HEALTH PROMOTION

Network Analysis of the HLS_{19}-Q12 Health Literacy Questionnaire: insights from an Italian Pilot Study

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Keywords

Health literacy • Network analysis • Health Literacy Survey Questionnaire • HLS-Q12

Summary

Background. *The widespread use of the internet and social media has transformed how people access health information impacting health literacy. Health literacy, the ability to access, understand, and use health information, is crucial to promote and maintain good health. This study is the first exploring with network analysis the correlation and distribution of the items of the Health Literacy Survey Questionnaire (HLS-Q) 12 short form to verify their correspondence to the principal domains of the health literacy conceptual model proposed by Sorensen et al. in 2013.*
Materials and Methods. *A digital version of the Italian HLS19-Q12 questionnaire was distributed online through social media and informal channels in May 2024. The sample consisted of 352 participants from the metropolitan area of Cagliari, Italy. Network analysis was employed to examine the clustering and relationships between the questionnaire items, via JASP using the Ising Fit method.*
Results. *Key findings include significant difficulties in accessing professional help and understanding medical emergencies. Network centrality measures highlighted the prominence of items related to understanding medical emergencies and making health decisions. Three clusters corresponding to healthcare, disease prevention, and health promotion, were visually identified with the last two closely interconnected. The item "making decisions to improve health" is crucial, acting as a bridge between clusters. Some items traditionally belonging to one domain shifted to another.*
Conclusions. *The network analysis provided a clear depiction of health literacy as complex system, emphasizing interactions. Health literacy involves accessing, evaluating, and applying information, with empowerment playing a key role according to our findings. By addressing identified needs and focusing on prominent items, healthcare professionals and policymakers can enhance health literacy and improve health outcomes for individuals and communities. This pilot study's findings could benefit future research and interventions to improve health literacy.*

Introduction

In recent years, communication and how information is obtained by people in their everyday life have undergone radical changes, affecting various sectors, including healthcare. This shift in the way people get informed is mainly due to the widespread use of the internet and social media across all age groups and the increase in communication channels compared to the past. New platforms can reach segments of the population that were previously inaccessible, allowing for broad-spectrum communication and dissemination. In 2024, the Facebook page of the Italian Ministry of Health had 1.5 million followers (Ministero della Salute, 2024), and its Instagram profile had 646,000 followers (Ministero della Salute, 2024), suggesting that people use these new channels to stay informed on specific topics.
The way people get informed changed, as well as the way of communicating with users, and the interaction between users and healthcare professionals. The modern user relies not only on the guidance of healthcare professionals but seeks information independently, reads, and navigates with more knowledge and awareness of available care and assistance options compared to the past. In this view, health is generated by a synergy of knowledge, behaviors, policies, provisions, social resources, and genetic heritage, which develop in different balances [3]. This vision of well-being emphasizes that health promotion becomes a dialogical exchange between educational, clinical, institutional, environmental, socioeconomic, and family contexts. This vision of well-being emphasizes that health promotion becomes a dialogical exchange between educational, clinical, institutional, environmental, socioeconomic, and family contexts. In this view, health is generated by a synergy of knowledge, behaviors, policies, provisions, social resources, and genetic heritage, which develop in different balances.
Recognizing that enhancing citizens' knowledge and awareness can improve their relationship with the systems they interact with. Recent years have seen increased attention to Health Literacy amidst the institutional and organizational restructuring of the healthcare system. Health literacy refers to the ability of individuals to access, understand, and use information in ways that promote and maintain good health for themselves, their families, and their communities. Although different

definitions are used and health literacy is an evolving concept, there is agreement that the meaning of health literacy goes beyond the simple ability to read brochures, make appointments, understand food labels, or follow doctor's advice. It encompasses citizens' skills in terms of personal abilities and the measure of interactions between groups and their living environment [4]. It also refers to the increase in empowerment, which is the acquisition of self-awareness and control over one's choices, decisions, and actions, both in personal relationships and in political and social life, and capability, which is the ability to do or be what one wants to do or be.

Over the years, the concept of health literacy introduced by Simonds in the '70 [5] has been reworked and expanded, and it is now intended more as an autonomous set of skills and learning processes A high level of health literacy is associated with better health conditions, compliance with treatments, and a conscious and effective use of healthcare services [6]. A low level of health literacy is correlated with poor understanding of health indications, errors in interpreting information, and consequent negative outcomes [7]. Furthermore, healthcare inequality is a key factor affecting disease rates, particularly in impoverished communities. Enhancing health literacy is crucial for reducing these disparities [8]. The Ottawa Charter in 1986 recognized the need to enable people to increase control over and improve their health and well-being, ensuring healthier and more sustainable environments where people live, work, study, and have fun [9]. Therefore, it is essential to monitor and assess the population's health literacy level and try to reduce inequalities.

