ORIGINAL ARTICLE

A Partial Least Squares-Structural Equation Modelling (PLS-SEM) Analysis of Health Information Usage Among Patients with Non-Communicable Diseases in Sarawak, Malaysia

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ABSTRACT

Introduction: Non-communicable diseases (NCDs), including diabetes, hypertension, and heart disease, remain the leading causes of morbidity and mortality in Malaysia, highlighting the growing importance of effective health information usage (HIU) for self-management and prevention. Although access to health information has expanded, disparities persist in how individuals particularly in rural areas such as Sarawak utilise this information in everyday health decisions. This study, guided by Longo's Expanded Model of Health Information-Seeking Behaviour (EM-HISB), examines how the type (THI), sources (SHI), and access (AHI) to health information collectively predict HIU among adults with NCDs. **Materials and Methods**: This cross-sectional study formed part of a larger investigation on health information-seeking behaviour in Sarawak. Data were collected from May to December 2023 using multi-stage random sampling in Kuching (urban) and Lubok Antu (rural). Of the 782 participants surveyed, 217 self-reported having at least one NCD. Partial Least Squares Structural Equation Modelling (PLS-SEM) was used to analyse the measurement and structural models. **Results**: Hypertension was the most commonly reported condition, particularly among participants aged 41–60. All three predictors: THI ($\beta = 0.200$, $p < 0.05$), SHI ($\beta = 0.476$, $p < 0.05$), and AHI ($\beta = 0.178$, $p < 0.05$) were significantly associated with HIU. The model demonstrated strong predictive validity ($R^2 = 0.612$), with SHI emerging as the most influential predictor, exhibiting the highest standardised beta coefficient and a moderate effect size ($f = 0.138$). **Discussion and Conclusion**: The strong influence of SHI reflects Sarawak's unique socio-cultural context, particularly in rural areas. These findings highlight the importance of developing multifaceted health promotion strategies that cater to the varied informational needs and preferences of NCD patients in Sarawak.
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Keywords: PLS-SEM Analysis, Health Information Usage, Patient, Non-communicable Disease, Sarawak Population

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INTRODUCTION

Non-communicable diseases (NCDs) including diabetes, hypertension, cardiovascular diseases, and cancer have emerged as the leading causes of morbidity and mortality in Malaysia over the past decade (1). As this burden continues to grow, the effective use of health information, or health information usage (HIU), has become increasingly vital (2). HIU empowers individuals with NCDs to make informed decisions, manage their conditions more effectively, and adopt preventive behaviours that enhance their quality of life.

Although access to health information has expanded through both formal and informal channels, substantial gaps persist in how individuals interpret and utilise this information particularly in rural, multicultural, and resource-limited settings especially in Sarawak, Malaysia (3–5). Existing research suggests that HIU is influenced by multiple factors, including health status, socio-economic background, cognitive ability, digital and health literacy, and cultural orientation (6,7). Yet, limited empirical evidence exists particularly in the Malaysian context on how these factors shape the actual use of information in daily health management especially among NCD patients. Moreover, much of the existing literature focuses on health information-seeking behaviour (HISB), often neglecting what happens after information is obtained. This narrow focus limits our understanding of HIU as a behavioural outcome and hinders the development of targeted interventions that support long-term self-management among NCD patients (8).

To address these gaps, this study applies the Expanded Model of Health Information-Seeking Behaviour (EM-HISB) (6,9) to examine the extent to which three key

predictors including the type of health information (THI), sources of health information (SHI), and access to health information (AHI) have the potential to influence HIU among adults with NCDs in Sarawak, Malaysia.

The study is guided by the following research question: how do THI, SHI, and AHI collectively predict HIU among adults with NCDs? By addressing this central question, the study provides deeper insight into HIU within an underserved and socio-culturally diverse context, offering guidance for evidence-based health promotion strategies to support NCD prevention in Sarawak.

Health information usage (HIU) refers the ways individuals actively seek, interpret, and utilise health information to manage their health-threatening conditions, engage in shared health decision-making regarding their disease, behavioural modification, and to foster positive health practices (10). Engaging in HIU also fosters empowerment and self-advocacy, which are integral to effective health promotion (11). One notable model that explained this framework is the Expanded Model of Health Information-Seeking Behaviour Model (EM-HISB), introduced by Daniel R. Longo, which highlights the dual pathways of active information seeking and passive information reception (6). This model posits the outcomes of health information-seeking processes can range from active acceptance to passive assimilation, reflecting the dynamic nature of HIU in addressing individuals' evolving health priorities.

The Expanded Model of Health Information-Seeking Behaviour (EM-HISB), provides a theoretical framework for understanding the factors that influence health information engagement (6,9). This model identifies a range of predisposing factors, enabling resources, and information-seeking strategies that collectively shape health information outcomes. A key strength of the EM-HISB lies in its recognition of the dynamic nature of HIU, which may range from passive assimilation to active application, depending on individuals' needs, capabilities, and social contexts. In this study, HIU is operationalised as the ways in which individuals actively seek, interpret, and utilise health information to manage health-threatening conditions, engage in shared decision-making, modify risk behaviours, and promote positive health practices. HIU also fosters empowerment and self-advocacy, which are central to health promotion and the effective management of chronic diseases (6,12).

