Influencing Factors in Digital Health Intervention Uptake: The Interplay of Education, Lifestyle, and Digital Literacy

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Abstract. Chronic diseases strain global healthcare economically, and integrating digital solutions are proposed to help in meeting the rising demand. Digital health interventions (DHIs) offer promise for personalized, and cost-effective health services, however, factors influencing their uptake remain unclear. We examined whether the probability of lifestyle DHI uptake varies among individuals with different educational levels and lifestyles, based on their attitudes and usage of e-services. We also examined the effect of sex and age, and the association between DHI uptake and both educational attainment and overall lifestyle. A possibility to start using a web-based lifestyle DHI was offered to a subgroup (n = 6978) of Healthy Finland survey participants and adjusted logistic regression models were used to investigate the factors affecting uptake. We found that higher education and healthier lifestyle, as indicated by lifestyle score, were related to higher odds of DHI uptake. However, the effects of age, sex, independence of e-service use, and competence to use online services varied across lifestyle score groups. No significant interactions were observed related to educational attainment. These results imply that lifestyle DHIs are less likely to reach individuals with less-healthy lifestyle habits and lower educational attainment. In addition, some predictors affected the uptake differently across lifestyle score groups, suggesting that implementations of DHIs might attempt strategies to optimize the participation rates in especially targeted subgroups.

Keywords: Digital health intervention · Lifestyle · Education · Uptake

1 Introduction

Chronic diseases pose a significant global health challenge, imposing a growing economic burden on healthcare services [1, 2]. Digital solutions integrated into service pathways have been proposed to offer a solution to increasing service demand.

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Lifestyle habits play an important role in individual's health, with factors like smoking, unhealthy diets, and physical inactivity contributing to several chronic diseases [3]. Adopting a healthy lifestyle can reduce the risk of such diseases by up to 80% [3]. Digital health interventions (DHIs) are interventions utilizing digital technologies (such as apps, digital platforms, and wearables) to enhance individual's health [4]. DHIs hold the potential to improve personalization, accessibility, and effectiveness of health-promoting services, while concurrently reducing scaling-up costs [5]. Despite the enormous potential of DHIs, our understanding of the factors influencing their uptake remains limited. Understanding these factors can help researchers and healthcare providers develop targeted interventions, thereby enhancing effectiveness.

In addition to lifestyle-related factors, educational level has also been shown to be associated with health [6]. Individuals with higher educational attainment generally experience better health and longer lives compared to those with lower educational attainment [6, 7]. When aiming to large-scale implementation of DHIs, it is essential to understand whether the intended population is reached. Particularly, the uptake of the DHI among individuals with less-healthy lifestyle habits and lower educational levels is crucial, as these groups are at a heightened risk of experiencing poorer health outcomes.

Previous research has focused on examining the lifestyle habits of users of health apps, but this approach introduces a potential bias, as the usage of the app itself may already impact lifestyle habits. The studies regarding health app users suggest a connection between smoking and health app usage [8], but findings on diet quality are controversial [9–11]. Regarding education, existing evidence suggests that individuals with higher educational levels are more inclined to use health apps [9, 12, 13]. Nonetheless, not all studies have found this association [14]. Other critical factors that could impact the uptake and adoption of DHIs are the previous use of electronic services and individuals' attitudes towards such services. Although the influences of these aspects remain largely understudied, there is some evidence suggesting that privacy concerns might play a significant role [15].

The main aim of the current study was to examine whether probability of DHI uptake in individuals with different educational levels and lifestyle vary based on their attitudes and usage of e-services. We also examined the effect of sex and age, and the association between DHI uptake and both educational attainment and overall lifestyle.