Several measurement tools were developed to measure health literacy and four of them are frequently used: Newest Vital Sign (NVS), the Short Test of Functional Health Literacy for Adults ((S)TOFHLA), the Brief Health Literacy Screener (BHLS), and the Health Literacy Questionnaire (HLQ) [10]leading to improved health outcomes. Assessment tools should ideally address multiple domains of health literacy, fit to the complex hospital context and have a short administration time, to enable routine assessment. This review aims to create an overview of tools for measuring (digital. They vary in approach and design, but only some have focused on comprehensive health literacy in populations. An example is represented by the European Health Literacy Survey Questionnaire (HLS-EU-Q47), which covers most domains of health literacy: i) access, ii) understanding, iii) appraise, iv) and apply. HLS-EU-Q47 is an innovative and comprehensive tool for measuring health literacy in populations, composed of 47 items [11]. The design process was guided by the conceptual model of health literacy derived from a systematic review of existing definitions and conceptualizations of the concept by Sorensen et al. (2013). Following this definition, the HLS-EU Consortium [12] developed a conceptual framework that outlines the main dimensions of health literacy mentioned in the literature and integrates them into a logical model. This model identifies proximal and distal factors that can impact health literacy with potential consequences regarding health behaviors, health outcomes, and the use of healthcare services. The core is a matrix of 12 areas derived from the intersection of healthcare, disease prevention, and health promotion domains with the key processes of health literacy study related to accessing, understanding, evaluating, and applying health-related information. A short version, HLS-Q12, was established in by HLS_{19} Consortium as a part of the Health Literacy Population Survey 2019-2021 [13]. HLS-Q12 meets the assumptions and requirements of objective measurement and offers a concise health literacy screening tool that is widely used. The aim of this pilot study was to evaluate the correlation and distribution of the items of the HLS-Q12 short form in the three domains, healthcare, disease prevention, and health promotion, to verify their effective correspondence to the conceptual model of health literacy proposed by Sorensen et al. [11]. For this purpose, we used the network analysis to study the clustering of the answers to the items of the Italian version of the HLS-EU-Q12 in a sample of questionnaires collected mostly in the metropolitan area of Cagliari (Italy) in 2024. Network analysis is a set of techniques based on graph theory [14] aimed at describing the main characteristics of a system composed of nodes and connections. Its applications span many fields, such as economics [15], public health [16], neuroscience [17], and social sciences [18]. The use of network analysis is constantly evolving, and an example is the recent exploratory graph analysis approach to the structure of SOC (sense of coherence)-13 questionnaire [19]. Rendering the health literacy questionnaire as a network of interacting elements offers a comprehensive representation of how the items are organized, grouped, or related to each other and how the dimensions are positioned relative to each other in a multidimensional space. To our knowledge, this is the first work using network analysis on health literacy data.

Materials and Methods

Measures

The measures included 12 out of the 47 items HLS-EU-Q47 survey questionnaire, gender, age, and highest level of education completed.

HLS-EU-Q47

Based on their conceptual framework, Sørensen and colleagues [11, 20-22] created the HLS-EU-Q47 items. They recommended using a 4-point Likert scale, with response options ranging from 1 (very easy) to 4 (very difficult); a 'do not know' category was also included to capture spontaneous responses from participants during the telephone interviews and was later re-coded to missing data.

HLS-Q12

Due to the length of the HLS-EU-Q47, shorter forms like the HLS-EU-Q16 and HLS-EU-Q6 were developed

and later validated and applied in several languages and regions [23-26]. The HLS-EU-Q16, although shorter, had some limitations in representing the theoretical model fully. A 12-item instrument was also developed independently of the HLS-EU consortium by different groups [27-30]. However, these Q12 short forms had essential differences regarding methodology, quality of data, sample size and degree of adherence to the underlying model and matrix of comprehensive, general HL. To address these issues, HLS_{19}. Consortium decided to develop a new short form HLS-EU-Q12 [13, 31-33]. This 12-item version is a refined instrument aimed to better represent the theoretical model while being more practical for research purposes and easier to use in diverse research contexts. The HLS_{19} Instrument used in this research was developed within "HLS_{19} – the International Health Literacy Population Survey 2019-2021" of M-POHL (Action Network on Measuring Population and Organizational Health Literacy of EHII – WHO Europe). The Italian National Institute of Health (ISS), which participated in M-PHOL, provided the translation and cultural adaptation of the HLS_{19} questionnaire in the Italian language in collaboration with the University of Florence and the Università Cattolica del Sacro Cuore of Rome. For the purpose of this pilot study, we used the Italian version of HLS_{19}-Q12 short form [31, 34, 35].