Guided by the Extended Model of Health Information-Seeking Behaviour (EM-HISB), this study develops three hypotheses to examine how key factors influence HIU. Hypothesis 1 posits a positive relationship between the type of health information (THI) and HIU, reflecting the model's assertion that individuals are more likely to use information aligned with their needs, comprehension, and health context. Hypothesis 2 proposes a positive association between sources of health information (SHI) and HIU, grounded in the EM-HISB's emphasis on the importance of source credibility, availability, and accessibility. Hypothesis 3 suggests a positive relationship between AHI and HIU, recognising access as an enabling resource that can facilitate or hinder engagement particularly salient in rural and underserved contexts such as Sarawak. Together, these hypotheses extend the EM-HISB by exploring how type, source, and access shape HIU among adults with non-communicable diseases (6,9).

This study positions the EM-HISB within the multicultural and underserved context of Sarawak, Malaysia, a state characterised by significant rural populations and ethnic diversity. The study advances the operationalisation of EM-HISB constructs by focusing on three predictors including THI, SHI, and AHI, each tailored to reflect the structural, informational, and digital realities of adults with NCDs in Sarawak (3,13).

Several studies conducted in Malaysia and other countries had used the health information-seeking behaviour model to explore patient's health information usage, highlighting the critical roles of evaluation skills and language comprehension in utilising disseminated health information effectively. For instance, a study by Lim et al. among patients attending an outpatient primary care clinic in Malaysia revealed that while the majority accessed health information online, particularly from platforms like Wikipedia and MyHEALTH, the low eHealth literacy hindered their ability to appraise the accuracy of the information (14). Similarly, research by Kim and Kim in Korea among coronary artery disease patients highlighted insufficient health literacy as a key barrier preventing patients from actively seeking health information (15). In Cyprus, Kyriacou et al. found that endocrine patients attending outpatient clinics widely practiced seeking health information online, and the availability of information in their native language significantly enhanced their engagement with digital health resources (16). These findings collectively emphasise the importance of health literacy competency and comprehensible health information for diverse populations.

The present study focuses on NCDs, such as diabetes, hypertension, and cardiovascular disease, which are leading contributors to disability, morbidity, and mortality globally (17). In Malaysia, NCDs represent a growing public health challenge, with findings from the National Health and Morbidity Surveys (NHMS) conducted by the MOH Malaysia between 2015 and 2023 revealing an increasing prevalence of NCD risk factors (11, 13). The surveys also showed that hypertension prevalence rose from 37.3% in 2015 to 40.5% in 2019, with the Bumiputera Sarawak population experiencing an even higher rate of 46.8% (20). These alarming statistics underscore the urgent need for targeted preventive

measures to mitigate the growing burden of hypertension within this population.

This rising prevalence of NCDs in Malaysia, particularly in Sarawak, underscores the pressing need to address the rising demand for diverse THI related to NCDs patient's informational need. Integral to this process is the THI, which refers to the specific categories of information individuals actively seek, receive, and utilise to meet their health-related needs (21).

The emergence of digital health platforms has significantly diversified the availability of various types of health information, providing NCD patients with a variety of options tailored to their unique needs, health situations, and capabilities. These platforms, offering personalised, accessible, and on-demand content, enhance the relevance and usability of information, making it more adaptable to individual preferences (22). Furthermore, when patients access their preferred THI, their ability to accurately interpret and comprehend it improves, resulting in better HIU outcomes, such as empowering patients to make informed decisions, particularly in managing chronic conditions such as NCDs. This alignment enhanced decision-making between patients and healthcare providers and strengthens patients' understanding of NCD management strategies (23). These insights form the basis for our first hypothesis (H1), which proposes a significant association between the type of health information and health information usage.

Engaging with credible SHI plays a pivotal role in empowering NCD patients in HIU for better health outcome. In this study, SHI refer to the various channels or platforms through which patients seek, access, or receive health-related knowledge to meet their informational needs (24). The diversity of SHI reflects the interplay between accessibility, trust, and preferences, which influence how patients prioritise and utilise these sources (25). By accessing trustworthy information, patients can gain a deeper understanding of their conditions, adhere more effectively to treatment plans, and actively engage in shared decision-making with their healthcare providers (26). A study in Malaysia by Maung et al. revealed that health staff were the most commonly accessed sources of health information, followed by mass media, friends, and health campaigns (27). The trust in professional expertise and the accessibility of these sources significantly influenced patients' preferences. These insights inform the basis of our second hypothesis (H2), which posits that preferred sources of health information are significantly associated with health information usage.

This study also examines AHI as a potential factor influencing HIU. Access to health information (AHI) refers to a patient's ability to obtain, verify, comprehend, and utilise relevant health information from various sources to address their health-related needs (28). In the context of Sarawak, disparities in social, health and digital access pose significant barriers to the effectiveness of both AHI and HIU, particularly among segments of the rural population (22, 23). Limited access to reliable health information impedes the development and implementation of effective health promotion initiatives concerning NCD prevention programs which are crucial for raising awareness and enhancing knowledge on NCD prevention (24, 25). Despite considerable government efforts to enhance information and communication technology (ICT) infrastructure over recent decades, these advancements have not consistently translated into improved health outcomes (32) (33). These persistent gaps in accessibility and utilisation underscore the ongoing challenges in leveraging HIU to improve population health. Several research highlights the impact of these disparities on NCD patients' ability to effectively use health information. For example, despite the increasing proportion of Internet users in Malaysia, which rose from 76.9% in 2016 to 87.4% in 2018 and reached 88.7% in 2020, the prevalence of online users aged 60 and above was only 6.5%, declining to 3.4% in 2020 (28, 29). This evidence forms the basis for the study's third hypothesis (H3), which postulates that the ability to overcome disparities in accessing health information is significantly associated with health information usage.

In the present study, our objective was to investigate the associations between the type of health information (THI), sources of health information (SHI), and the ability to access to health information (AHI) with health information usage (HIU) among adult's patients with NCDs in Sarawak.

