80% had at least two chronic conditions [5, 7]. A similar pattern is seen in Denmark with 47% of citizens aged 75 years or older having multimorbidity, higher among women than men [8].

A consequence of the shift in ageing would be a larger proportion of the population living with chronic diseases, which is expected to create financial pressure on healthcare systems, as healthcare costs are higher for the elderly population [9] and for people with one or more chronic diseases [10].

One proposed solution to address the challenge has been to digitalize healthcare. Digital solutions in healthcare have the potential to reduce costs [11] and to improve the quality of healthcare [12–14]. As such, digital solutions might contribute to addressing the demographic development of a more elderly population with chronic diseases, potentially affecting millions of people [15]. In the light of these developments, the European Commission considered it necessary to rethink the European healthcare system and stated that further digitization of health services could also help to strengthen citizen empowerment [15]. However, not everyone has the same capability to use digital platforms and resources [16], as age, education level, income and sex affected citizen level of digital health literacy (DHL) [17, 18].

We use the WHO-Action Network "Measuring Population and Organizational Health Literacy" (M-POHL) definition of DHL "…*digital HL for promoting health includes the ability to search for*, *access*, *understand*, *appraise*, *validate*, *and apply online health information*, *the ability to formulate and express questions*, *opinion*, *thoughts*, *or feelings when using digital devices*" [17] p. 278.

A low level of DHL affects citizens' use of digital solutions, as not everyone has the same opportunity to make use of these solutions in the healthcare system due to limited DHL. A correlation between socioeconomic status (SES) and DHL has been reported [17, 19–21], with lower levels of education [19–21] and higher financial deprivation being associated with a lower level of DHL [18].

Chronic disease morbidity has independently been associated with a lower level of general health literacy (HL) [22, 23]. However, whether chronic disease is also associated with DHL and whether it influences the relationship between SES and DHL is yet to be examined. Particularly regarding the impact of the number of chronic diseases on the relationship between SES and DHL, as it is possible that the presence of multiple chronic diseases at the same time will disproportionately increase the demands of people with low education. We aimed to examine the association between SES and having chronic diseases respectively with DHL, and whether the prevalence of chronic diseases was modifying the association between SES and DHL.

2 Materials and methods

We conducted a cross-sectional study in a random sample of the Danish population aged 18 and above.

2.1 Data collection

As part of the European HLS_{19} project [17], a random sample of 29,998 citizens from the Danish population was extracted by the Danish Health Data Agency. The sample included potential participants 18 years of age or older, having lived in Denmark for more than 6 months and not being declared incapable of managing their own affairs. The sample was stratified by sex, seven age groups ("18–25", "26–35", "36–45", "46–55", "56–65", "66–75", "76 or older") and three levels of urbanization (predominantly urban with a rural population of 20% or less, intermediate with a rural population of 20% to 50%, and predominantly rural regions had rural population of 50% or more) [17]. An invitation to participate and a personal link to the questionnaire in REDCap [24] was distributed using the Danish Public Digital Mail System (e-Boks). Since 2015 it has been mandatory for all 15-year-olds or older to use e-Boks, unless being personally exempted [25]§3. 2,271 citizens from the sample were exempt from e-Boks and did not receive the invitation. The questionnaire was thus delivered to 27,727 citizens, of whom 4,605 responded to the questionnaire. Of the 4,605 responses 926 were not complete and did not meet the requirements of at least 80% of the items in the questionnaire to be answered in order to be included in the study. A further 35 participants were removed as they had missing answers to the questions included in the analysis, leaving a total sample of 3,644 (13.1%) for analysis.

2.2 Variables

2.2.1 Educational level

Educational level was used as a proxy for SES because education usually precedes entry into employment and thereby affects income [26]. Education is at the same time associated with literacy. Educational level was self-reported and originally formulated by the European Health Interview Survey (EHIS), classifying educational attainment according to the International Standard Classification of Education (ISCED), but with a national adaptation of the answers. The question stated: "*What is your highest level of education?*" with eight response categories (primary education (1–7 year), lower secondary (8–10 year), upper secondary, vocational, short cycle tertiary (short term higher), bachelor or equivalent (medium higher), master or equivalent (long term higher) or doctoral or equivalent (PhD or equivalent)). In the analyses responses were collapsed into five groups corresponding to

of ISCED 1–3 (primary or secondary education), ISCED 5 (Vocational education), ISCED 5 (short cycled tertiary education), ISCED 6 (bachelor's level or equivalent) and ISCED 7–8 (master's level or higher).

