Configurational analysis of improving digital health literacy among older patients with non-communicable diseases: A fuzzy-set qualitative comparative analysis

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Abstract

Background: The ageing of the population and the digitalisation of information are currently developing in parallel worldwide. The rapid development of digital health has created a digital inequality for many older patients with chronic diseases. The generally low level of digital health literacy (DHL) among older patients with non-communicable diseases (NCDs) cannot be ignored. Although some studies have investigated the factors influencing digital health literacy in older patients with NCDs, few studies have examined the causal relationship between different combinations of factors and DHL from a configurational perspective.

Objective: To analyse the causal relationship between different combinations of factors and the level of digital health literacy in older patients with NCDs, in order to clarify the path of digital health literacy improvement in older patients with NCDs.

Methods: In this study, older patients with NCDs were recruited from September to December 2023 using convenience sampling method. Fuzzy-set qualitative comparative analysis (fs-QCA) was then employed by conducting necessity and sufficiency analysis.

Results: A total of 538 older patients with NCDs participated in the survey. The necessity analysis showed that digital health literacy in older patients with NCDs doesn't have the necessary conditions. Sufficiency analyses generated six different groups of digital health literacy for older patients with NCDs. Of these six pathways, the combination of high educational attainment, lower number of NCDs, high health concern, and positive attitudes towards digital technology is the most important path. In addition, we analyzed the sufficiency of the three dimensions of digital health literacy to derive the most important pathways for each of the three different dimensions.

Conclusions: The results of this study differ from those reported in traditional regression analyses or path analyses. It considers the combined effect of each of the different variables on the level of digital health literacy of older patients with NCDs. This suggests that health workers should consider a combination of influences rather than focusing on a single factor

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Configurational analysis of improving digital health literacy among older patients with non-communicable diseases: A fuzzy-set qualitative comparative analysis

Abstract

Background: The ageing of the population and the digitalisation of information are currently developing in parallel worldwide. The rapid development of digital health has created a digital inequality for many older patients with chronic diseases. The generally low level of digital health literacy (DHL) among older patients with non-communicable diseases (NCDs) cannot be ignored. Although some studies have investigated the factors influencing digital health literacy in older patients with NCDs, few studies have examined the causal relationship between different combinations of factors and DHL from a configurational perspective.

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analyses or path analyses. It considers the combined effect of each of the different variables on the level of digital health literacy of older patients with NCDs. This suggests that health workers should consider a combination of influences rather than focusing on a single factor.

Keywords: digital health literacy; older patients; NCDs; fuzzy-set qualitative comparative analysis.

Introduction

With the rapid development of modern science and technology, the results of artificial intelligence, virtual and augmented reality, machine learning and other digital technologies are becoming increasingly mature(1). The development of information and communication technology (ICT) has further advanced the application of digital technology in healthcare, providing the public with a new way of seeking health information, facilitating health communication, and treating diseases(2), i.e., e-health(3), also known as digital health(4). The World Health Organization (WHO) defines digital health as "the field of knowledge and practice relating to any aspect of the adoption of digital technologies to improve health, from inception to operation"(5). Digital health can make it easier for patients to access health information and improve self-care. This leads to improved health outcomes and better quality of life(6). In addition, in recent years, in order to reduce the risk of cross-infection and other risks in offline healthcare, governments have encouraged online medical care, home delivery of medicines, online health insurance and other services, which have contributed to the further development of digital health(7).

As digital health technology continues to evolve, the way older people access and share their health knowledge is also changing(8). Worldwide, the rate of population ageing is more rapid than in the past(9), by 2025, the number of people aged 60 and over will grow from 900 million to 2 billion globally(10). Older people commonly suffer from multiple NCDs, and self-management of health is one of the most important ways to improve their health status(11). Digital health offers new opportunities for self-management in older people with NCDs. However, previous research has shown that the uptake and adoption of digital health technology by older people is very limited(12, 13). Therefore, while enjoying the convenience of digital health, we should pay more attention to the digital inequality faced by older patients with NCDs as a vulnerable group in the digital era.

Proper use of digital health requires a wide range of skills, including numeracy, scientific literacy, technology use, and ability to critically evaluate health information(14, 15). However, older patients with NCDs generally have low levels of using digital health due to hearing and vision loss, limited learning ability and acceptance of new technologies, delayed thinking, lack of experience in using smartphones, and low perceptibility and ease of use of digitalization (16). The ability to use digital health, that is, digital health literacy, is defined as "the ability to search for, understand and assess health information in digital media, to communicate and interact with health information, and to use the information gained to solve health problems"(17). Current research suggests that digital health literacy deficits occur to varying degrees in older patients with NCDs around the world(12, 18, 19). The lack of digital health literacy has become a major obstacle to the integration of older people with NCDs into the digital society and the enjoyment of convenient and efficient digital health services(20). Therefore, research and management of digital health literacy in older patients with NCDs is necessary to improve their quality of life as well as their disease management.

However, digital health literacy in older patients with NCDs is affected by diverse conditions. These conditions include both internal factors (socio-demographic factors, psychological factors, physiological factor) and external factors (digital environment factors, social support factors)(12, 21). Previous studies have shown that socio-demographic aspects such as age or education level can influence the level of digital literacy in older people with NCDs, with age having a significant negative effect on digital health literacy and individuals with higher levels of education tending to have higher levels of digital health literacy than those with lower levels of education(22, 23). Those older people with NCDs who live in urban areas generally have higher levels of digital health literacy than those who live in rural areas. In addition, health status is significantly correlated with digital health literacy levels in older patients with NCDs (20). Previous studies in Chinese older adults have found that patients with a high number of NCDs and poor health status are the main influences on low levels of digital health literacy in them (21). At the same time, older patients with NCDs with high health concerns are more willing to learn about health information through digital health devices and have a higher level of digital health literacy. Attitudes towards digital health technology among older people with NCDs are also an important influence on their level of digital health literacy (22, 24). Those older patients with NCDs who had more positive attitudes towards digital health and higher interest in digital technology had higher levels of digital literacy(24, 25). In terms of external factors, whether or not older patients with NCDs own digital devices and the type of digital device they own affects their level of digital health literacy. Also, the level of proficiency in the use of digital devices by older patients with NCDs is directly related to their level of digital health literacy (26, 27). Social support factors are also closely related to digital health literacy in older patients with NCDs as well(28). Studies have shown that in samples of older people with chronic conditions, participants report that the internet is a useful source of information about their condition and that they rely on relatives and friends for help in obtaining and assessing information. It can be seen that existing studies have explored the influencing factors a great deal, applying different research methods.