2 Methods

2.1 Participants and Study Design

This cross-sectional study was a sub-study of a Healthy Finland Survey [16], where a questionnaire on health, well-being and service use was sent to randomly selected persons over the age of 20, representing the entire adult population of Finland. Finnish speaking individuals aged 20 to 74 years who had answered the Healthy Finland questionnaire by the end of 2022 and who were not invited to participate to a health examination part of the main study, were considered eligible for this current study. An SMS invitation was sent in February 2023 to all eligible individuals with a known phone number (n = 4978 [71%]). Additionally, 2000 (29%) individuals from the rest of the eligible population were sampled based on 5-year age-groups to receive a letter invitation in February

2023. The invitation letter included web address and SMS message a direct link to the project's web page where information regarding the study, a link to the lifestyle DHI app (BitHabit), and brief information about the app and instructions on how to begin the use were given. Three participants asked their data to be removed resulting in a final sample size of 6975 individuals. The ethical approval for the study was obtained from the research ethics committee of the Finnish Institute for Health and Welfare (THL/5335/6.02.01/2022).

2.2 Digital Health Intervention App (BitHabit)

The BitHabit web-based app was developed to support the formation of healthy lifestyle habits in adults at an increased risk of type 2 diabetes [17, 18]. It is based on habit formation and self-determination theories and it aims to help the app user to try small healthy habits in their everyday life, gradually building a healthier, permanent lifestyle. Invitees had approximately three weeks to start using the app, and those who began using it within this timeframe were considered as having started using the app. To log into the app, the users had to provide a phone number and a user id that was given in the invitation. The uptake of the app was defined as accepting the invitation to participate, agreeing to the terms of the BitHabit app, and registration to the app with a phone number and user id.

2.3 Study Variables

Age and sex were obtained from Finnish National Population Register and all other study variables were obtained from the Healthy Finland survey. Age was categorized into four classes (20 – 34, 35 – 49, 50 – 64, 65 – 74 years).

The participants' educational levels were assessed by asking about the number of years of education. We categorized the participants within each age group into three education level groups (low, middle, and high) by dividing them into tertiles based on the length of their education. Overall lifestyle was evaluated with a summary score on questions about diet quality, amount of sleep (do you get enough sleep: yes, almost always or often, rarely or hardly ever, or not sure), smoking (daily, occasionally, not at all, or have never smoked) and amount of physical activity (whether or not, the participants achieve the Finnish physical activity recommendations). Diet quality included questions related frequency of consumption of different foods and drinks, and quality score was created following a method by Lindström et al. [19]. A higher lifestyle score indicated healthier lifestyle. The participants where then assigned into three groups based on their score (low, middle, high).

Use of electronic services was assessed in 6 categories: independence of e-service use, competence to use e-services, non-accessibility of e-services, concerns about data security, poor internet connections, and perceived benefits of e-services. Individual answers were used as categories for all questions except for perceived benefits of e-services. For the latter, a summary score was calculated based on participants' level of agreement with six claims, and then assigning the participants into three groups based on tertiles. Questions and the answer options are presented in Table1.

Table 1. Questions used to assess the use of electronic services

Category	Question(s)	Answer options
Use of e-services	Do you use the Internet to access e-services (e.g. My Kanta, MyTax, OmaKela)?	1) I use it independently, 2) I use it with another person's help or someone else uses it on my behalf, 3) I don't use it
Competence to use e-services	How would you rate your competence to use online services (on a computer or smartphone)?	1) No competence or low competence, 2) Moderate competence, 3) High or very high competence
Non-accessibility of e-services	How do you feel about the following statement: the electronic services are not accessible to me e.g. due to my visual impairment	1) Completely agree or somewhat agree, 2) Neither agree nor disagree, 3) Somewhat disagree or strongly disagree
Data security	How do you feel about the following statement: I am concerned about data security when it comes to my personal details	1) Completely agree, 2) Somewhat agree, 3) Neither agree nor disagree, 4) Somewhat disagree, 5) Strongly disagree
Data connections	How do you feel about the following statement: data connections are poor in my area	1) Completely agree or somewhat agree, 2) Neither agree nor disagree, 3) Somewhat disagree or strongly disagree
Benefits of digital services	Electronic services… 1) Help me to assess the need for services, 2) Support me in finding and choosing the most suitable services, 3) Make it easier for me to use services regardless of where I am and when, 4) Make it easier for me to collaborate with professionals 5) Help me to take an active role in looking after my own health and welfare, 6) Help me to take care of the health, welfare and functional capacity of family or friends	1) Completely agree, 2) Somewhat agree, 3) Neither agree nor disagree, 4) Somewhat disagree, 5) Strongly disagree