Data collection

Using an online form tool (Google form), we distributed an open-to-all digital version of the Italian HLS-EU-Q12 through the most popular social media platforms, such as Instagram, Facebook, and LinkedIn. The questionnaire was also diffused through informal channels such as word-of-mouth among acquaintances and family members of students' population. The questionnaire was sent and disseminated by sharing the online link to invite participants to complete the questionnaire. The home page of the questionnaire displayed an image with keywords related to the topic and provided a brief description of the survey's objectives and detailed information on data processing. A constraint was set, allowing participants to fill out the form only if they were of legal age. We collected 353 questionnaires completed by participants aged 18 or over in May 2024. All participants provided informed consent before participating in the study, and 352 out of 353 consented to the use of data collected for research purposes. No IP addresses were recorded, guaranteeing anonymity, and no sensitive data was requested. Each participant could independently decide whether to provide their email address to receive research updates. This pilot study received the approval of the Territorial Ethical Committee of Sardinia (Italy).

Network analysis

Methods

The data was processed with JASP software (JASP Team (2024). JASP (Version 0.19.3) [Computer software]) using the Ising Fit method through the eLasso procedure [36] for estimating network structures. Ising Fit focuses on binary data and is useful for identifying clusters of highly correlated variables and generating hypotheses about the underlying relationships between the variables. ELasso network estimation procedure is based on the Ising model and integrates l1-regularized logistic regression with model selection using the Extended Bayesian Information Criterion (EBIC). EBIC serves as a fit measure to identify relevant relationships between variables. The resulting network represents variables as nodes and their significant relationships as edges.

Our input

To create the input matrix of binomial data, the answers to each of the 12 HLS-EU-Q items were dichotomized in two categories with two scores, "easy" ("easy" or "very" easy = 1) and "difficult" ("difficult", "very difficult" and "don't know" = 2).

The regularization parameter lambda (λ) was set by default to a value 0.25 to identify the strongest relationships and reduce the risk of overfitting. This parameter controls the sparsity of the network, determining which edges (relationships between variables) are included in the final model and balancing the trade-off between model complexity and fit. A higher λ results in a sparser network with fewer edges, a lower λ includes more edges, potentially leading to overfitting.

Output and interpretation

We obtained a weight's matrix and network plots showing i) the nodes, namely the items presented as questions to participants, ii) the edges, namely the partial correlation between two nodes, and iii) the clusters or sets of nodes connected using undirected network models. Each entry in the weights matrix corresponds to the interaction weight between pairs of binary variables. A positive weight indicates a positive relationship, meaning the variables are likely to have the same value, while a negative weight indicates a negative relationship, meaning they are likely to have different values. The magnitude of the weight reflects the strength of the relationship. The relationship between the weight's matrix and odds ratios could be considered to help move from the mathematical framework of Ising Fit to a more interpretable language. The weights in the matrix represent the log odds ratios between pairs of variables and indicate the strength and direction of the relationship. A positive weight suggests a positive association (variables are likely to have the same value), and a negative one suggests a negative association (variables are likely to have different values). The log odds ratios (weights) are converted to odds ratio with the formula:

$$\text{Odds Ratio} = e^{\text{weight}}$$

Since Ising Fit assumes that the interaction between two variables is symmetric, the weight value (log odds ratio) calculated for the interaction between A and B is identical from B to A and describes the strength and

direction of the relationship. Odds Ratios > 1 indicate a positive relationship, < 1a negative relationship, = 1 no relationship.

Several centrality measures were employed to assess the importance and influence of each node within the network. These measures include betweenness centrality, closeness centrality, strength, and expected influence. Betweenness centrality measures how often a node (in our case, a questionnaire item) lies on the shortest path between other nodes. This can help identify items that act as bridges or connectors within the network, providing insights into the structure and dynamics of the relationships between items. Closeness centrality measures how close a node is to all other nodes in the network. A node with high closeness centrality can quickly interact with all other nodes in the network, indicating its efficiency in spreading information. In the context of an Ising Fit model, the strength of a node indicates the overall level of connectivity or influence that node has within the network. A node with high strength is strongly connected to many other nodes. The expected influence is similar to strength but accounts for the signs of the weights (positive and negative influences), considering both the direct and indirect effects of a node on the network.