2.2.2 Chronic diseases

Information on chronic disease was self-reported. The respondents were asked: *"For each of the following diseases and health problems, please indicate whether you have [the disease] now or have had it in the past. If you have had it in the past, please also indicate if you have any after-effects*". The respondents were asked about 13 named chronic diseases, and the number of positive answers were summarized and grouped into "no chronic diseases", "1 chronic disease" and "≥2 chronic diseases". The list of the 13 chronic diseases is shown in Table 3.

2.2.3 Digital health literacy

The measure of DHL, HLS_{19}-DIGI, was based on the evaluation for eight items asking for difficulties or ease in searching, understanding, judging and using information on health on the Internet [17]. The answer categories were given as "very difficult", "difficult", "easy" or "very easy" and coded 1–4. Answers were summarized (8–32) and transformed into a score of 0–100 with higher values reflecting higher DHL. The scale has been validated in Danish with a Cronbach's alpha of 0.85, a reasonable fit with a one-factor model and an overall fit with a Rasch analysis [17].

2.2.4 Other covariates

Information on age and sex was retrieved from the Personal Identification Number. Age was grouped into four age groups ("18–45 years", "46–55 years", "56–65 years" and "≥ 66 years") to allow for non-linear associations, as chronic diseases become more prevalent with age.

2.3 Data analysis

Variables were described with number and proportions and further described by mean and standard deviation of DHL.

Simple and multiple linear regression models were used to estimate the relationship between educational level and chronic disease as exposures and DHL as outcome, using vocational education and no chronic disease as the reference groups. Age and sex were included as covariates. The models estimated beta with 95% confidence interval. The model fits were evaluated by examining whether the residuals were normally distributed and homogeneity. We estimated robust standard errors to account for the stratification of the sample.

Age was also included in the models as an interaction term, comparing a nested model with the same model without interaction. The Likelihood Ratio test had a p-value of 0.0502, verifying that age was formally not an effect modifier and therefore included as a confounder.

The final linear regression models, examining whether chronic disease was an effect modifier for the association between educational level and DHL, was adjusted for sex and age. The interaction was tested as nested models as described for age above, but to describe the results, stratified results are presented. The significance level was set at 0.05.

All analyses were conducted in STATA 17 (StataCorp LLC, College Station, Texas).

2.4 Ethics

Questionnaire based studies do not require ethical approval in Denmark [27] § 14 Sect. 2.

The study is in compliance with the General Data Protection Regulation and is registered in North Denmark Region's record of processing activities (2020-018). The data was collected in accordance with the Helsinki Declaration [28]. The participants were informed about the purpose of the questionnaire, that participation was voluntary, and that they had to indicate their informed consent in the questionnaire.

3 Results

65% of the participants had at least one chronic disease. A third had vocational education as their highest completed educational level, while 25% had bachelor level or equivalent (Table 1). Participants without chronic diseases had a higher DHL-level than those with one or more chronic diseases. DHL increased with the level of education, decreased with higher age and females had a higher DHL level than men.

The level of education was associated with the DHL-level when adjusting for age and sex (Table 2). Those with bachelor level or higher had statistically significantly higher DHL than those with "vocational education" as their highest completed education. Those with "primary or secondary -" or with "short-cycled tertiary" education as their highest completed level of education had the same DHL level as the reference group. Those with two or more chronic diseases had a lower DHL than the reference group even when adjusting for age and sex.