2.4 Statistical Methods

Logistic regression models were used to assess the associations of education level and lifestyle with the uptake of the DHI as well as the interaction of either lifestyle or education level and age, sex, and use of e-services. The results are presented as adjusted

odds ratios (aORs) with 95% confidence intervals (CIs). The models were adjusted for contact method (SMS or letter), age, sex, and annual household income. Model implied probabilities of uptake, shown in Fig. 1, 2, and 3, were calculated for a hypothetical population distributed uniformly over the adjusted covariates. The confidence intervals for the probabilities were obtained by non-parametric bootstrap methods, using 1000 bootstrapped samples of the study population.

The overall significance of the associations between the categorical predictors and the outcome were assessed with likelihood ratio tests (LRT), for which p-values less than 0.05 were determined to indicate significant associations. The R software, version 4.3.2. Was used to perform all statistical analyses [20].

3 Results

Of the 6975 (57% females) invitees, 1282 (67% females) started using the application. The distribution of sex, age, education, and lifestyle score is presented in Table 2 for those who started using the app and those who did not. Information regarding educational attainment was missing from 95 participants and lifestyle score was missing from 886 persons due to a missing answer in one or more of the sub questions.

Table 2. Comparison of sex, age, lifestyle score, and education among those who started using the DHI app, those who did not, and total population. Data presented as N (%).

	All	Started using DHI	Did not start using the DHI
Sex			
Female	3975 (57%)	868 (67%)	3107 (55%)
Male	3000 (43%)	419 (33%)	2581 (45%)
Age (years)			
20 – 34	1229 (18%)	250 (19%)	979 (17%)
35 – 49	1254 (18%)	303 (24%)	951 (17%)
50 – 64	2066 (30%)	361 (28%)	1705 (30%)
65 – 74	2426 (35%)	373 (29%)	2053 (36%)
Lifestyle score			
Low	1150 (19%)	172 (15%)	978 (20%)
Middle	2350 (39%)	422 (36%)	1928 (39%)
High	2588 (43%)	576 (49%)	2013 (41%)
Education			
Low	1791 (26%)	206 (16%)	1585 (28%)
Middle	3036 (44%)	549 (43%)	2487 (44%)
High	2053 (30%)	522 (41%)	1531 (27%)