Most studies on factors influencing digital health literacy in older patients with NCDs have used regression analyses, structural equation modelling, or studies using longitudinal data(12, 13, 21, 29). However, in traditional methods, the effect of a single factor on the level of digital health literacy in older patients with NCDs is usually only derived. It is important to note that in most real-life situations, the level of digital health literacy among older people with NCDs may be the result of a combination of factors (12). Secondly, traditional research methods only yield correlations between influential factors and digital health literacy levels of older patients with NCDs, without sufficiently considering the causal relationships between different factors. This implies that it is necessary to apply new research methods to explore the complex causal relationship between digital health literacy levels of older patients with NCDs from a group perspective. Qualitative comparative analysis(QCA) is an aggregation approach that compensates for the shortcomings of traditional analyses that focus on a single influencing factor through a new lens(30). QCA has two different characteristics, the first is equivalence, meaning that different combinations of conditioning variables can produce the same results, which is an important difference from regression analysis(31). QCA focuses on group effects between condition variables, which contributes to a more detailed understanding of the causal mechanisms of digital health literacy levels in older patients with NCDs in this study. The second characteristic is asymmetry, meaning that the conditions leading to the outcome are asymmetrical, and the same conditions can lead to different outcomes by combining them in different ways(32). Therefore, this study applies the QCA method to explore the different combinations of factors that lead to high and low levels of digital health literacy in older patients with NCDs, and explores the path to improve the digital health literacy level of older patients with NCDs from a configurational perspective.

Methods

Research Design and Data Collection

From September to November 2023, convenience sampling was applied to recruit participants from geriatric, respiratory, cardiology, neurology, nephrology, endocrinology and oncology departments of tertiary comprehensive hospitals in Qingdao, Shandong province, China. The inclusion criteria of the study population were: (a) aged 60 years and above; (b) diagnosed as NCDs, such as chronic obstructive pulmonary disease, asthma, coronary heart disease, stroke, chronic kidney disease, cancers and diabetes; (c) voluntary participation. Exclusion criteria of the study population were: (a) those with mental illness or confusion; (b) those who were too ill to cooperate. Sample size selection is highly correlated with the number of conditions included in the fs-QCA. In order to make the fs-QCA results more scientific, if the number of conditions is k, the sample size should be at least 2^k. If the sample size is insufficient, there are problems of diversity, theoretical interpretation, and limited validity. Nine conditioning variables were included in this study, resulting in a sample size of at least 2^9, namely 512.

Questionnaires were distributed using both online platforms (Questionnaire Star) and offline methods, with participants providing their contact details to the researcher. Research team members who had received standard training explained the purpose and significance of the study to the participants and administered the questionnaire after obtaining informed consent. The questionnaires were filled out by the participants themselves, and for individuals who had difficulty completing the form, the investigator read the questionnaire to them item by item and then recorded their responses. The online questionnaire was distributed through the online survey platform "Questionnaire Star". Only one submission per participant was allowed and we excluded duplicate IP addresses. A total of 552 questionnaires were finally recovered, and after excluding 14 invalid questionnaires (e.g., consecutive repetitions, regular answers, logical contradictions, etc.), the final valid questionnaires were 538, and the effective recovery rate of the questionnaires was 97.46%.

This study was performed according to the Declaration of Helsinki and was approved by Ethics Committee of Medical College of Qingdao University (Approval number: QDU-)(33).

Instruments

The general information questionnaire consisted of 7 entries, gender, age, education level, place of residence, degree of health concerns, number of NCDs, type of digital device owned.

Attitudes towards technology were measured using the Attitudes Towards Technologies Questionnaire (ATTQ). The scale was designed by Zambicanchi in 2013 and contains six items(34).

The scale is based on a 5-point Likert scale, with higher scores indicating more positive attitudes towards digital technology, and has demonstrated good reliability and validity in previous studies(35). The Cronbach's alpha coefficient was 0.90.

Proficiency in the use of digital devices was measured using the Mobile Device Proficiency Questionnaire (MDPQ). The questionnaire was developed by Roque in 2018 and contains six entries for computer use and eight entries for mobile device use. The scale was scored on a 5-point Likert scale, with the scale score being the mean of the scores for each entry, which has demonstrated good reliability and validity in previous studies, with a Cronbach's alpha coefficient of 0.99(36).

Social support was measured using the Web Use Support Scale. The scale was developed by Shaojie Li in 2022 and contains a total of nine entries in two dimensions, including family member support and friend and community support. The scale is rated on a five-point Likert scale, with higher scores indicating higher levels of support. Previous studies have shown good reliability and validity with Cronbach's alpha coefficient = 0.953 and split-half reliability 0.945(37).

The outcome variable in this study was digital health literacy. Therefore, the Digital Health Literacy Assessment Scale for Community-Dwelling Elderly was used in this study to assess the level of digital health literacy among older patients with NCDs. The scale was developed by Liu Siqi in 2022 and includes 3 dimensions with 15 entries respectively: digital health information acquisition and assessment ability, digital health information interaction ability, and digital health information application ability. Scale scores were based on a 5-point Likert scale ranging from 15 to 75, with higher scores indicating higher levels of digital health literacy. The item-level CVIs were 0.833~1.000, and the scale-level CVI was 0.967; the Cronbach's alpha was 0.941; the split-half reliability was 0.889; and the test–retest reliability after 2 weeks was 0.941. It usually took 10 to 20 min to complete the questionnaire in most older adults. The above results suggested that the scale had good reliability, validity and practicability.

Data Analysis

Qualitative comparative analysis (QCA) is a research method between qualitative and quantitative proposed by Ragin in 1987. The research methodology is based on Boolean algebra and set theory and allows for the exploration of logical relationships between multiple conditions and outcomes (38). QCA is an asymmetric research method that, unlike traditional linear-based research methods, identifies possible asymmetric relationships between premises and outcomes, i.e. an outcome may be equally well explained by other combinations of causal conditions(39).

The three most frequent types of QCA are Crisp-set qualitative comparative analysis (cs-QCA), Fuzzy-set qualitative comparative analysis (fs-QCA) and Multi-value qualitative comparative analysis (mv-QCA). The application of cs-QCA requires the condition and outcome variables to be 2-point variables, each assigned a value of 0 or 1. Mv-QCA should be used when the condition and outcome variables are multicategorical, and each variable can be assigned a value of 0.1.2, etc. Fs-QCA is mainly used in continuous, ordered and proportional data (30). This study used fuzzy-set qualitative comparative analysis (fs-QCA) to explore the factors influencing the level of digital health literacy among older patients with NCDs, which was the combination of fuzzy sets and logic principles with QCA. The difference with crisp-set QCA (cs-QCA) is that fs-QCA applies the fuzzy-set method by using a fuzzy-set scale (continuous from full non-membership (0) to full membership (1)), and (0.5) considers a midpoint, neither inside nor outside the set(40, 41). This study was analysed by fs-QCA 3.0 software. QCA models identify the percentage of variance explained, or cases in which the model is adequate coverage, as well as indicators of goodness-of-fit and consistency.