We proposed three hypotheses to examine the relationships as follows: Hypothesis 1 posits a significant positive association between THI and HIU. Hypothesis 2 suggests a significant positive association between SHI and HIU. Finally, Hypothesis 3 proposes a significant positive association between AHI and HIU. By exploring these relationships, the study aims to contribute valuable insights that can inform the development of tailored health promotion strategies to various segment of population in Sarawak.

MATERIALS AND METHODS

This study is part of a broader research project investigating health information-seeking behaviour among adults in Sarawak. It specifically focuses on health information usage (HIU) among participants who self-reported having at least one non-communicable disease, providing important insights into the HIU patterns and behaviours within the NCDs patient population.

The conceptual model guiding this study (see Fig. 1) is grounded in Longo et al.'s (2010) Expanded Model

of Health Information-Seeking Behaviour (EM-HISB). It posits those three key independent variables including the THI, SHI, and AHI are significantly associated with HIU, the study's primary outcome. This model adopts an integrative lens, capturing both cognitive and contextual factors in information-seeking, while extending the EM-HISB by foregrounding HIU as a behavioural outcome. By doing so, it enables an empirical assessment of how the nature, source, and accessibility of health information influence individuals' capacity to make informed health decisions.

Study design

We employed a cross-sectional research design to evaluate participants' health information-usage behaviour at a single point in time, providing a snapshot of their practices and preferences.

This design is particularly suited for identifying associations between key variables namely, the type, sources, and access to health information and the extent of health information usage. (26). Aligned with the study's objective to investigate HIU across a demographically and geographically diverse population in Sarawak, the cross-sectional approach enabled the collection of data from a broad sample efficiently and within resource constraints.

Location and study population

The unit of analysis for this study included Malaysian adults living in residential areas, such as housing estates, villages, and longhouses, within the districts of Kuching and Lubok Antu in Sarawak. These locations were specifically selected to reflect the diversity of living environments in Sarawak, encompassing both urban and rural populations (36). This selection method is consistent with the approach used in the NHMS 2020, which included these districts to ensure a representative sample of Sarawak's population (20).

Sampling frame and participant criteria

The sampling frame for this study was developed using a list of localities according to the respective local leadership jurisdiction (37). The frame for eligible households was based on official household registration records maintained by the neighbourhood committee and the village development committee. The study included Malaysian adults aged 18 and above who were willing to participate and were present in the selected household during the community survey.

Sample size

The overall sample size for this study was determined using Cochran's formula (38), a statistical method used to determine a representative sample size for estimating population proportions with a specified confidence level and margin of error. This formula considers the required level of precision (0.05), the desired confidence level (1.96), and the expected prevalence of the attribute in the population. The estimated proportions for this study were based on local studies, which reported a prevalence of 46% of respondents seeking health information in urban areas and 68.9% in rural communities (23, 33). Based on these estimates, the required sample size was calculated to be 382 for Kuching and 385 for Lubuk Antu, resulting in a total sample size of 767 participants.

Sampling procedures

A multi-stage random sampling method was employed for this study (40). The sampling process was carried out in three distinct stages, each employing a different sampling technique to ensure the randomness and representativeness of the data collection process. The stages included quota sampling, cluster sampling, and simple random sampling. This approach ensured a comprehensive and unbiased selection of participants from both urban and rural areas, thereby enhancing the generalizability of the study findings.

This study recognises the potential influence of several confounding variables and biases that may affect the relationships between THI, SHI, AH and HIU. Sociodemographic characteristics including age, education, income, digital literacy, cultural norms, and language proficiency, may independently shape information-seeking and usage behaviours (10). Moreover, the use of self-reported measures introduces possible biases such as recall error and social desirability. To address these concerns, the present study employed rigorous sampling techniques, including multi-stage random sampling and quota sampling, to control for variability across these factors, thereby minimising potential confounding effects and strengthening the validity of the findings.

Study instruments

The items measuring the three independent variables: type of health information (THI- 6 items), sources of health information (SHI - 8 items), and access to health information (AHI -5 items) as well as the dependent variable, health information usage (HIU - 4 items). We assessed THI through multiple dimensions of health and wellness, encompassing information regarding disease symptoms, preventive measures, treatment alternatives, medications, and health screenings. SHI was measured based on participant's preferred formal channel such as healthcare professionals, community leaders and health campaign, as well as informal channels like social media, and online health platforms. AHI was measured by assessing participants' ability to locate and understand health information from diverse sources, navigate barriers to obtaining such information, and apply it to their health concerns. HIU was measured as how patient used health information to reduce anxiety about illnesses, addressing uncertainties regarding symptoms, share health information with family members, and used health information to adopt healthier practices.

We assessed three items to determine whether participants had diabetes, hypertension, or heart disease, using categorical response options of "Yes" or "No." Participants who responded "Yes" to any of the listed NCDs were categorised as NCD patients.

This present study adapted Longo's Extended Model of Health Information-Seeking Behaviour (EM-HISB) to develop the items measuring THI, SHI, and HIU (6). Responses for THI and SHI were assessed using a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree), while HIU was measured on a scale from 1 (never) to 5 (very often). The AHI scale was adapted from the COM-B Model (41). The scale used a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The study instrument was designed in standard Malay language, equivalent to a lower secondary school language level, to ensure comprehensibility across participants with diverse backgrounds.