A nonparametric bootstrap analysis with 1,000 bootstraps was conducted to assess the stability of the network.

Results

Sample demographics

Of 352 participants, 93% were from the metropolitan area of Cagliari (Italy), 21.6% identified as men, 78.1% as women, and 0.3% preferred not to disclose their gender. Regarding the sample distribution by sex, 77 participants were males and 275 females. The youngest participant was 19 years old, while the oldest was 74 years old. There was a higher participation of people aged between 30 and 40 years. 50% of participants had a university degree, 41% had at least a high school diploma, and 9% had a middle school diploma. None of the participants declared no educational qualifications or an elementary school diploma. See Table I for participants' details.

Questionnaire

Here we present the highlights of the varying levels of difficulty people in our sample experienced in different aspects of health literacy and decision-making:

1. *Difficulty in Obtaining Professional Help:* 51.7% of respondents found it "difficult" to get professional help when unwell, while 30% found it "easy";
2. *Understanding Medical Emergencies:* 57.1% of respondents found it "difficult" to understand what to do in a medical emergency, whereas 23.6% found it "easy";
3. *Evaluating Treatment Options:* 59.9% of respondents found it "difficult" and 17.3% "very difficult" to evaluate the advantages and disadvantages of different treatment options;
4. *Following Medical Instructions:* 72.2% of respondents found it "easy" to follow the doctor's or pharmacist's instructions, with 19.6% finding it "Very easy";
5. *Managing Mental Health Information:* 48.6% of respondents found it "difficult" to find information on managing mental health problems like stress or depression, and 21.6% found it "very difficult";
6. *Understanding Screenings Importance:* 44.3% of respondents found it "easy" to understand why health screenings are necessary, and 34.1% found it "very easy";
7. *Evaluating Health Warnings:* 44.6% of respondents found it "easy" to evaluate the reliability of health warnings, and 35.2% found it "very easy";
8. *Deciding on Disease Prevention based on Media Info:* Opinions were mixed, with 41.8% finding it "difficult" and 36.1% finding it "easy" to decide how to protect themselves from diseases based on media information;
9. *Understanding Health Advice from Family/Friends:* 53.1% found it "easy" to understand health advice from family or friends, while 23.6% found it "difficult";
10. *Finding Information on Healthy Activities:* 54.3% found it "easy" to find information on healthy activities like exercise and healthy eating, and 29.8% found it "very easy";
11. *Evaluating Living Conditions:* 50.9% found it "easy" to evaluate how their living conditions help them stay healthy, followed by 20.2% who found it "very easy". Meanwhile, 21% found it "difficult," and 6.5% found it "very difficult";
12. *Making Decisions to Improve Health:* the sample was divided, with 41.8% finding it "difficult" and 8% finding it "very difficult" to make decisions to improve their health, while 37.2% found it "easy" and 12.2% found it "very easy".

Network

The network consisted of 12 nodes and 18 non-zero edges, resulting in a sparsity of 0.727.

Tab. I. Participants' demographic characteristics.

N. participant	Female	Percentage	Male	Percentage	
352	275	78%	77	22%	
Education level					Total
Middle School Diploma	25	9%	6	8%	9%
High School Diploma	111	41%	34	44%	41%
University Degree	139	50%	37	48%	50%

Tab. II. Weights matrix. Correspondence between HLQ-47 original items and acronyms used for the network analysis (NA).

Items HLQ-47	Items NA	HC1	HC2	HC3	HC4	DP5	DP6	DP7	DP8	HP9	HP10	HP11	HP12
HL-4	HC1	0.000	0.850	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
HL-7	HC2	0.850	0.000	1.174	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.463
HL-10	HC3	0.000	1.174	0.000	0.000	0.751	0.000	0.000	0.479	0.000	0.000	0.000	0.000
HL-8	HC4	0.000	0.000	0.000	0.000	0.000	0.000	0.488	0.000	0.000	0.000	0.000	0.000
HL-18	DP5	0.000	0.000	0.751	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
HL-23	DP6	0.000	0.000	0.000	0.000	0.000	0.000	1.184	0.286	0.000	0.000	0.000	0.541
HL-24	DP7	0.000	0.000	0.000	0.488	0.000	1.184	0.000	0.000	0.811	0.596	0.247	0.000
HL-31	DP8	0.000	0.000	0.479	0.000	0.000	0.286	0.000	0.000	0.911	0.275	0.399	0.000
HL-32	HP9	0.000	0.000	0.000	0.000	0.000	0.000	0.811	0.911	0.000	0.000	0.000	0.444
HL-37	HP10	0.000	0.000	0.000	0.000	0.000	0.000	0.596	0.275	0.000	0.000	0.000	0.440
HL-42	HP11	0.000	0.000	0.000	0.000	0.000	0.000	0.247	0.399	0.000	0.000	0.000	1.025
HL-44	HP12	0.000	0.463	0.000	0.000	0.000	0.541	0.000	0.000	0.444	0.440	1.025	0.000

Tab. III. Centrality measures per item. Correspondence between HLQ-47 original items and acronyms used for the network analysis (NA).