First, we calibrated the raw data to a score from 0 to 1 using a direct calibration method to indicate the degree to which the condition variable was fully present in each case, with (0) indicating that the condition was not present at all and (1) indicating that the condition was fully present. The calibration anchor points use the 90% quantile (high level or totally within the set), 50% quantile (intermediate level, neither inside nor outside the set), and 10% quantile (low level or totally outside the set) normally used in fs-QCA(31). Use of fs-QCA software to recalibrate variables such as attitudes towards technology, proficiency in digital device use, level of social support, and level of digital health literacy. The data were calibrated by bringing the anchor point values for each condition variable into the calibrate function in the fs-QCA software.

Secondly, the calibrated data were used to analyse the necessity and sufficiency of the conditioning variables. Consistency and coverage are key indicators for assessing the necessity and sufficiency of conditions. According to existing studies, the conditional variable is judged to be necessary when consistency□0.9 (38), necessary conditional causation means that if a particular conditional variable does not exist, the outcome will not occur.

Finally, when conducting the sufficiency analysis, it is necessary to construct truth tables to classify and categorise the sample cases into different combinations (groupings) of conditions. After the initial generalisation, there are some cases of low consistency in the truth table. Thresholds need to be set to manually encode the result variables corresponding to groupings with too low a consistency to 0 (representing that the result does not exist). Based on previous research, this threshold was recommended to be set at 0.75 in this study(42). Three solutions are generated after the sufficiency analysis: complex solution, parsimonious solution and intermediate solution. The intermediate solution compensates for the shortcomings of the complex and parsimonious solutions and is more consistent with theoretical and empirical knowledge(38, 42). Therefore, this study is based on the intermediate solution to understand the effect of the grouping of condition variables on the outcome variables.

Results

Sample characteristic

The study included 538 older patients with NCDs during hospitalisations or consultations, which including 281 male patients (52.2%) and 257 female patients (47.8%). And with ages ranging from 60 to 80 (Mean = 68.64 years, SD = 5.49). These include 213 from rural households and 325 from urban households. Among them, 240 had primary school education or less, 155 had junior high school education, 84 had high school education, and 59 had university education or more. 140 patients suffered from only one chronic disease, 222 patients suffered from two to three NCDs and 176 patients suffered from more than three NCDs. 62 patients had low health concern, 385 patients had moderate health concern and 91 patients had high health concern. 94 patients did not have digital devices, 375 patients had one or two digital devices, and 69 patients had three or more digital devices. Table 1 showed the general information about the participants.

Calibration

We convert the raw scores of the variables into fuzzy affiliations between 0.0 and 1.0. In our case (0=rural domicile; 1=urban domicile), (0=Primary and below; 0.49=middle school; 1=university and above), (0=one chronic disease; 0.49=2-3 NCDs; 1=more than three NCDs), (0=low health concern; 0.49= middle health concern; 1= high health concern), (0=no digital devices; 0.49=one or two digital device; 1=three or more digital devices). This study used three thresholds that have been commonly applied in previous studies: 10%, 50%, and 90%. Threshold 0 means that the observation is completely outside the 10% set range, threshold 0.5 places the observation at an intermediate level, indicating that it is neither inside nor outside the set, and the last threshold, 1, means that the observation is completely above 90%. The descriptive statistics and calibration of variables were shown in Table 2.

Requirements Analysis

After calibrating the study variables, we analysed the scores for necessity; in general, a variable was considered necessary if its consistency score exceeded 0.90(38). According to the results obtained in Table 2, the number of NCDs is a necessary condition for DHL (consistency=0.92), Older patients with NCDs who have a smaller number of NCDs have higher levels of digital health literacy. In addition, most of the conditions have a coverage of the outcome greater than 0.5, which means that each condition has sufficient explanatory strength for the outcome variable(43). More information saw Table 3.

Sufficiency Analysis

In this study, the QCA graphical method proposed by Fiss was used(44), which allows the relative importance of the factors in the configuration of the reaction conditions to be charted.

In this study, ● indicates the presence of a conditional variable, ⊗ indicates the absence of a conditional variable, ● indicates the presence of a core condition, and ⊗ indicates the absence of a core condition. Through fs-QCA analyses, the model provides nine different pathways to digital health literacy for older patients with NCDs.

In addition, according to Ragin, the coefficient of consistency of results should be >0.75 and the coverage should be >0.25. As a result, we removed three configurations, ultimately concluding that six different grouping pathways for digital literacy levels in older patients with NCDs explained 68% of the cases with high levels of digital health literacy(Overall Consistency=0.92; Overall Coverage=0.68). Among the most relevant groupings or pathways were the outcomes of high education, low number of diseases, high health concern, and positive attitudes towards digital technology (Overall consistency = 0.95, Overall coverage = 0.39). Other configurations are detailed in table 4.

Moreover, for high level of acquiring and assessing capacity, seven paths explained 68% of the cases (overall consistency=0.80; overall coverage=0.68). The most relevant path or combination to explain high levels of acquiring and assessing capacity was the interaction of being older, having a high number of NCDs, having a high number of digital devices, and having a low level of social support (raw coverage=0.43; consistency=0.95).

Ten paths were observed for high levels of interactive capacity, which clarified 69% of the variance explained (overall consistency=0.81; overall coverage=0.69). The most relevant path or combination to explain high levels of interactivity are younger age, more positive attitudes toward digital technology, high levels of social support, high level of proficiency in digital device use (raw coverage=0.34; consistency=0.94).

Finally, nine paths clarified 66% of the variance explained in the case of high levels of application capability (overall consistency=0.82; overall coverage=0.66). The most relevant path or combination accounted for 42% of the cases (raw coverage =0.42; consistency = 0.91), and was younger age, high education, urban residence, high number of digital devices, high level of mobile device proficiency. The results of the sufficiency analysis for each dimension were shown in Table 5.

Discussion

Principal Findings

This study explored and compared the ability of socio-demographic characteristics (gender, age, education, place of residence), health status (number of NCDs, health concerns), attitudes towards technology, proficiency in the use of digital devices, and social support in the prediction of digital health literacy among older patients with NCDs, based on the analytical methodology of the fs-QCA model. The main difference between fs-QCA and path analysis (eg. structural equation modelling) is that they are working based on different principles and different focus(45). The fs-QCA is a case-oriented technique focuses on combinatorial effects. It assumes an asymmetric relationship between the independent variable and the dependent variable, and multiple different combinations of conditional variables can lead to the same outcome(46).