As the measurement instruments were adapted, several validation procedures were conducted prior to the pilot study to ensure their appropriateness for the study context. Content validity was established through expert review by a public health specialist and a health educationist. In addition, face validity was assessed with 30 adult participants representing diverse demographic backgrounds to evaluate the clarity, cultural relevance, and overall acceptability of the items. Following these steps, a pilot study was conducted to assess the reliability and feasibility of the instrument in preparation for the main data collection.

A pilot study was conducted with 182 participants from the Samarahan District, which represents a suburban and rural population mix. The internal reliability of the four variables was found to be good, as indicated by Cronbach's alpha values: THI (0.84), SHI (0.80), AHI (0.71), and HIU (0.74), which are considered acceptable for research purposes (42).

To enhance the reliability assessment of the measurement instrument, a test-retest analysis was conducted to evaluate its temporal stability. This approach verifies whether the instrument consistently yields stable results over time, thus reinforcing the replicability of the study. Reliability was assessed using the intraclass correlation coefficient (ICC), with values below 0.5 indicating poor reliability, 0.5 - 0.75 moderate, 0.75 - 0.90 good, and above 0.90 excellent reliability (43). The instrument was administered twice to a subsample of 30 participants from the pilot study. Results demonstrated good reliability across all constructs, confirming the instrument's stability for use in the main study.

Exploratory Factor Analysis (EFA) was performed on pilot data from 182 participants using principal axis factoring with varimax rotation to identify the underlying structure of the adapted measurement scales. The analysis confirmed sampling adequacy (KMO > 0.70; Bartlett's Test, $p < 0.001$), and items with factor loadings below 0.50 or significant cross-loadings were removed. This process resulted in a final set of validated constructs used in the main study.

Some of the examples of items include: THI1 - I seek health information regarding the symptoms of diseases. SHI1 - I seek health information from healthcare personnel. AHI1 - I verify the authenticity of the health information I seek. HIU1 - The health information I receive helps reduce my anxiety about the illness I am experiencing.

Ethics approval

This study was approved by the National Medical Research Registration (NMRR) and the Medical Review & Ethics Committee (MREC) of the MOH, Malaysia, with registration number NMRR-20-2537-57272 (IIR). Detailed information about the study, along with informed consent forms, was provided to participants, emphasising participant confidentiality and data security measures to enhance trust in the study.

Data collection procedures

This study employed a survey to collect data from eligible participants within the selected households. The multiple survey methods were implemented to offer participants various options based on their convenience. The community survey was conducted from May to December 2023. The data collection methods included: a) A self-administered questionnaire was delivered to eligible households, with completed questionnaires later collected using the drop-and-pick method. Designated collection points included community leader offices, village head residences, and other local locations. b) A face-to-face interview with an assisted questionnaire was conducted to accommodate participants who were less literate, or preferred verbal communication.

Data analysis

We used Partial Least Squares Structural Equation Modelling (PLS-SEM) and using SmartPLS 3 software package to analyze the patterns of HIU among NCD patients in Sarawak, as described in the research model in Fig. 1. PLS-SEM is a predictive-oriented method, making it particularly suitable for exploring how various factors influence HIU (44).

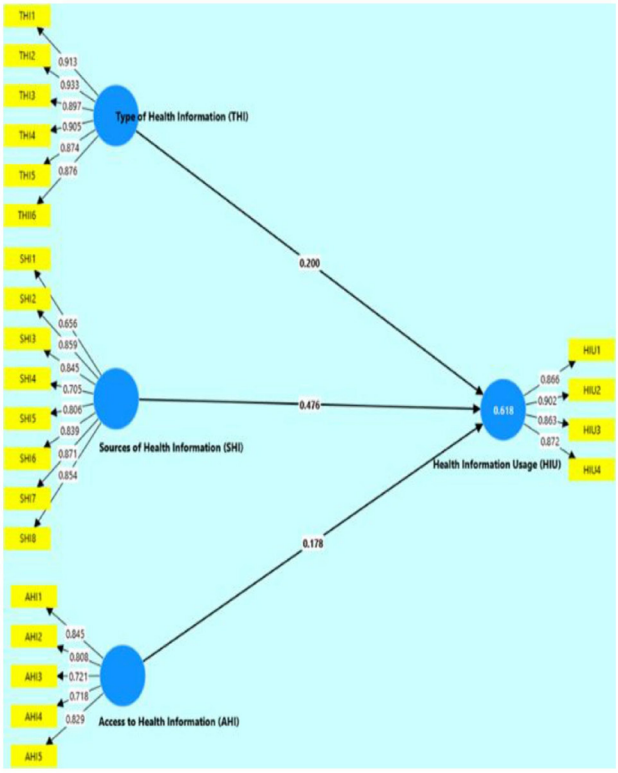

Fig. 1: Partial least squares structural equation modelling (PLS-SEM) model of health information usage among NCD patients in Sarawak

Partial Least Squares Structural Equation Modelling (PLS-SEM) was employed in this study due to its appropriateness for exploratory research involving complex models with multiple latent variables and a primary focus on prediction (45).

Data analysis was conducted in three stages, as outlined by Hair et al. (46). The first stage involved assessing the measurement model, including the outer loadings, Average Variance Extracted (AVE), and Composite Reliability (CR). Discriminant validity (DV) was evaluated using the Heterotrait-Monotrait ratio criterion (HTMT). The second stage focused on evaluating the structural model, which involved examining the path coefficients, standard errors, t-values, p-values, and the f^2 effect size. Finally, the predictive performance of the model was measured using PLS Predict.

RESULTS

This study utilised a subset of data derived from a larger research project focused on health information-seeking behaviour among urban and rural communities in Sarawak. While the original dataset encompassed 782 participants, the current analysis specifically targeted participants who self-reported to have at least one NCD (N=217).