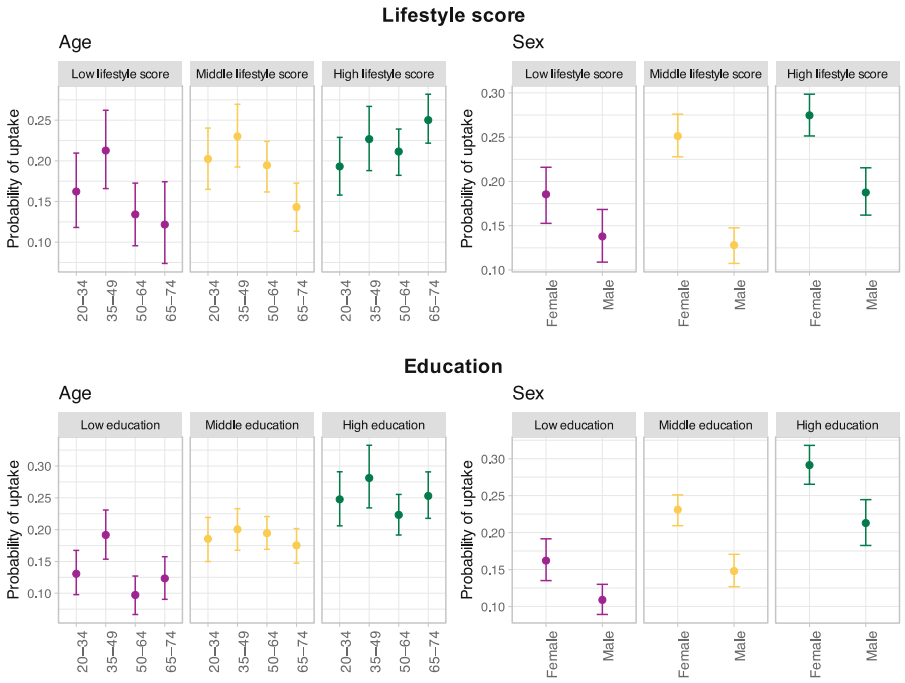

Fig. 1. Probabilities (with 95% CI) of DHI uptake in different lifestyle score and educational groups by age and sex.

Overall lifestyle and educational level were significantly associated with DHI uptake. Higher odds of DHI uptake were found in those with higher educational level (middle vs. low: aOR: 1.52, 95% CI: 1.27–1.82; high vs. low: 2.19, 1.82–2.63). Those with healthier overall lifestyle score had also higher odds of the DHI uptake (middle vs. low: 1.25, 1.03–1.53; high vs. low: 1.58, 1.30–1.93).

The interaction analyses did not reveal statistically significant interaction between education and either age or sex, but the interaction between lifestyle and age ($p = 0.001$) and sex ($p = 0.029$) was significant. In all lifestyle score groups men had significantly lower odds for DHI uptake than women but this difference was smallest in the low lifestyle score group (low aOR: 0.70, 0.50–0.98; middle 0.43, 0.34–0.54; high 0.60, 0.49–0.74). When comparing the uptakes in different lifestyle and age groups, in high lifestyle score group oldest participants (60–74-years) had significantly higher odds for uptake compared to youngest group (1.40, 1.03–1.90). On the contrary, in the middle lifestyle score group oldest age group had significantly lower odds for uptake than the reference youngest group (0.65, 0.46–0.92). In the low lifestyle score group, no age group differed significantly from the reference group. The probabilities for each category are presented in Fig. 1.

The interaction analyses regarding lifestyle and use of e-services revealed a significant interaction between lifestyle and independence of e-service use ($p = 0.042$) and competence to use online services ($p = 0.039$). Within-group comparisons showed that