According to the results derived from the fs-QCA model, there are no necessary conditions for digital health literacy levels. However, in addition to the necessity condition, the consistency results show that health concern is the more important condition. This may be because older patients with high health concerns may have a stronger sense of maintaining their health and thus consciously seek, use and communicate with digital resources to improve their health status(47). In addition, by comparing six different configurations of DHL, the present study found that the conditional variable of number of digital facilities appeared in five out of six configurations considered in the study. This suggests that the number of digital facilities is an important influence on digital health literacy among older patients with NCDs. Previous research has shown that respondents with multiple digital facilities have higher rates of internet usage than those with only one or no digital facility, thus affecting levels of digital health literacy(14, 23). Next, we detailed the optimal configuration of the digital health prime level and each of its dimensions for older patients with NCDs.

For the best configuration leading to a higher total digital health literacy score, the combination of educational, health concerns, number of NCDs, and attitudes toward digital technology influence the level of digital health literacy among older patients with NCDs. Numerous previous studies have shown that there is a positive effect of educational level on digital health literacy(7, 25, 28). Especially for older patients with NCDs, they are usually accompanied by deterioration of physical functions and cognitive functions. Older patients with low literacy levels have limited literacy and comprehension skills, and are fraught with difficulties in comprehending and identifying digital health information(48). Older patients with NCDs who have higher literacy level qualifications are more capable of accessing and understanding digital health information(49). Meanwhile, they can better distinguish the correctness, scientificity and validity of digital health information in the digital environment, so that they can make better use of digital health information to enhance their health status. In addition, improved health status promotes them to take a more active interest in their personal health care(50). With a higher level of health concern, they are more likely to make active use of digital health information and apply it in the disease management process (45). The high level of concern for their own health status may lead to a better health status for this group of older patients, with a lower number of NCDs. Older patients with NCDs who have a high health concern are in better physical health, have more energy to access digital devices, have better literacy skills, and have higher digital health literacy (51). Therefore, the overlap of high educational attainment, low number of NCDs, high health concerns, and positive attitudes toward digital technology together contributed to the level of digital health literacy among older patients with NCDs.

Adequacy analyses were conducted for each dimension of digital health literacy. For acquisition and assessment capabilities, health concerns and number of NCDs exist as core conditions. Age, number of digital devices, social support exist as peripheral conditions. In this study even older patients with NCDs with higher age throw have a high level of access and assessment ability. This result appears to be at variance with previous studies showing lower digital health literacy at higher ages (52). This may be because the present study found that most older patients with NCDs own at least one digital device, and that age-related barriers to technology use are gradually being eroded by the high penetration of digital technology (53). Older patients with NCDs who have a higher age will have more pronounced fear and anxiety about death, so health concerns are higher in older patients (54). In order to maintain a stable daily life, they are usually more active in health management and have a greater need for digital health information. This is in line with previous studies, where older NCDs patients with high health concerns have a stronger sense of self-management and health information needs (55). In addition, a higher number of NCDs exist as core conditions in this configuration. Previous studies have shown that older people with more serious illnesses or multiple chronic diseases are more eager to learn how to effectively manage their illnesses, and digital health provides them with a convenient and rich source of health information (56). Due to the increase in health concerns, traditional single information channels cannot meet the needs of older patients with NCDs, who are beginning to accept and gradually try to use digital devices to seek health guidance (57). At the same time, the number of digital devices owned by this group of patients is high, and the diversification of digital devices may further increase the sources of digital health information for older patients with NCDs, thus enhancing their ability to access and assess digital health information.

It's important to note that, patients in this configuration had low levels of social support, although previous research has suggested that a lack of social support may result in older patients with NCDs not being able to ask for help when they have difficulty using digital devices (58). However, this may, on the other hand, lead them to perceive a lack of help from the outside world and therefore pay more attention to the information delivered by digital devices (59). They prefer to manage their health through digital health information to reduce the impact of NCDs on them.

For the ability to interact with digital health information, more positive attitudes towards digital technology and younger age served as core variables, with proficiency in digital device use and social support as peripheral conditions. Previous studies have shown that older NCDs people are accustomed to acting as audiences rather than communicators in digital health environments (60). Those younger patients have a more positive attitude towards digital technology and want to share health information related to their experiences such as illness to others through digital technology by sharing and evaluating it. Studies have shown that older people with NCDs have difficulties interacting with the internet and digital devices compared to younger people, which is related to their lack of experience and confidence in using digital devices (61). Older patients with NCDs who do not use digital devices or who use them less often are often fearful or anxious about digital technology (62). This result is consistent with previous research that age and attitudes towards digital technology are significant predictors of digital health literacy (63). The technology acceptance model also mentions that younger individuals usually have more positive attitudes towards digital technology, which will directly influence their behaviour, leading to more positive use of digital technology and thus higher digital health literacy (64). In addition, social support as peripheral condition also has an impact on interaction ability. Prior research has shown that social support for the use of digital devices by older patients with NCDs comes primarily from family members. The active involvement of family members in their digital technology use process can motivate older patients to use digital devices more actively and increase their desire to interact (65). At the same time, older patients are more likely to want the support and attention of their family members due to their perennial suffering from the NCDs. The interaction of digital health information also has a good effect on the emotional enhancement of the older patients and family members, which also increases the attitude of them towards digital technology (66). Therefore, in this configuration, we considered that age, attitudes towards digital technology, proficiency in the use of digital devices, and social support collectively influence the ability of older patients with chronic diseases to communicate digital health information

Finally, we found that level of education and place of domicile were the core variables in the ability to apply digital health in older patients with NCDs. Digital health information application competence is the highest perceived level of digital health literacy, informed and built from all lower levels of digital health literacy dimensions (i.e., ability to acquir and assess, ability to interact) (67). Older patients with NCDs who have higher education are more capable of accepting and learning new technologies, and they can effectively master digital technology and digital devices when facing them, and even if they encounter some difficulties, they can reasonably solve them by learning and asking questions. This is consistent with previous research that older patients with NCDs who have higher education levels have higher proficiency in the use of digital health devices and use them for longer periods of time (68). Urban residents have more access to new digital health devices and technologies, research shows that older patients with NCDs living in urban areas use health apps and health publics more extensively. Older patients with NCDs living in rural areas face more difficulties in using digital health technologies, which may be related to the fact that rural areas in China are poorly equipped with digital devices and have fewer opportunities for social support such as education and training (69). At the same time, there is currently a large gap between the level of economic development in urban and rural China, and the financial cost of using digital technology is often a major concern for older patients with NCDs (70). Individuals at lower economic levels are less likely to have a higher number of digital devices. They have lower internet usage due to lack of access to key media for digital health information, which further contributes to their lower digital adoption capacity. Therefore, in this pathway, place of residence, number of digital devices, and proficiency in digital device use, are interrelated and collectively influence the ability of older NCDs patients using digital health technologies. This finding seems obvious in most cases, but varies slightly in studies from developed countries (23, 71). It's important to note that this may be because most rural patients in developed countries almost have at least one digital device at home as well as an internet link, and they prefer to access health information through digital media (72,73). Moreover, in rural China, even though older patients have digital devices, rural residents' use of digital devices is mainly focused on entertainment and socialising. Further promotion and popularisation of deeper applications such as digital health, digital healthcare and online consultation are still required.