Demographic characteristics

Table 1 provides an overview of the sociodemographic characteristics of the 217 participants which categorized as NCD patient. The sample included 40.1% urban residents and 59.9% rural residents, with 51.6% male and 48.4% female participants. The majority (61.3%) were aged between 41 and 60 years. The most common self-reported NCD conditions were hypertension (47%), followed by a combination of diabetes and hypertension (20.7%), and diabetes (13.8%).

Table I: Sociodemographic characteristics (N=217).

Variable	Frequency	Percent (%)
Strata		
Urban	87	40.1
Rural	120	59.9
Gender		
Male	112	51.6
Female	105	48.4
Age group		
18 - 40 years old	39	18.0
41 - 60 years old	133	61.3
61 - 90 years old	45	20.7
Ethnicity		
Malay	33	15.2
Iban	110	50.7
Chinese	23	10.6
Bidayuh	34	15.7
Orang Ulu	5	2.3
Melanau	6	2.8
Others	6	2.8
Religion		
Islam	47	21.7
Christian	127	58.5
Buddha	10	4.6
Hindu	3	1.4
Traditional Chinese Religion	8	3.7
Traditional ethnic religion	22	10.1
Education Level		
Never attend school	28	12.9
Primary School	27	12.4
Secondary School	65	30.0
Certificate/Diploma	59	27.2
Bachelor Degree	31	14.3
Post Graduate Degree	7	3.2

CONTINUE

Table I: Sociodemographic characteristics (N=217). (CONT.)

Variable	Frequency	Percent (%)
Occupation		
Working in government sector	80	36.9
Working in private sector	43	19.8
Self-Employed	51	23.5
Housewives	23	10.6
Pensioner	16	7.4
Unemployed	2	0.9
Student	2	0.9
Household Monthly Income		
Below RM4,850	130	59.9
RM4,851 - RM10,970	62	28.6
More than RM10,971	3	1.4
No income because of not working	22	10.1
Self-reported NCDs		
Diabetes	30	13.8
Hypertension	102	47
Diabetes and hypertension	45	20.7
Heart disease	15	6.9
Diabetes and heart disease	4	1.8
Hypertension and heart disease	7	3.2
Hypertension, heart disease and diabetes	14	6.5

Source: Survey, May-December, 2023

Collinearity assessment

The lateral collinearity assessment presented in Table II evaluates the variance inflation factor (VIF) values for the independent variables predicting HIU. The results show that all VIF values are below the threshold of 5.0, indicating no severe multicollinearity issues among the predictors (47). Specifically, AHI has a VIF of 1.808, demonstrating low collinearity with other variables. In contrast, SHI and THI have higher VIF values of 4.293 and 4.067, respectively, but these are still within acceptable limits. These findings suggest that each variable contributes uniquely to the model without significant redundancy, supporting the validity of the structural model's estimates.

Table II: Lateral collinearity assessment.

Variable	Variance inflation factor (VIF)
Access to Health Information (AHI) - > Health Information Usage (HIU)	1.808
Sources of Health Information (SHI) - > Health Information Usage (HIU)	4.293
Type of Health Information (THI) - > Health Information Usage (HIU)	4.067

Source: Survey, May-December, 2023

Measurement model

Table III displays the measurement model indicators, including the loadings, composite reliability (CR), and average variance extracted (AVE) for the four variables examined in this study. These indicators are assessed against established thresholds, with factor loadings greater than 0.70, CR values exceeding 0.70, and AVE values above 0.50 (48). For AHI, the item loadings range from 0.718 to 0.845, with a CR of 0.851 and an AVE of 0.618, indicating good reliability and moderate explanatory power. HIU shows strong item loadings between 0.863 and 0.902, with a CR of 0.901 and an AVE of 0.767, reflecting high reliability and good explanatory power. The SHI has item loadings between 0.656 and 0.871, a CR of 0.931, and an AVE of 0.653, which shows high reliability but a slightly lower level of explanatory power. Lastly, the THI has the highest loadings, ranging from 0.874 to 0.933, a CR of 0.954, and an AVE of 0.810, indicating excellent reliability and strong explanatory power. These results suggest that all four variables have reliable measurement indicators and are valid in representing the variables.

Table III: The measurement model indicators.

Variable	Item	Loadings	Composite Reliability (CR)	Average Variance Extracted (AVE)
Access to Health Information (AHI)	AHI1	0.845	0.851	0.618
	AHI2	0.808		
	AHI3	0.721		
	AHI4	0.718		
	AHI5	0.829		
Health Information Usage (HIU)	HIU1	0.866	0.901	0.767
	HIU2	0.902		
	HIU3	0.863		
	HIU4	0.872		
Sources of Health Information (SHI)	SHI1	0.656	0.931	0.653
	SHI2	0.859		
	SHI3	0.845		
	SHI4	0.705		
	SHI5	0.806		
	SHI6	0.839		
	SHI7	0.871		
	SHI8	0.854		
Type of Health Information (THI)	THI1	0.913	0.954	0.810
	THI2	0.933		
	THI3	0.897		
	THI4	0.905		
	THI5	0.874		
	THII6	0.876		

Source: Quantitative survey, May-December, 2023

Structural model

Table IV presents the results of the hypothesis testing for the relationships between the independent variables (THI, SHI, and AHI) and HIU. THI (β = 0.200, p < 0.05), SHI (β = 0.476, p < 0.05) and AHI (β = 0.178, p < 0.05), had a significant positive relationship with HIU. All three hypotheses (H1, H2 and H3) were supported. Specifically, the relationship between SHI and HIU was the strongest. The model explained 61.2% of the variance in HIU (R2 = 0.612) indicating a substantial predictive validity (Hair et al., 2017). In term of effect sizes, the f2 values indicates a medium effect sizes for SHI (f2 = 0.138) and small effect sizes for THI and AHI (49).