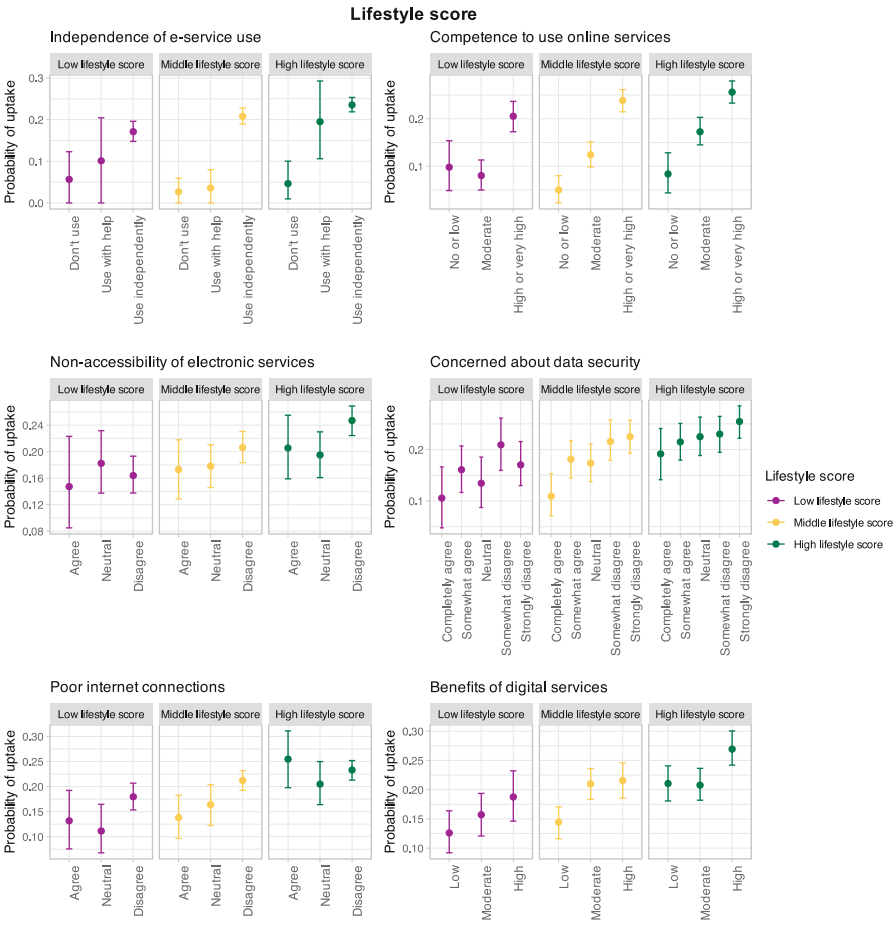

Fig. 2. Probabilities (with 95% CI) of DHI uptake in different lifestyle groups with use of e-services.

in low and middle lifestyle score groups those reporting to use e-services independently had significantly higher odds of DHI uptake than those who do not use e-services (low: 3.47, 1.07–11.2; middle 9.74, 3.07–30.86). In high lifestyle score group, those reporting to use e-services with help (5.01, 1.54–16.31) or independently (6.43, 2.35–17.62) had significantly higher odds to start using the DHI than those who did not report to use e-services. Regarding competence to use e-services, in low lifestyle score group those with high or very high competence had significantly higher odds for DHI uptake than those with no or low competence (2.44, 1.30–4.6). In middle and high lifestyle score groups those with moderate competence (middle: 2.72, 1.42–5.22; high: 2.33, 1.31–4.17) or high or very high competence (middle: 6.20, 3.30–11.64; high: 3.93, 2.22–6.95) had

higher odds of uptake than those with no or low competence. Other interactions with lifestyle were non-significant. The probabilities for each category are presented in Fig. 2. There were no significant interactions between educational attainment and any of the use of e-services variable. Probabilities for different educational groups are presented in Fig. 3.