Limitations

Despite the importance of the information obtained in this study for older patients with NCDs, the study has the following limitations. Firstly, the survey sample of this study was only sampled in Qingdao, China, and there may be data bias. The data obtained in only one city means that replication is difficult. In the future, it may be more meaningful to extend this study to other regions or countries. Secondly, the data collected in this study was based on a questionnaire, which, although a standard research tool, is still not immune to subjective bias. Third, the conditional variables explored in this study are limited by the complexity of the fs-QCA model. In future studies, more variables affecting the digital health literacy pathway in older patients with NCDs should be considered. In addition, as with all qualitative research, findings will vary depending on the sample. In future studies, it will also be possible to compare the different configurations of the linear regression model and the QCA model. Finally, fs-QCA can effectively identify the necessary conditions for an outcome variable, but it cannot quantify "how necessary a condition is for an outcome". In future studies, the new method of necessary conditions analysis (NCA) can be used in combination with fs-QCA.

Practice Implications

The results of this study can be used by healthcare providers to develop comprehensive and accurate interventions. This study derived different configurations that lead to high and low levels of digital health literacy among older patients with NCDs, and based on the characteristics of the different configurations, healthcare providers can provide detailed interventions depending on the type of patients.

Identified immutable factors such as educational attainment and place of residence can be used to determine which individuals are at risk of digital health literacy deficits and to help health professionals identify vulnerable groups that need to be targeted. In addition, this suggests that healthcare workers need to intervene to address the physical condition of older patients with NCDs. Provide them with disease counselling and guidance on the adoption of reasonable diet, exercise and other living habits, so as to actively improve their chronic disease conditions (74).

This study declared the most important groupings of older patients with NCDs with high digital health literacy: high educational attainment, low number of NCDs, high health concern, and positive attitudes towards digital technology. This suggests that healthcare providers should offer targeted interventions for older NCDs patients with low education. By designing structured courses, providing intergenerational guidance for older patients with NCDs, and organizing unified training in libraries and communities, healthcare staff can improve the reading and writing skills and the use of digital devices of older patients with NCDs who are less educated (75).On the other hand, there is a need to design digital devices or digital device applications that are more suitable for older NCDs patients, and adapt to the usage habits of older NCDs patients with low education level by expanding fonts, simplifying the operation interface, simplifying the operation steps, and providing graphic and video instructions. In addition, healthcare providers should strengthen digital health promotion and popularisation activities to improve the enthusiasm of older NCDs patients on digital technology, so that they recognise and accept digital health technology, thus enhancing digital health literacy (76). Various digital technology operating platforms should strengthen the quality control of digital information, create a safe and healthy digital technology environment, and improve the trust of older patients with NCDs in digital health information. Finally, health education for older patients with NCDs should be strengthened to promote older people's awareness of self-care and digital health information needs, and increase their health concerns, so as to urge them to seek digital health information more proactively.

Conclusion

This study investigated the factors influencing digital health literacy in older patients with NCDs using fs-QCA analysis. This methodology takes into account the different combinations of conditions that influence digital health literacy in older patients with NCDs. This study derived different configurations of conditioning variables leading to total digital health literacy scores and three dimensions (acquiring and assessing capacity, interactive capacity and application capacity) in older patients with NCDs.

This suggests that when devising interventions, healthcare workers and health authorities should consider that it is not just a single factor that affects the level of digital health literacy among older patients with NCDs, but that different conditions combine to influence it. Combining different grouping types with appropriate interventions, this is more conducive to improving the level of digital health literacy in older patients with NCDs.

Acknowledgments

Conflicts of Interest

None declared.

References

1. Dunn P, Conard S. Digital health literacy in cardiovascular research. Int J Cardiol. 2018; 269:274-275.

2. Shan R, Sarkar S, Martin SS. Digital health technology and mobile devices for the management of diabetes mellitus: state of the art. Diabetologia. 2019;62(6):877-887.

3. Fjellså HMH, Husebø AML, Storm M. eHealth in care coordination for older adults living at home: scoping review. Journal of Medical Internet Research. 2022;24(10):39-58.

4. Kabukye JK, Kakungulu E, de Keizer N, Cornet R. Digital health in oncology in Africa: a scoping review and cross-sectional survey. International Journal of Medical Informatics. 2022;15(8):46-59.

5. Godinho MA, Martins H, Al-Shorbaji N, Quintana Y, Liaw ST. "Digital Health Diplomacy" in Global Digital Health? A call for critique and discourse. Journal of the American Medical Informatics Association : JAMIA. 2022;29(5):1019-1024.

6. Li S, Cui G, Yin Y, Wang S, Liu X, Chen L. Health-promoting behaviors mediate the relationship between eHealth literacy and health-related quality of life among Chinese older adults: a cross-sectional study. Qual Life Res. 2021;30(8):2235-2243.

7. Rahimi-Ardabili H, Magrabi F, Coiera E. Digital health for climate change mitigation and response: a scoping review. Journal of the American Medical Informatics Association. 2022;29(12):2140-2152.

8. De Santis KK, Mergenthal L, Christianson L, Busskamp A, Vonstein C, Zeeb H. Digital technologies for health promotion and disease prevention in older people: scoping review. Journal of Medical Internet Research. 2023;25(2):43-54.

9. Chen X, Giles J, Yao Y, Yip W, Meng Q, Berkman L, et al. The path to healthy ageing in China: a Peking University–Lancet Commission. The Lancet. 2022;400(10):1967-2006.

10. Kanasi E, Ayilavarapu S, Jones J. The aging population: demographics and the biology of aging. Periodontology 2000. 2016;72(1):13-18.

11. Facchinetti G, D'Angelo D, Piredda M, Petitti T, Matarese M, Oliveti A, et al. Continuity of care interventions for preventing hospital readmission of older people with chronic diseases: A meta-analysis. International journal of nursing studies. 2020;10(1):10-23.

12. Liu S, Zhao H, Fu J, Kong D, Zhong Z, Hong Y, et al. Current status and influencing factors of digital health literacy among community-dwelling older adults in Southwest China: a cross-sectional study. BMC public health. 2022;22(1):90-96.

13. Wang X, Luan W. Research progress on digital health literacy of older adults: A scoping review. Frontiers in public health. 2022;10(9):06-08.