Items HLQ-47	Items NA	Betweenness	Closeness	Strength	Expected influence
HL-4	HC1	-0.980	-1.066	-1.169	-1.169
HL-7	HC2	1.346	0.390	0.665	0.665
HL-10	HC3	0.829	0.048	0.571	0.571
HL-8	HC4	-0.980	-1.683	-1.575	-1.575
HL-18	DP5	-0.980	-1.396	-1.281	-1.281
HL-23	DP6	0.054	0.208	0.130	0.130
HL-24	DP7	0.829	0.581	1.605	1.605
HL-31	DP8	0.054	1.062	0.511	0.511
HL-32	HP9	0.054	0.906	0.306	0.306
HL-37	HP10	-0.980	-0.422	-0.654	-0.654
HL-42	HP11	-0.980	-0.174	-0.249	-0.249
HL-44	HP12	1.734	1.545	1.142	1.142

Weights Matrix

The weights matrix, shown in Table II, indicates the strength of the connections between the variables. Notable connections include HC2-HC3 (1.174), DP6-DP7 (1.184), and HP11-HP12 (1.025).

Centrality Measures

The centrality measures for each variable are summarized in Table III and Figure 1. DP7 and HP12 items exhibited the highest strength values, indicating their significant influence within the network. HC2 and HP12 items had the highest betweenness and closeness centrality, followed by HC3 and DP7, and can be considered key nodes. Furthermore, HC2 and HP12 features suggest they can be considered as bridge nodes, connecting different parts of the network. Variables such as HC1, HC4, and DP5 showed negative values across multiple centrality measures, indicating their lesser influence and potential peripheral roles in the network.

Network plot

The visual representation of the network provides a depiction of the relationships between the items in HLS19-Q12 in our sample (Fig. 2). The edges between nodes vary in thickness, representing the strength of the connections. Strong connections (*e.g.*, HC2-HC3) are depicted with thicker lines, indicating robust associations. Examining the network plot, it is possible to visually identify the presence of two or three clusters within the network.

HC: health care; DP: disease prevention; HP: health promotion. HC1 (HL-4, …to find out where to get professional help when you are ill? (Instructions: such as doctor, nurse, pharmacist, psychologist); HC2 (HL-7, … to understand information about what to do in a medical emergency?); HC3 (HL-10, …to judge the advantages and disadvantages of different treatment options?); HC4 (HL-8,…to act on advice from your doctor or pharmacist?); DP5 (HL-18, …to find information on how to handle mental health problems? (Instruction: stress, depression or anxiety); DP6 (HL-23, …to understand information about recommended health screenings or examinations?); DP7 (HL-24, …to judge if information on unhealthy habits, such as smoking, low physical activity or drinking too much alcohol, are reliable?); DP8 (HL-31, …to decide how you can protect yourself from illness using information from the mass media? (Instructions: *e.g.*, Newspapers, TV or Internet); HP9 (HL-32, …to find information on healthy lifestyles such as physical exercise, healthy food or nutrition?); HP10 (HL-37, …to understand advice concerning your health

Fig. 1. Centrality plot.