There was no interaction between chronic disease and education on the level of DHL as the same patterns of associations were present in all three stratified groups (Fig. 1). Finally, chronic disease was also included in the

Table 1 Sample characteristics for 3644 participants in the Danish HLS_{19} survey, n (%) and mean (SD) level of DHL in each group. DHL has a range of 0–100

	n (%) (*n* = 3644)	DHL Mean (SD)
Chronic diseases		
0	1259 (34.46)	61.64 (18.78)
1	1093 (29.99)	59.00 (18.42)
≥2	1292 (35.46)	54.99 (19.84)
Educational level		
Primary or secondary education (ISCED 1–3)	550 (15.09)	53.96 (21.27)
Vocational education (ISCED 5)	1100 (30.02)	54.29 (18.76)
Short-cycled tertiary (ISCED 5	375 (10.29)	56.89 (17.33)
Bachelor or equivalent (ISCED 6)	986 (27.06)	61.93 (17.87)
Master or equivalent and above (ISCED7-8)	633 (17.37)	65.31 (18.49)
Sex		
Male	1600 (43.91)	56.24 (19.24)
Female	2044 (56.09)	60.25 (19.09)
Age		
18–45 years-old	795 (21.82)	63.92 (19.70)
46–55 years-old	704 (19.32)	60.65 (18.73)
56–65 years-old	885 (24.29)	58.58 (17.78)
+66 years-old	1260 (34.58)	53.79 (19.16)

Table 2 The association between educational level and chronic disease respectively, with DHL, adjusted for sex and age. Results estimated from linear regression models, beta and (95% conf. interval)

Exposure	Unadjusted	Adjusted for sex	Adjusted for age group and sex
Primary or secondary education (ISCED 1–3)	0.70 (−1.78; 3.18)	0.78 (−1.71; 3.26)	−0.68 (−3.09; 1.73)
Vocational education (ISCED 5)	Reference	Reference	Reference
Short-cycled tertiary (ISCED 5)	1.02 (−1.33; 3.37)	1.11 (−1.25; 3.46)	1.43 (−0.88; 3.74)
Bachelor or equivalent (ISCED 6)	7.31 (5.45; 9.18)	7.06 (5.18; 8.94)	6.49 (4.68; 8.30)
Master or equivalent and above (ISCED7-8)	10.62 (8.67; 12.58)	10.66 (8.71; 12.61)	9.39 (7.43; 11.36)
No chronic disease	Reference	Reference	Reference
One chronic disease	−2.98 (−4.73; −1.22)	−3.05 (−4.80; −1.30)	−1.22 (−3.00; 0.55)
2+chronic diseases	−7.17 (−8.90; −5.44)	−7.24 (−8.96; −5.51)	−3.88 (−5.68; −2.08)

linear regression models as an interaction term, comparing a nested model with the same model without interaction. The Likelihood Ratio test had a p-value of 0.45, verifying that chronic disease was not an effect modifier.

We also examined the relationship between specific individual chronic diseases and the level of DHL (Table 3). The majority of those with a specific chronic disease had a lower DHL than the group with no chronic disease. The exception was for asthma, cancer and mental disorders, where no differences in DHL level were found. Some of the differences were due to age, as the estimated differences became in general smaller when adjusting for age and sex, with the exception for mental disorders, where the differences became larger and statistically significant in the adjusted model. Most diseases were still associated with lower levels of DHL, statistically significant for hypertension, angina pectoris, brain hemorrhage and osteoporosis. Further adjustment for educational level diminished the differences.

4 Discussion

Our study demonstrated a relationship between both education level and having more than one chronic disease, and the level of DHL, with DHL being 10% points higher with the highest level of education and 4% point higher when having no chronic disease compared with two or more chronic diseases, also after adjustment for age and sex. The two factors were however not interacting in relation to DHL. The association of educational level and higher DHL was consistent with other studies [19, 20, 29, 30], and in a systematic review of 27 cross-sectional studies, 14 studies found that a higher education level was significantly associated with higher DHL [18]. A single study asking for any chronic disease found similar results for the association with chronic disease, as those with a chronic disease had a lower DHL compared with those having no chronic disease [20], but the opposite finding has also been reported [31]. Our study also showed that DHL decreased with increasing age. This