14. Arcury TA, Sandberg JC, Melius KP, Quandt SA, Leng X, Latulipe C, et al. Older Adult Internet Use and eHealth Literacy. Journal of applied gerontology : the official journal of the Southern Gerontological Society. 2020;39(2):141-150.

15. Spatz ES, Ginsburg GS, Rumsfeld JS, Turakhia MP. Wearable Digital Health Technologies for Monitoring in Cardiovascular Medicine. The New England journal of medicine. 2024;390(4):346-356.

16. Shi Y, Ma D, Zhang J, Chen B. In the digital age: a systematic literature review of the e-health literacy and influencing factors among Chinese older adults. Zeitschrift fur Gesundheitswissenschaften = Journal of public health. 2023;31(5):679-687.

17. Paige SR, Stellefson M, Krieger JL, Anderson-Lewis C, Cheong J, Stopka C. Proposing a Transactional Model of eHealth Literacy: Concept Analysis. J Med Internet Res. 2018;20(10):10-17.

18. Eronen J, Paakkari L, Portegijs E, Rantanen T. Coronavirus-related health literacy and perceived restrictiveness of protective measures among community-dwelling older persons in Finland. Aging clinical and experimental research. 2021;33(8):2345-2353.

19. Verma R, Saldanha C, Ellis U, Sattar S, Haase KR. eHealth literacy among older adults living with cancer and their caregivers: A scoping review. Journal of geriatric oncology. 2022;13(5):555-562.

20. Ginsburg GS, Picard RW, Friend SH. Key Issues as Wearable Digital Health Technologies Enter Clinical Care. The New England journal of medicine. 2024;390(12):1118-1127.

21. Estrela M, Semedo G, Roque F, Ferreira PL, Herdeiro MT. Sociodemographic determinants of digital health literacy: A systematic review and meta-analysis. Int J Med Inform. 2023;17(7):10-14.

22. Morton E, Ho K, Barnes SJ, Michalak EE. Digital Health Literacy in Bipolar Disorder: International Web-Based Survey. JMIR mental health. 2021;8(10):29-34.

23. Cherid C, Baghdadli A, Wall M, Mayo NE, Berry G, Harvey EJ, et al. Current level of technology use, health and eHealth literacy in older Canadians with a recent fracture-a survey in orthopedic clinics. Osteoporosis international: a journal established as result of cooperation between the European Foundation for Osteoporosis and the National Osteoporosis Foundation of the USA. 2020;31(7):1333-1340.

24. Guo Z, Zhao SZ, Guo N, Wu Y, Weng X, Wong JY, et al. Socioeconomic Disparities in eHealth Literacy and Preventive Behaviors During the COVID-19 Pandemic in Hong Kong: Cross-sectional Study. J Med Internet Res. 2021;23(4):24-35.

25. De Santis KK, Jahnel T, Sina E, Wienert J, Zeeb H. Digitization and Health in Germany: Cross-sectional Nationwide Survey. JMIR public health and surveillance. 2021;7(11):32-41.

26. Wang W, Zhuang X, Shao P. Exploring Health Information Sharing Behavior of Chinese Elderly Adults on WeChat. Healthcare (Basel, Switzerland). 2020;8(3):207.

27. Aponte J, Nokes KM. Validating an electronic health literacy scale in an older hispanic population. Journal of clinical nursing. 2017;26(17-18):2703-2711.

28. Cui GH, Li SJ, Yin YT, Chen LJ, Li JQ, Liang FY, et al. The relationship among social capital, eHealth literacy and health behaviours in Chinese elderly people: a cross-sectional study. BMC public health. 2021;21(1):45.

29. Schreiter S, Mascarell-Maricic L, Rakitzis O, Volkmann C, Kaminski J, Daniels MA. Digital Health Applications in the Area of Mental Health. Deutsches Arzteblatt international. 2023;120(47):797-803.

30. Ragin CC. The Comparative Method: Moving Beyond Qualitative and Quantitative Strategies:2014.

31. Giménez-Espert MDC, Prado-Gascó VJ. The role of empathy and emotional intelligence in nurses' communication attitudes using regression models and fuzzy-set qualitative comparative analysis models. Journal of clinical nursing. 2018;27(13-14):2661-2672.

32. Navarro-Mateu D, Alonso-Larza L, Gómez-Domínguez MT, Prado-Gascó V, Valero-Moreno S. I'm Not Good for Anything and That's Why I'm Stressed: Analysis of the Effect of Self-Efficacy and Emotional Intelligence on Student Stress Using SEM and QCA. Frontiers in psychology. 2020;11(2):295.

33. Helsinki WMADO. Ethical principles for medical research involving humans (2013 version). 2013.

34. Zambianchi M, Carelli MG. Positive Attitudes towards Technologies and facets of Well-being in Older Adults. Journal of Applied Gerontology. 2016;37(3):371-388.

35. Zambianchi M, Rönnlund M, Carelli MG. Attitudes Towards and Use of Information and Communication Technologies (ICTs) Among Older Adults in Italy and Sweden: the Influence of Cultural Context, Socio-Demographic Factors, and Time Perspective. Journal of Cross-Cultural Gerontology. 2019;34(3):291-306.

36. Roque NA, Boot WR. A New Tool for Assessing Mobile Device Proficiency in Older Adults: The Mobile Device Proficiency Questionnaire. Journal of applied gerontology: the official journal of the Southern Gerontological Society. 2018;37(2):131-156.

37. Nick EA, Cole DA, Cho SJ, Smith DK, Carter TG, Zelkowitz RL. The Online Social Support Scale: Measure development and validation. Psychological assessment. 2018;30(9):1127-1143.

38. Ragin CC. Redesigning Social Inquiry: Fuzzy Sets and Beyond By Charles C. Ragin University of Chicago Press. 2008. 240 pages. $45 cloth, $18 paper. Social Forces. 2010;88(4):1936-1938.

39. Julieth, Ospina-Delgado, Ana, Zorio-Grima. Innovation at universities: A fuzzy-set approach for MOOC-intensiveness. Journal of Business Research. 2016;69(4):1325-1328.

40. Ragin CC. Fuzzy-Set Social Science. University of Chicago Press Economics Books. 2000.

41. Woodside AG. Moving beyond multiple regression analysis to algorithms: Calling for adoption of a paradigm shift from symmetric to asymmetric thinking in data analysis and crafting theory. Elsevier. 2013(4).

42. Eng S, Woodside AG. Configural analysis of the drinking man: fuzzy-set qualitative comparative analyses. Addictive behaviors. 2012;37(4):541-543.

43. Verweij S. Set-Theoretic Methods For The Social Sciences: A Guide To Qualitative Comparative Analysis. International Journal of Social Research Methodology. 2012;16(2):165-166.

44. Munoz P, editor A Fuzzy Set Approach to Empirical Typologies in Sustainability Entrepreneurship. Babson College Entrepreneurship Research Conference; 2013.