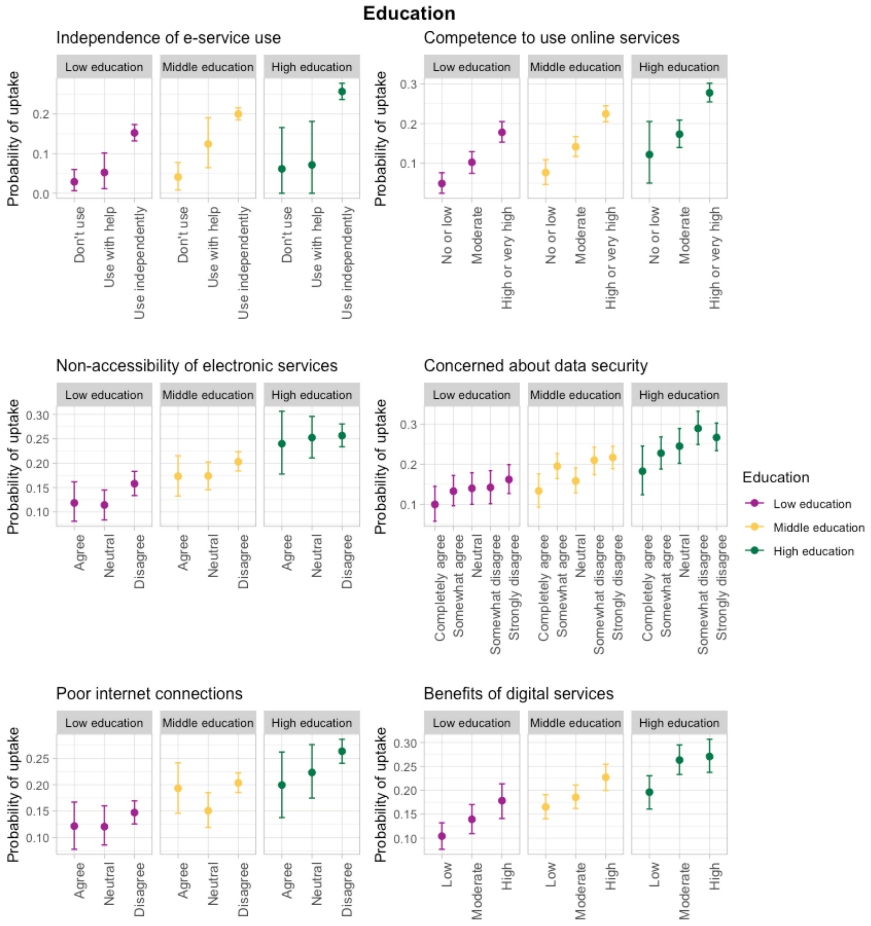

Fig. 3. Probabilities (with 95% CI) of DHI uptake in different educational groups with use of e-services.

4 Discussion

Our study showed that higher education and healthier lifestyle as indicated by higher lifestyle score are related to higher odds of lifestyle DHI uptake. However, we found that the effects of age, sex, independence of e-service use, and competence to use online services varied across lifestyle score groups. No significant interactions were observed related to educational attainment.

Lifestyle interventions, including DHIs, would be most effective in decreasing the burden of chronic diseases if they would reach individuals with less-healthy lifestyle. Reaching these individuals is crucial for preventive healthcare as these individuals are at higher risk for chronic diseases [3]. While analyzing overall barriers and facilitators of DHI uptake is crucial, a deeper understanding of these factors in various subgroups is equally essential. Firstly, adjusted logistic regression revealed that those with healthier lifestyle have higher odds of the DHI uptake. These results imply that when offering DHIs, we might not efficiently get individuals with less-healthy lifestyle habits to start using DHIs. Secondly, we found significant interactions between lifestyle groups and variables related to skills on e-service use. These findings suggest a nuanced relationship between DHI uptake, lifestyle, and competence or independence of e-service usage highlighting the importance of digital proficiency across lifestyle strata. Interestingly, significant interactions also between lifestyle groups and both age and sex were observed. In the group with the least beneficial lifestyle the probability of uptake was lowest in the oldest age group but in group with best lifestyle the probability of uptake was highest in the oldest age group. Thus, when targeting older adults with less-healthy lifestyle habits there is a need for tailored recruitment strategies and interventions.

While higher educational attainment was related to higher probability of DHI uptake the effects of age, sex and use of e-services did not seem to vary across educational levels. The uptake probability was consistently higher in those with more favorable attitudes and better skills on using e-services. The results regarding the association between education and DHI uptake in the whole study population align with earlier evidence on health app usage [9, 12, 13]. While these results show the importance of education on DHI uptake, the differences in DHI uptake among individuals with different educational attainment does not vary based on their digital literacy. These results regarding education imply a potential existence of a digital divide, wherein individuals with lower education levels may be at a disadvantage when it comes to using digital tools for managing their health. This may have a potential to worsen health inequalities as individuals with lower educations are at a heightened risk of experiencing poorer health outcomes.

Strengths of this study include large sample size and the available knowledge of the background characteristics of the whole approached population, instead of only studying health app users that is a common approach in prior research. This study was conducted in Finland and the caution should be exercised in generalizing these findings to populations in other countries with potentially different cultural, social, and economic contexts.

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