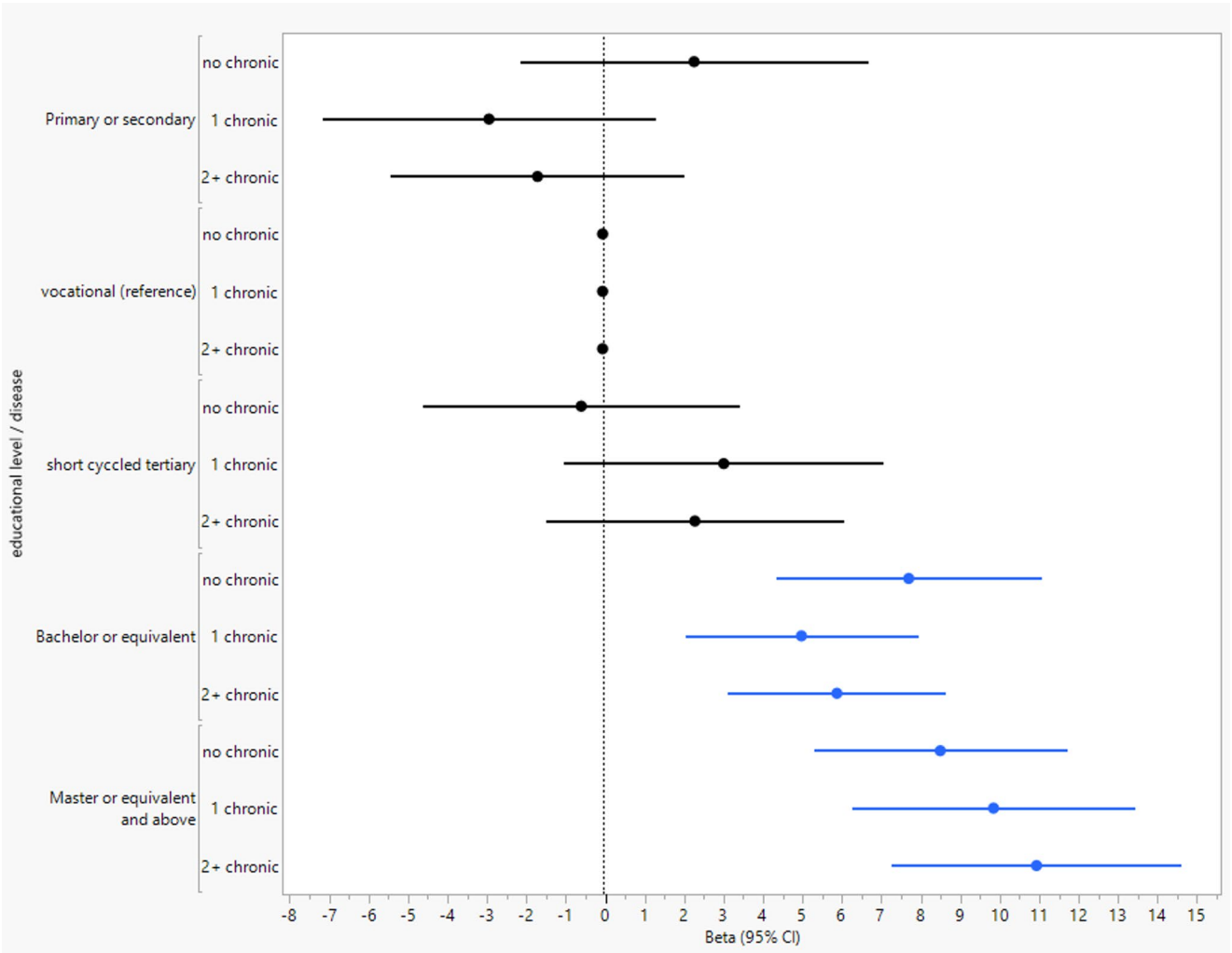

Fig. 1 The association between education level and DHL, compared with vocational education, adjusted for age and sex and stratified by number of chronic diseases. Results from linear regression, beta coefficient and 95% confidence interval. Statistically significant results are shown in blue

Table 3 Actual or after effect of single chronic diseases and difference in DHL-level, unadjusted and adjusted beta with 95% CI, compared with not having the disease. National prevalence figures (percent) in square brackets for each disease are derived from a National health survey, 2021, using similar questions*