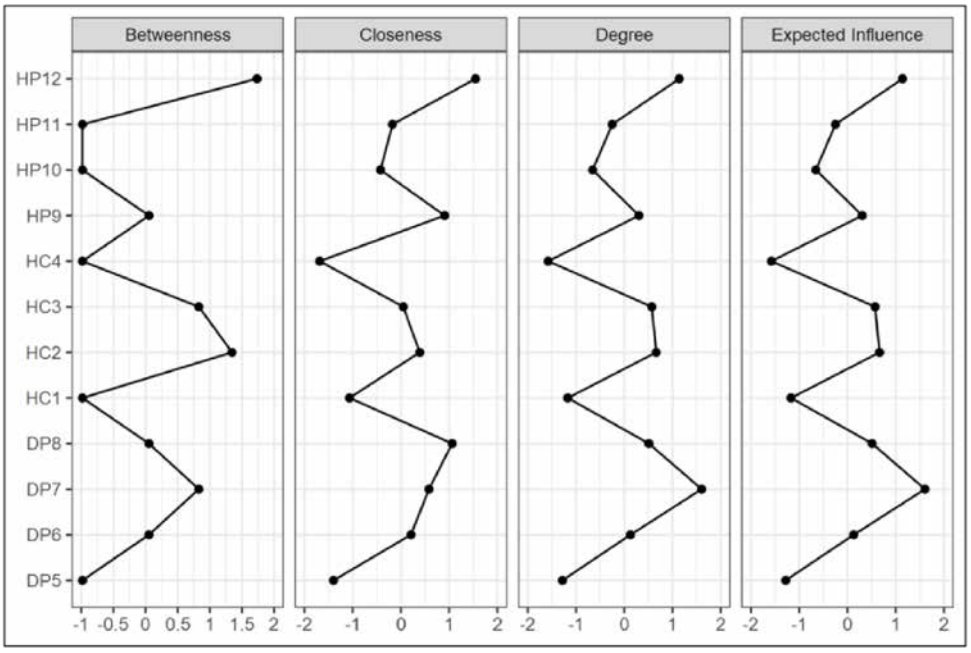
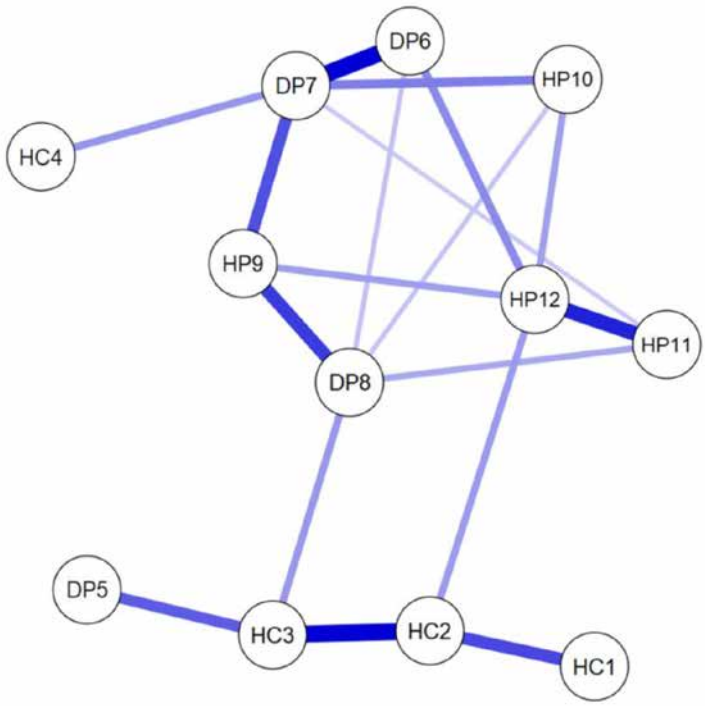


Fig. 2. Network plot.



from family or friends?); HP11 (HL-42, …to judge how your housing conditions may affect your health and well-being?); HP12 (HL-44, …to make decisions to improve your health and well-being?").

The presence of the clusters seems supported by the centrality measures:

Cluster 1) HC1, HC2, HC3, and DP5 appear strongly interconnected, and separated from the other items, with high weights between nodes, particularly between 2HC and 3HC. HC2 is a key bridge node with high betweenness and moderate strength, central to the network. HC3 is significant within the cluster with moderate betweenness and strength. HC1 and DP5 have peripheral roles in the network with negative centrality measures.

Cluster 2) DP6, DP7, DP8, HP9, DP7 and HC4. The item DP7 stands out with high strength and moderate betweenness, indicating its significant influence. DP8 and HP9 are well-connected within the cluster,

particularly through high closeness, although they have lower betweenness and strength. DP6, however, is less central. HC4 is loosely connected with DP7 and has weaker connections compared to other nodes. Its centrality measures indicate HC4 is the least influential in the cluster.

Cluster 3) HP10, HP11, and HP12. This cluster is dominated by HP12, which serves as a key bridge node with the highest betweenness and closeness, highlighting its central role and high influence. In contrast, HP10 and HP11 are more peripheral with negative centrality measures.

While cluster 1 seems to be clearly separated from the other two, with HC2 acting as bridge, clusters 2 and 3 seem way more interconnected, with HP12 acting as bridge.