Table IV: Hypothesis testing.

Hypothesis	Relationship	Standard Beta	Standard Error	t-value	Decision	R^2	f^2
H1	THI -> HIU	0.200	0.091	2.202*	Supported	0.612	0.026
H2	SHI -> HIU	0.476	0.083	5.751*	Supported		0.138
H3	AHI -> HIU	0.178	0.059	2.994*	Supported		0.046

Access to Health Information (AHI), Health Information Usage (HIU), Sources of Health Information (SHI), Type of Health Information (THI)
*p < 0.05

Notably, sources of health information (SHI) emerged as the most influential predictor of health information usage (HIU), with the highest standardised beta coefficient (β = 0.476, p < 0.05) and a medium effect size (f = 0.138).

Table V presents the results of the PLS Predict analysis, which evaluates the predictive performance of the PLS-SEM model for the HIU indicators. The Q predict values for HIU1, HIU2, HIU3, and HIU4 indicate moderate predictive relevance, with values ranging from 0.397 to 0.526, suggesting that the model can effectively predict these HIU indicators (50). The PLS-SEM model performs reasonably well, with Root Mean Squared Error (RMSE) values ranging from 0.712 to 0.825 and Mean Absolute Error (MAE) values between 0.580 and 0.654. These values are generally lower than those for the Linear Model (LM) and Iterative Algorithm (IA) models, indicating that the PLS-SEM model has a better predictive fit (51).

Table V: The predictive fit of health information usage model.

	Q predict	PLS-SEM_ RMSE	PLS-SEM_ MAE	LM_RMSE	LM_MAE	IA_RMSE	IA_MAE
HIU1	0.526	0.712	0.580	0.720	0.576	1.034	0.839
HIU2	0.459	0.789	0.632	0.782	0.622	1.072	0.881
HIU3	0.397	0.825	0.654	0.835	0.660	1.062	0.879
HIU4	0.440	0.809	0.618	0.819	0.631	1.081	0.901

Health Information Usage (HIU), Root Mean Squared Error (RMSE), Mean Absolute Error (MAE), Linear Model (LM), and Iterative Algorithm (IA)

DISCUSSION

The primary aim of this study was to explore the associations between the type of health information (THI), preferred sources of health information (SHI), and the ability to access health information (AHI) with health information usage (HIU) among NCDs patient in Sarawak.

The findings showed that THI, SHI, and AHI are significant predictors of HIU, with SHI demonstrating the strongest relationship (β = 0.476, p < 0.05). Our findings align with existing literature, which highlights that the relevance and reliability of information sources play a critical role in shaping how NCD patients seek and utilise health information (26). This is particularly because NCD patients' health information needs often vary depending on their cognitive abilities and specific health situations (52). The moderate effect size of preferred sources of health information (f = 0.138) further highlights its significance in influencing health information usage. This suggests that whether individuals prefer formal sources (example, healthcare professionals and health authority) or informal sources (example, friends and social media), these preferences have a substantial impact on their HIU (25).

The relatively strong predictive power of SHI may reflect Sarawak's distinctive socio-cultural and infrastructural landscape, where interpersonal communication, cultural trust in health intermediaries, and community-oriented norms significantly influence health behaviours (53). In many rural and semi-urban areas of Sarawak, formal health services may be geographically distant or inconsistently accessed, leading individuals to rely heavily on trusted interpersonal sources such as community leaders, traditional healers, family members, and peers for health advice and guidance (53–55). These informal networks often act as the first point of contact, providing not only information but also emotional

support, validation, and cultural interpretation of health messages.

This pattern of reliance on interpersonal and culturally embedded information sources is not unique to Sarawak. Similar findings have been reported in Nigeria and Uganda, where studies show that trusted community-based figures, including traditional healers and religious leaders, often mediate access to health information, especially in settings where formal healthcare access is limited (56,57). These sources can enhance comprehension, trust, and uptake of health messages by aligning information with local beliefs and social norms. Thus, the strong predictive role of SHI in this study underscores the importance of leveraging both formal and informal communication channels when designing culturally sensitive and accessible health interventions for NCD management.

The significant positive association between THI and HIU ($\beta = 0.200$, $p < 0.05$) aligns with existing research that underscores the importance of providing tailored health information to address specific needs, such as disease symptoms, treatment options, and preventive strategies to NCD patients (58) (14) (16). The positive relationship between AHI and HIU ($\beta = 0.178$, $p < 0.05$) supports studies emphasizing the critical role of accessibility in engaging with health information (59). Although the effect sizes for both THI ($f = 0.026$) and AHI ($f = 0.046$) are smaller, their contributions remain significant, particularly in contexts where overcoming barriers such as digital and health disparities is essential for improving HIU among NCD patients, especially in underserved populations like those in rural Sarawak (3) (33).

The model explained 61.2% of the variance in HIU ($R = 0.612$), indicating strong predictive validity. The results of the PLS Predict analysis provide important implications for the study by demonstrating that the PLS-SEM model offers moderate predictive relevance for HIU indicators, as evidenced by the Q predict values (0.397 to 0.526) (50). Additionally, the lower RMSE and MAE values of the PLS-SEM model compared to the alternative models (Linear Model and Iterative Algorithm) highlight its strong predictive fit, reinforcing its suitability for analysing the relationships among health information factors in this study (51). This highlights the significant role of THI, SHI, and AHI, further reinforcing Longo's, the EM-HISB, which describes health information-seeking and usage behaviours, whether through active engagement or passive reception (6).