Disease	Number (percent) [national prevalence proportion*]	beta (95% CI), unadjusted	beta (95% CI), adjusted for age-group and sex	beta (95% CI), further adjusted for educational level
Asthma	328 (9.32) [8.5]	0.32 (−2.17; 2.81)	0.30 (−2.09; 2.69)	0.63 (−1.75; 3.01)
Diabetes	268 (7.63) [5.8]	−4.21 (−7.04; −1.39)	−1.97 (−4.73; 0.78)	−1.04 (−3.71; 1.64)
Hypertension	1002 (28.08) [20.5]	−6.50 (−8.09; −4.91)	−2.89 (−4.50; −1.29)	−1.70 (−3.27; −0.12)
Myocardial infarction	46 (1.31) [1.3]	−7.15 (−14.05; −0.24)	−3.98 (−10.49; 2.53)	−2.83 (−9.46; 3.80)
Angina pectoris	77 (2.20) [2.2]	−9.88 (−15.20; −4.55)	−7.29 (−12.67; −1.92)	−6.51 (−11.63; −1.40)
Brain hemorrhage	78 (2.23) [2.0]	−9.68 (−16.01; −3.34)	−6.24 (−12.30; −0.18)	−5.51 (−11.54; 0.52)
COPD	199 (5.65) [5.2]	−6.00 (−9.29; −2.72)	−2.80 (−6.03; 0.43)	−2.21 (−5.34; 0.92)
Arthrosis	1083 (30.58) [22.5]	−4.77 (−6.37; −3.18)	−1.48 (−3.16; 0.20)	−0.45 (−2.12; 1.21)
Arthritis	276 (7.97) [7.9]	−4.29 (−6.91; −1.68)	−2.00 (−4.57; 0.57)	−1.23 (−3.81; 1.36)
Osteoporosis	176 (5.05) [4.5]	−7.96 (−11.60; −4.33)	−4.66 (−8.39; −0.93)	−3.62 (−7.20; −0.04)
Cancer	181 (5.15) [3.7]	−2.38 (−5.24; 0.48)	1.22 (−1.59; 4.03)	1.15 (−1.66; 3.97)
Mental disorder	385 (11.02) [12.9]	−0.59 (−2.93; 1.74)	−2.99 (−5.33; −0.65)	−2.06 (−4.38; 0.26)
Back disorder	670 (19.09) [14.8]	−3.28 (−5.06; −1.50)	−1.71 (−3.45; 0.03)	−0.90 (−2.61; 0.81)

* National prevalence figures are from the publication "*Danes' health: the national health profile, 2021*" [8 p. 147]

is consistent with other studies [18–21]. This emphasizes that the desire to address the challenges of an aging population by digitizing healthcare must be done with a corresponding focus on adapting solutions to a population with a lower DHL level. Both DHL [17] and HL [32] involve the ability to understand, judge and use health information, underlining the strong relation between the two terms. As DHL is placed in the digital realm [17] and HL focusing on general health information [32], citizens could have a high HL but at the same time have a low DHL, as lack of digital skills could lead to citizens not being able to use electronic tools. It could be assumed that if citizens had a low HL, they probably also have a low DHL, despite high digital skills, because citizens still need to be able to understand and use health information whether on a digital platform or not. Based on this we include studies that address chronic disease and general HL in the following discussion. Our findings were based on a list of specific chronic diseases in the Danish data collection, while the joint HLS_{19} survey used a single item asking for long-term illness or health problems, finding an association with low general HL [17]. Other studies have also found statistically significant relationships between having one or several chronic diseases and a lower level of HL compared to those with no chronic diseases [22, 23]. A correlation between HL and the number of reported chronic diseases was found in one previous study, where those with only one chronic disease had higher HL than those with more diseases [33]. This was in accordance with our results, showing that those with two or more chronic diseases had a lower DHL than those with one chronic disease. The individual chronic diagnoses were predominantly all related to a lower level of DHL, and it could seem unintuitive that having experience with chronic diseases and by that having a higher chance of engaging in handling health related digital information, would not lead to higher DHL. One explanation for these results could be attributed to the Dunning-Kruger effect, where people overestimated their competence within a field that they haven't used before [34]. People with chronic conditions will have been exposed to digital healthcare and digital health information and will know how difficult it can be to use digital services, thereby estimating their DHL lower than those without a chronic disease. People without a chronic condition, on the other hand, might overestimate their DHL because they have not used digital health services to the same extent. It is also possible that managing two chronic diseases at the same time can pose an additional challenge in handling health related information, both in relation to general HL and to DHL.