Bootstrap Analysis

The results indicate that the network structure is stable, with consistent edge and centrality measures across bootstrap samples. See Supplementary for Figure S1 and Figure S2 about edge stability and centrality stability.

Discussion

The questionnaire responses reveal several important insights about health literacy in Cagliari's metropolitan area. Many people struggle to access professional help when unwell, indicating a need for better healthcare accessibility and awareness. Public education on emergency procedures is also necessary, as many find it challenging to know what to do in a medical emergency. There is a significant gap in understanding treatment options and health warnings, highlighting the need for simplified medical information and decision-making support tools. Mental health resources and awareness need improvement, as many have difficulty finding information on managing stress and depression. Public health campaigns on preventive care, such as health screenings, are somewhat effective, but continued efforts are needed. Media literacy is crucial, as mixed responses on disease prevention based on media information suggest. Social support networks play a vital role in health decision-making, with many participants finding health advice from family and friends easy to understand. Public health messages on healthy activities like exercise and healthy eating are reaching people effectively, supporting public health. Awareness of the impact of living conditions on health can be leveraged to promote healthier environments. Finally, the division in responses about making health decisions indicates a need for more personalized decision-making support tools and resources. Providing tools and resources that help individuals weigh their options and make informed choices can improve health outcomes.

Overall, these findings suggest the need for targeted interventions to improve health literacy, accessibility to healthcare, mental health support, and public education on emergency preparedness and media literacy. By addressing these areas, we can help people feel more secure and capable in managing their health and well-being.

The network analysis of the HLS-EU-Q12 items using the Ising Fit method has provided valuable insights into the structure and interrelationships of health literacy components within our sample. The identification of three distinct clusters, each roughly corresponding to the three areas of health literacy according to Sorensen, highlights the multifaceted nature of health literacy and its various dimensions. The healthcare cluster was clearly distinct from the other two clusters and lost item 4HC (following medical instructions), which in turn was loosely connected with the disease prevention cluster. Notably, healthcare cluster included an item traditionally related to disease prevention (5DP) about managing mental health information. Participants seem to consider mental health not as a condition to be preserved with prevention but more as an active problem to be solved when is not good, hence the shift of 5DP to disease prevention cluster. In our opinion, this could be closely related to the cultural Italian context and the approach of politics and healthcare to mental health. The centrality of items such as HC2 (understanding medical emergencies) suggests that these aspects are pivotal for individuals to effectively manage their health. The strong connections within this cluster suggest that improving healthcare literacy could have a significant impact on individuals' ability to access and utilize healthcare services effectively. The disease prevention and health promotion clusters were more interconnected, although their internal structures remained identifiable. We wondered if the overlapping may be linked to the focus of health promotion items on practical aspects (*e.g.,* individual/family management) rather than on broader community and political aspects. The disease prevention cluster encompassed items related to evaluating health warnings and understanding disease prevention measures. The central role of DP7 (evaluating health warnings) within this cluster suggests, again, that the ability to critically assess health information is crucial for making informed decisions about disease prevention. The health promotion cluster, dominated by items related to making decisions to improve health and evaluating living conditions, emphasizes the role of personal empowerment and environmental factors in health literacy. The prominence of HP12 (making decisions to improve health) indicates that health promotion is a key component of health literacy, reflecting the need for individuals to be empowered to make informed health decisions and take proactive steps to improve their well-being. This is in line with its clear inspiration to the Ottawa Charter.

All findings align with the broader understanding that health literacy involves not only the ability to access information but also the capacity to evaluate and apply it in practical contexts and seems to have a lot to do with empowerment. From this perspective, it seems very interesting that "making decisions to improve health (HP12)" is the most prominent item. HP12 represents

a key node and a bridge between clusters, posing health promotion in the position of acting as a glue between the other aspects of health literacy. Skills and behaviors interact with each other, and it is important to identify the key ones that drive the system. In health promotion, we do not think of a measure that completely changes the world, but rather actions that shift the balance and readjust the system. We found that the network model of our analysis depicts the complexity and fine balance of the interactions between all the aspects of health literacy and may help us understand where we can apply a little pressure to readjust the system. Interventions should prioritize central and bridge items. By focusing on these key aspects, interventions can enhance individuals' overall health literacy and their ability to navigate the healthcare system, understand health information, and make informed health decisions. Tailored strategies for different clusters may address synergistically different aspects of health literacy.