45. Mustafa S, Zhang W, Shehzad MU, Anwar A, Rubakula G. Does Health Consciousness Matter to Adopt New Technology? An Integrated Model of UTAUT2 With SEM-fsQCA Approach. Frontiers in psychology. 2022;13:83.

46. Teng C. Using the fsQCA approach to investigate factors affecting university students' satisfaction with online learning during the COVID-19 pandemic: A case from China. Frontiers in psychology. 2023;14:1123774.

47. Stellefson ML, Shuster JJ, Chaney BH, Paige SR, Alber JM, Chaney JD, et al. Web-based Health Information Seeking and eHealth Literacy among Patients Living with Chronic Obstructive Pulmonary Disease (COPD). Health Communication. 2017;33(12):1410-1424.

48. Schrauben SJ, Appel L, Rivera E, Lora CM, Lash JP, Chen J, et al. Mobile Health (mHealth) Technology: Assessment of Availability, Acceptability, and Use in CKD. American Journal of Kidney Diseases. 2021;77(6):941-950.

49. Amonoo HL, Massey CN, Freedman ME, El-Jawahri A, Vitagliano HL, Pirl WF, et al. Psychological Considerations in Hematopoietic Stem Cell Transplantation. Psychosomatics. 2019;60(4):331-342.

50. Kang H, Baek J, Chu SH, Choi J. Digital literacy among Korean older adults: A scoping review of quantitative studies. Digital health. 2023;9(2):20.

51. Vicente R, Maria, Madden, Gary. Assessing eHealth skills across Europeans (vol 6, pg 161, 2017). Health policy and technology. 2017.

52. Gordon NP, Hornbrook MC. Older adults' readiness to engage with eHealth patient education and self-care resources: a cross-sectional survey. BMC health services research. 2018;18(1):220.

53. Oshima SM, Tait SD, Thomas SM, Fayanju OM, Ingraham K, Barrett NJ, et al. Association of Smartphone Ownership and Internet Use With Markers of Health Literacy and Access: Cross-sectional Survey Study of Perspectives From Project PLACE (Population Level Approaches to Cancer Elimination). J Med Internet Res. 2021;23(6):24-47.

54. Laupland KB, Ramanan M, Shekar K, Edwards F, Clement P, Tabah A. Long-term outcome of prolonged critical illness: A multicentered study in North Brisbane, Australia. PLoS One. 2021;16(4):24-40.

55. Stormacq C, Van den Broucke S, Wosinski J. Does health literacy mediate the relationship between socioeconomic status and health disparities? Integrative review. Health promotion international. 2019;34(5):1-17.

56. Lorusso L, Mosmondor M, Grguric A, et al. Design and evaluation of personalized services to foster active aging; the experience of technology pre-validation in ltalian pilots. J Sensors.2023,23(2):1-41.

57. Bergman L, Nilsson U, Dahlberg K, Jaensson M, Wångdahl J. Health literacy and e-health literacy among Arabic-speaking migrants in Sweden: a cross-sectional study. BMC public health. 2021;21(1):2165.

58. Portz JD, Bayliss EA, Bull S, Boxer RS, Bekelman DB, Gleason K, et al. Using the Technology Acceptance Model to Explore User Experience, Intent to Use, and Use Behavior of a Patient Portal Among Older Adults With Multiple Chronic Conditions: Descriptive Qualitative Study. J Med Internet Res. 2019;21(4):11-14.

59. Papp-Zipernovszky O, Horváth MD, Schulz PJ, Csabai M. Generation Gaps in Digital Health Literacy and Their Impact on Health Information Seeking Behavior and Health Empowerment in Hungary. Frontiers in public health. 2021;9: 635943.

60. Bai Z, Wang Z, Shao T, Qin X, Hu Z. Relationship between Individual Social Capital and Functional Ability among Older People in Anhui Province, China. International journal of environmental research and public health. 2020;17(8): 2775.

61. Tao D, Shao F, Wang. Het allntegrating usability and social cognitive theories with the technology acceptance modelto understand young users' acceptance of a health information portal. Health lnform J. 2020; 26(2): 1347-1362.

62. Shiferaw KB, Tilahun BC, Endehabtu BF, Gullslett MK, Mengiste SA. E-health literacy and associated factors among chronic patients in a low-income country: a cross-sectional survey. BMC Medical Informatics and Decision Making. 2020;20(1):181.

63. Thorlu-Bangura Z, Poole L, Sood H, Khan N, et al. Digital health, cardiometabolic disease and ethnicity: an analysis of United Kingdom government policies from 2010 to 2022. J Public Health Policy. 2023 Jun;44(2):179-195.

64. Nadal C, Sas C, Doherty G. Technology Acceptance in Mobile Health: Scoping Review of Definitions, Models, and Measurement. J Med Internet Res. 2020;22(7):1725.

65. Tao D, Shao F, Wang. Het allntegrating usability and social cognitive theories with the technology acceptance modelto understand young users' acceptance of a health information portal. Health lnform J. 2020; 26(2): 1347-1362.

66. Desteghe L, Kluts K, Vijgen J, Koopman P, Dilling-Boer D, Schurmans J, et al. The Health Buddies App as a Novel Tool to Improve Adherence and Knowledge in Atrial Fibrillation Patients: A Pilot Study. JMIR mHealth and uHealth. 2017;5(7):98.

67. Portz JD. A review of web-based chronic disease self-management for older adults. Gerontechnology : international journal on the fundamental aspects of technology to serve the ageing society. 2017;16(1):12-20.

68. Zhu Y, Song Y, Wang Y, et al. Relationships among patient activation,social support and online health information seeking of community-dwelling older adults living with coronary heart disease. J Adv Nurs. 2023; 79(1):161-169.

69. Oh Y S, Lim J. Patient-provider communication and online health information seeking among a sample of US older adults. J Health Commun. 2021; 26(10):708-716.

70. Gordon NP, Hornbrook MC. Older adults' readiness to engage with eHealth patient education and self-care resources: a cross-sectional survey. BMC health services research. 2018;18(1):220.

71. Oshima SM, Tait SD, Thomas SM, Fayanju OM, Ingraham K, Barrett NJ, et al. Association of Smartphone Ownership and Internet Use With Markers of Health Literacy and Access: Cross-sectional Survey Study of Perspectives From Project PLACE (Population Level Approaches to Cancer Elimination). J Med Internet Res. 2021;23(6):24-47.

72. Latulippe K, Hamel C, Giroux D. Social Health Inequalities and eHealth: A Literature Review With Qualitative Synthesis of Theoretical and Empirical Studies. Journal of Medical Internet Research. 2017;19(4):13.