Our findings regarding the self-reported NCDs underscores the concerning prevalence of chronic health conditions among participants. The findings indicate that hypertension is the most prevalent condition among participants and frequently co-occurs with diabetes and/or heart disease, reflecting a high rate of comorbidity. Furthermore, a significant proportion (20.7%) reported having both diabetes and hypertension, highlighting the frequent co-morbidity of these conditions. This finding is consistent with the trends observed in the NHMS 2015, 2019, and 2023 (11 - 13). This suggests that individuals with one NCD, especially hypertension, are at an increased risk of developing additional NCDs (comorbidity), such as diabetes and heart disease (19).

When stratified by location, a higher prevalence of NCDs was observed in rural areas compared to urban areas. In terms of age, nearly 80% of participants with NCDs were aged 40 and above. Ethnically, almost half of the reported cases were from the Iban community. In addition, nearly 60% of participants had incomes below RM4,850, categorising them within the B40 income group or those with the lowest income levels (60). The education level also appeared to be an important factor to take into account, with 12% of patients reporting no formal schooling and another 12% having only attended primary school, suggesting a lower level of education among those affected. The sociodemographic and epidemiological characteristics highlight that this population group could be susceptible to the impacts of health and digital disparities in Sarawak (22, 26), emphasising the need for further investigation into how these NCD patients manage their health conditions and adopt behaviours that support their overall well-being (23).

Similar patterns have been observed in other third world countries where rural and socioeconomically disadvantaged populations encounter considerable obstacles in accessing and using health information. For instance, a study conducted in India revealed that individuals with lower education and income levels were less likely to engage with formal healthcare systems and instead relied more heavily on informal networks such as family members, community leaders, and traditional healers to manage chronic illnesses (61). These informal sources are often preferred because they are more accessible, culturally familiar, and trusted within local communities, particularly in areas where formal health services are scarce or viewed as inadequate. Furthermore, limited health literacy and digital exclusion exacerbate difficulties in obtaining accurate and timely health information from formal channels (12). These findings highlight the urgent need for inclusive health communication strategies that effectively connect formal healthcare systems with community-based support networks in underserved populations.

These findings underscore the importance of developing multifaceted health promotion strategies that cater to the varied informational needs, and preferences of NCD patients in Sarawak. From a health promotion perspective, providing culturally appropriate, easily comprehensible and credible sources of health information to the right

audience via effective channels is crucial (62).

This study enhances theoretical insights into HIU by broadening the application of Longo's EM-HISB within the context of NCD management in Sarawak, Malaysia. Empirically, the predominant influence of SHI underscores the vital role of healthcare practitioners and informal networks in promoting informed health behaviours. These findings have practical implications for patient-centred clinical approaches and advocate for the development of culturally sensitive, accessible patient education strategies. From a policy perspective, the evidence supports prioritising investments in digital infrastructure, health literacy programs, and inclusive information dissemination to mitigate the NCD burden, especially among underserved and diverse populations.

CONCLUSIONS

In conclusion, this study revealed a high prevalence of NCDs, particularly among vulnerable populations, highlighting the need for further research into how these individuals manage their chronic conditions and identifying them as a potential target group for health promotion interventions. The findings demonstrated that the type of health information, sources of health information, and access to health information are significant predictors of health information usage, supporting all three hypotheses (H1, H2, and H3), with sources of health information exerting the most substantial influence. The model for health information usage among NCD patients in Sarawak proved its predictive fit, validating its applicability in analysing the relationships among health information usage related factors. These insights underscore the importance of developing multifaceted health promotion strategies tailored to the diverse informational needs, preferences, and access challenges faced by adult NCD patients.

Our study has limitation, including the potential for salience bias (63). Salience bias may have influenced participants' responses, as they might have been more focused on their recent experiences or ongoing concerns related to COVID-19 rather than issues pertaining to non-communicable diseases since this survey was conducted during the post-COVID-19 period. This could have inadvertently shifted attention away from the intended research focus and potentially over-representing pandemic-related perceptions and behaviours. Future studies should consider employing longitudinal designs to mitigate the influence of such temporal biases and ensure a more balanced perspective on the factors influencing health information usage among NCD patients.