Limitations

While the network analysis provided valuable insights related to our sample, there are several limitations to consider. The study was conducted on a sample of 352 participants mostly from the metropolitan area of Cagliari, Italy. The composition of the sample was influenced by the willingness of the population reached through dissemination to complete the questionnaire. Students and their friends and relatives were supposedly more interested in participating. Future research should include a larger sample to enhance the generalizability of the findings. The nature of the study limits the ability to draw causal inferences. We should also consider that the use of the HLS-EU-Q12 short form, while practical, may not capture the full complexity of health literacy.

Conclusion and future steps

The network analysis using the Ising Fit method provided a nuanced understanding of the relationships among health literacy items in our sample, and valuable information about the central items. The network analysis seems very promising in handling health promotion data, just as it was in analyzing salutogenesis data [19]. Classic epidemiology methods lack in encompass the multi-faceted aspects linked to systems made up by complex relationships between elements, such as SOC and health literacy. Going beyond the cause-effect model, the network analysis returned a comprehensible depiction of a complex system giving due importance to the interactions. The findings from this pilot study may be useful for future research and interventions aimed at improving health literacy. The identification of clusters and key and bridge items in a larger and representative sample might offer insights for designing targeted interventions that might influence the overall balance between the areas composing the complex concept of health literacy. By addressing the specific needs identified and focusing on the items that are more prominent, healthcare professionals and policymakers can enhance health literacy and promote better health outcomes for individuals and communities.

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Ethical approval

Ethical approval for this study was obtained from Territorial Ethical Committee of Sardinia [Comitato Etico Sardegna istituito con Decreto N° 18 del 04/05/2023 dell'Assessorato dell'igiene e sanità e dell'assistenza sociale della Regione autonoma della Sardegna] – Deliberazione N. 560 DEL 16.05.2024.

Conflicts of interest statement

The authors declare no conflicts of interest.

Author's contributions

All the authors made substantial contribution to different aspects of the work: SMP, PC: conceptualization; SMP, SM: writing-original draft; SM: data collection; SMP, PC: investigation, formal analysis: PC, SMP, SM, MF, CS, AM: visualization; PC, SMP, SM, MF, CS, AM: results interpretation, PC: project administrator; MF: validation; PC: resources, supervision; SMP, SM, MF, CS, AM, PC: writing -review and editing.

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Supplementary Materials

Fig. S1. Centrality Plot

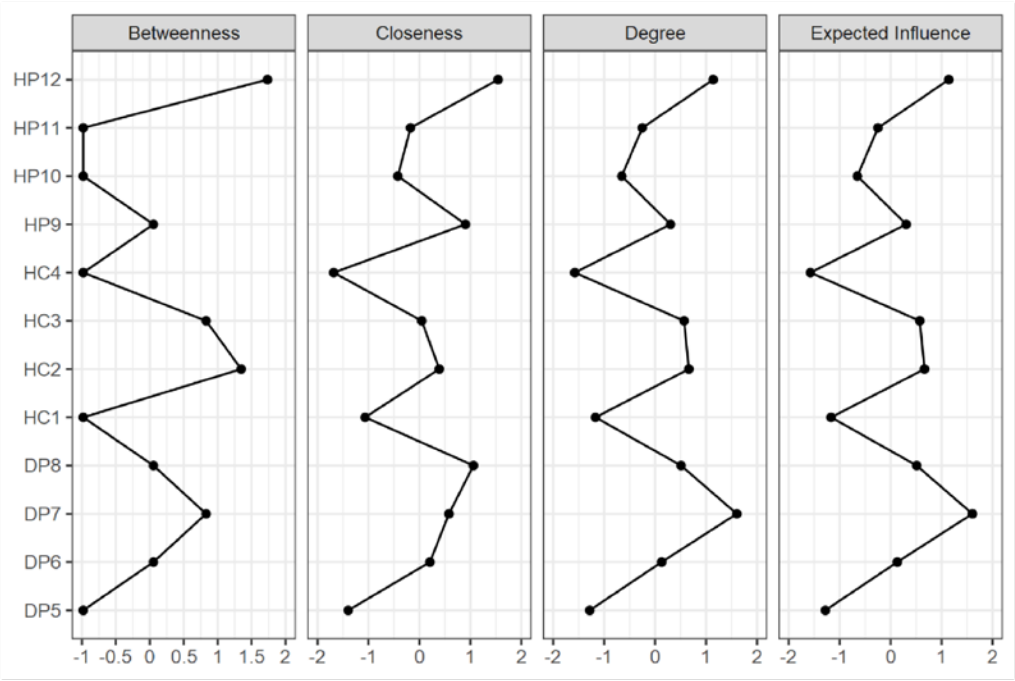

Fig. S2. Edge Stability – Network.