73. Borkert M, Fisher KE, Yafi E. The Best, the Worst, and the Hardest to Find: How People, Mobiles, and Social Media Connect Migrants In(to) Europe. Social Media + Society. 2018;4(1):20.

74. Masterson Creber R, Dodson JA, Bidwell J, Breathett K, Lyles C, Harmon Still C, et al. Telehealth and Health Equity in Older Adults With Heart Failure: A Scientific Statement From the American Heart Association. Circulation Cardiovascular quality and outcomes. 2023;16(11):123.

75. Yeo G, Reich SM, Liaw NA, Chia EYM. The Effect of Digital Mental Health Literacy Interventions on Mental Health: Systematic Review and Meta-Analysis. J Med Internet Res. 2024; 26:68.

76. Stara V, Soraci L, Takano E, Kondo I, Möller J, Maranesi E, et al. Intrinsic Capacity and Active and Healthy Aging Domains Supported by Personalized Digital Coaching: Survey Study Among Geriatricians in Europe and Japan on eHealth Opportunities for Older Adults. J Med Internet Res. 2023;25(2):35.

Supplementary Files

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Figures

General information for participants (N=538).

Table 1. General information for participants (N=538)

Variables	Participants, n (%)
Gender	
Male	281 (52)
Female	257 (48)
Age	
60-64	185 (34)
65-69	129 (24)
70-74	141 (26)
75-80	83 (16)
Place of residence	
Urban	325 (60)
Countryside	213 (40)
Education	
Primary and below	240 (45)
Junior high school	155 (28)
Senior high school	84 (16)
University and above	59 (11)
Number of NCDs	
One	140 (26)
Two or three	222 (41)
More than three	176 (33)
Health concerns	
Low	62 (12)
Middle	385 (72)
High	91 (16)
Number of digital device	
Zero	94 (17)
One or two	375 (70)
Three or more	69 (13)
Marital status	
Married	404(75)
Unmarried/Divorced/Widowed	134(25)
Monthly household income per capita (RMB)	
<1000	43(8)
1000 – 2999	194(36)
3000 – 4999	226(42)
≥5000	75(14)
Living arrangement	
Live with a spouse only	258(48)
Live with children and/or a spouse	221(41)
Live alone	59(11)

Main descriptions and calibration values.

Table2. Main descriptions and calibration values

	Age	ATT	MDP	SS	DHL
M	68.64	3.25	2.38	23.22	45.70
SD	5.49	0.78	0.87	8.01	14.19
Min	60	1.00	1.00	9.00	15.00
Max	80	5.00	4.00	40.00	71.00
Calibration values					
P10	60.00	2.25	1.13	11.00	22.00
P50	68.00	3.25	2.25	24.00	49.00
P90	74.00	4.25	3.75	34.00	64.00

Note: DHL: digital health literacy; ATT: attitudes toward technologies; MDP: Mobile Device Proficiency; SS: social support.

Summary of necessary conditions.

Table 3. Summary of necessary conditions

Condition variable	DHL		AA		I		A	
	Cons	Cov	Cons	Cov	Cons	Cov	Cons	Cov
Age	0.57	0.56	0.56	0.65	0.57	0.65	0.57	0.65
~Age	0.66	0.66	0.69	0.60	0.67	0.61	0.68	0.58
Education	0.51	0.67	0.54	0.51	0.52	0.55	0.54	0.49
~Education	0.77	0.55	0.76	0.79	0.77	0.78	0.77	0.74
Place of residence	0.69	0.54	0.70	0.56	0.69	0.57	0.67	0.58
~Place of residence	0.30	0.49	0.42	0.42	0.44	0.55	0.42	0.46
Number of NCDs	0.22	0.51	0.16	0.40	0.56	0.49	0.52	0.51
~Number of NCDs	0.83	0.62	0.88	0.71	0.88	0.70	0.87	0.66
Digital device	0.85	0.68	0.72	0.60	0.70	0.56	0.68	0.59
~Digital Device	0.42	0.54	0.64	0.74	0.64	0.78	0.61	0.70
Health concern	**0.88**	0.65	0.87	0.77	0.87	0.61	0.84	0.76
~Health concern	0.36	0.55	0.47	0.56	0.49	0.74	0.47	0.54
ATT	0.82	0.85	0.87	0.46	0.84	0.48	0.83	0.47
~ATT	0.46	0.50	0.43	0.84	0.54	0.84	0.45	0.80
MDP	0.69	0.68	0.70	0.62	0.67	0.62	0.65	0.60
~MDP	0.61	0.62	0.61	0.67	0.59	0.66	0.59	0.63
Social support	0.86	0.87	0.85	0.50	0.86	0.48	0.86	0.47
~Social support	0.45	0.48	0.44	0.83	0.46	0.87	0.52	0.83

DHL-related configuration.

Table 4. DHL-related configuration

Condition variable	DHL					
	H1	H2	H3	H4	H5	H6
Age		⊗	•	⨂	●	⊗
Education	•					
Place of residence		●		•	•	⊗
Number of NCDs	⊗			⊗		
Digital Device		●	●	•	•	●
Health concerns	•				●	
ATT	•			●		•
MDP			●			●
Social support		•	●		⊗	
Consistency	0.97	0.95	0.95	0.92	0.91	0.81
Raw coverage	0.37	0.33	0.39	0.32	0.27	0.26
Unique coverage	0.06	0.06	0.10	0.01	0.04	0.01
Solution consistency	0.92					
Solution coverage	0.68					

Note: " • ": peripheral condition; " ● ": core condition; " ⨂ ": absent as a core condition; " ⊗ ": absent as a peripheral condition; Blank cells represent ambiguous condition; DHL: digital health literacy; ATT: attitudes toward technologies; MDP: Mobile Device Proficiency.

Summary of three main sufficient conditions for the intermediate solution of DHL.

Table 5. Summary of three main sufficient conditions for the intermediate solution of DHL

Condition variable	AA		I		A	
	H1	H2	H1	H2	H1	H2
Age	•		⨂		⊗	
Education				⊗	●	•
Place of residence		•			●	
Number of NCDs	●	⊗				•
Device	•			●	•	
Health concern	●			•		•
ATT			●			
MDP			•		•	
Social support	⊗	•	•			⊗
Consistency	0.95	0.93	0.94	0.93	0.91	0.89
Raw coverage	0.43	0.38	0.34	0.32	0.42	0.26
Unique coverage	0.09	0.07	0.08	0.07	0.14	0.03
Solution consistency	0.80		0.81		0.82	
Solution coverage	0.68		0.69		0.66	

Note: "•": peripheral condition; "●": core condition; "⨂": absent as a core condition; "⊗": absent as a peripheral condition; Blank cells represent ambiguous condition; AA: acquiring and assessing capacity; I: interactive capacity; A: application capability; ATT: attitudes toward technologies; MDP: mobile device proficiency.