The study examined the potential effect modification of chronic disease on the association between SES and DHL, which if present would have suggested that having educational competencies could alleviate the effect of chronic diseases. This was however not the case, and the finding demonstrated that SES and chronic diseases were independent of each other in their association with DHL. It is important to emphasize that as it is a cross-sectional study, causality cannot be determined, but it seems plausible that a person having one or several chronic diseases to a larger extent has difficulties to participate in the modern healthcare system with more digital solutions, despite the level of SES.

4.1 Limitations

There were several weaknesses of the study. The response proportion was only 13% [17]. Nevertheless, other countries in the HLS_{19} survey such as Germany, Slovakia and Ireland, which had a higher response proportion at 64%, 67% and 27%, also identify a similar correlation between DHL and education level [17]. This suggests that the Danish survey might not have been affected by the low response. Secondly, a potential selection bias could have been that people with chronic condition could have a different response proportion than those without chronic condition. However, when comparing (Table 3) the distribution of chronic diseases with figures from a larger national survey on the health of Danes [8], the proportion was rather equal for most of the conditions.

For asthma, diabetes, hypertension, arthrosis, osteoporosis, cancer, mental disorder and back disorder, this study generally had a higher prevalence than the national rates with the largest difference for hypertension (28% versus 21% in the national survey) and back disorders (19 versus 15%). Only for mental illness was the prevalence slightly lower in our study (11 versus 13%). It should be noted that the wording of the questions and the answer categories differed slightly. Commitment or involvement theory suggests that people participate in surveys that they find relevant for them [35]. It could be that individuals with chronic disease found it relevant to participate in this study as they might have experienced challenges in understanding health information or navigating the healthcare system and knowing it could be difficult to use.

The HLS_{19}-DIGI scale has been validated in the national form, finding a Cronbach alpha of 0.83, and in the remaining countries that used the questionnaire in HLS_{19}, the scale was likewise found reliable with Cronbach alpha ranging from 0.77 to 0.87 [17]. Furthermore, a principal component factor analysis showed that the HLS_{19}-DIGI measure was adequate unidimensional, corresponding to the theoretical model [17]. Additionally, correlation between HLS_{19}-DIGI and general HL was demonstrated in the international report, suggesting that DHL correlated with HL to the extent that it is measuring HL, but independent from HL for measuring a specific aspect of HL [17]. Therefore, the HLS_{19}-DIGI questionnaire was considered a valid instrument for measuring DHL.

Our study did not adjust for ethnicity although a Danish cross-sectional study has shown that pregnant immigrants had lower levels of DHL than Danish pregnant women [36] and a German cross-sectional study have also found that migrants, categorized as persons not born in Germany, searched for health information on the internet to a lesser extent than persons who did not have a migrant background [37]. These findings suggested that ethnicity might be a confounder, the questionnaires used were only offered in the Danish language, which might have been a barrier to participation among participants with a different ethnicity and this may have led to a selection bias.

Finally, the survey was distributed as a link leading to a web-based questionnaire, which might have been a barrier for people with a low DHL to participate, given that they might find it more difficult to access, navigate and understand the questionnaire than participants with a high DHL. It could have been relevant to include a Computer Aided Personal or Telephone Interview (CAPI/CATI) to collect information from the group who were exempt from e-boks.

5 Conclusion

In this large Danish population-based study we demonstrated independent associations between SES and chronic disease on the level of DHL. The negative effect of having chronic diseases was not diminished by having higher educational level as a proxy of SES, which means that the effect of chronic disease would have to be handled independently of educational level. To reduce the risk for a digital divide it would be important to identify groups associated with low DHL such as citizens with a chronic condition and low education level and tailor interventions to increase their inclusivity in the digital health services. Lastly, the research can inspire system's change to facilitate digital health literacy needs in association to co-morbidity.

Author contributions All authors contributed to the study conception and design. Henrik Bøggild, Kristine Sørensen and Marie Germund Nielsen contributed to the data collection. Analysis was performed by Lise Lind Kristensen and Henrik Bøggild. The first draft of the manuscript was written by Lise Lind Kristensen and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Declarations

Ethics approval and consent to participate In Denmark, questionnaire-based studies do not require ethical approval. Data was collected in accordance with the Helsinki Declaration. The participants had to indicate their informed consent in the questionnaire.

Consent to publish No individual data, images or videos are included in the study.

Competing interests The authors did not have any financial or non-financial interests.

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