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REFERENCES

1. Ministry of Health Malaysia (MOH). Health White Paper For Malaysia. 2023.
2. Zimmerman MS, Shaw G. Health information seeking behaviour: a concept analysis. Health Info Libr J. 2020;37(3):173–91.
3. Horn C, Gifford SM. ICT uptake and use and social connectedness in rural and remote communities: a study from Sarawak, Malaysia. Inf Technol Dev. 2022;28(4):721–46.
4. Horn C, Rennie E. Digital access, choice and agency in remote Sarawak. Telemat Informatics [Internet]. 2018;35(7):1935–48. Available from: https://doi.org/10.1016/j.tele.2018.06.006
5. Songan P, Ab K, Yeo A, Gnaniah J, Zen H. Community Informatics : Challenges in Bridging the Digital Divide. Work with Comput Syst. 2004;267–70.
6. Longo DR, Schubert SL, Wright BA, LeMaster J, Williams CD, Clore JN. Use in diabetes self-management. Ann Fam Med. 2010;8(4):334–40.
7. Diviani N, Obrenovic J, Montoya CL, Karcz K. Disentangling health information appraisal competence: Results from an interdisciplinary scoping review and online consultation among Swiss stakeholders. PLoS One [Internet]. 2020;15(7):1–19. Available from: http://dx.doi.org/10.1371/journal.pone.0235474
8. Jaafar N, Perialathan K, Zulkepli MZ, Mohd Zin Z, Jonoi PE, Johari MZ. Patients' perception towards health education services received at the enhanced primary healthcare facilities: a qualitative exploration. J Prim Care Community Heal. 2020;11(1).
9. Longo DR. Understanding health information, communication, and information seeking of patients and consumers: A comprehensive and integrated model. Heal Expect. 2005;8(3):189–94.
10. Zare-Farashbandi F, Lalazaryan A. A review of models and theories of health information seeking behavior. Int J Heal Syst Disaster Manag. 2014;2(4):193.
11. Swire-Thompson B, Lazer D. Public Health and Online Misinformation: Challenges and Recommendations. Annu Rev Public Health. 2020;41(1):433–51.
12. Sørensen K, Van Den Broucke S, Fullam J, Doyle G, Pelikan J, Slonska Z, et al. Health literacy and public health: A systematic review and integration of definitions and models. BMC Public Health [Internet]. 2012;12(1):80. Available from: http://www.biomedcentral.com/1471-2458/12/80
13. Alan R, Salleh Hassan M, Nizam Osman M. Frequency of Radio Consumption Among the Rural Community in Sarawak. Int J Soc Sci Res [Internet]. 2020;2(3):66–76. Available from: http://myjms.

moe.gov.my/index.php/ijssrhttp://myjms.moe.gov.my/index.php/ijssrhttp://myjms.moe.gov.my/index.php/ijssr

14. Lim BC, Kueh YC, Arifin WN, Ng KH. Modelling knowledge, health beliefs, and health-promoting behaviours related to cardiovascular disease prevention among Malaysian university students. PLoS One [Internet]. 2021;16(4 April):1–17. Available from: http://dx.doi.org/10.1371/journal.pone.0250627
15. Kim MS, Kim SH. Health information-seeking behavior in patients with coronary artery disease: Activating methods. PLoS One [Internet]. 2024;19(4 April):1–13. Available from: http://dx.doi.org/10.1371/journal.pone.0300755
16. Kyriacou A, Sherratt C. Online health information–seeking behavior by endocrinology patients. Hormones. 2019;18(4):495–505.
17. Chatterjee S, Khunti K, Davies MJ. Type 2 diabetes. Lancet [Internet]. 2017;389(10085):2239–51. Available from: http://dx.doi.org/10.1016/S0140-6736(17)30058-2
18. Ministry of Health (MOH) M. Malaysia Health Systems Research (MHSR) Vol I: Methodology & General Findings [Internet]. Vol. I, Ministry of Health Malaysia. 2015. 327 p. Available from: http://www.iku.gov.my/images/IKU/Document/nhmsreport2015vol2.pdf
19. Ministry of Health (MOH) M. National Health and Morbidity Survey (NHMS) 2023: Non-communicable Diseases and Healthcare Demand - Key Findings. 2024.
20. Ministry of Health (MOH) M. The impact of noncommunicable diseases and their risk factors on Malaysia's gross domestic product [Internet]. 2020. Available from: https://www.moh.gov.my/index.php/database_stores/attach_download/554/64%0A1
21. Grasso KL, Bell RA. Understanding health information seeking: A test of the risk perception attitude framework. J Health Commun. 2015;20(12):1406–14.
22. Neto OL, Wyl V Von. Digital Transformation of Public Health for Noncommunicable Diseases: Narrative Viewpoint of Challenges and Opportunities. JMIR Public Heal Surveill. 2024;10(1):1–11.
23. Budreviciute A, Damiati S, Sabir DK, Onder K, Schuller-Goetzburg P, Plakys G, et al. Management and Prevention Strategies for Non-communicable Diseases (NCDs) and Their Risk Factors. Front Public Heal. 2020;8(November):1–11.
24. Schiavo R. Health communication: From theory to practice. Jossy-Bass; 2014.
25. Mohan J. Dutta-Bergman. Primary sources of health information: comparisons in the domain of health attitudes, health cognitions , and health behaviors. Health Commun. 2004;16(3):273–88.
26. Sillence E, Blythe JM, Briggs P, Moss M. A revised model of trust in internet-based health information and advice: Cross-sectional questionnaire study. J Med Internet Res. 2019;21(11):1–14.
27. Maung TM, Deborah S, Narayanam H, Fernandez K, Kumari U. Morbidity and health seeking behavior among the rural Population, Malaysia. Asian J Med Sci. 2020;11(3):1–5.
28. Nutbeam D. The evolving concept of health literacy. Soc Sci Med [Internet]. 2008;67(12):2072–8. Available from: http://dx.doi.org/10.1016/j.socscimed.2008.09.050
29. Mohd-Nor R, Chapun TE, Rinen C. Malaysian rural community as consumer of health information and their use of ICT komuniti luar bandar Malaysia sebagai pengguna maklumat kesihatan dan penggunaan ICT. J Komun Malaysian J Commun. 2013;29(291):1–27.
30. Khoo S, Poh BK, Suhaimi SA, Chong KH, Ramirez Varela A. Physical activity promotion in Malaysia: Challenges and opportunities. Front Public Heal. 2020;8(October):8–12.
31. Froze S, Arif MT, R. S. Determinants of health literacy and healthy lifestyle against metabolic syndrome among major ethnic groups of Sarawak, Malaysia: a multi-group path analysis. Open Public Health J. 2019;12(1):172–83.
32. Yap CS, Tiew FNH, Ngadan AA, Ho PL. Information needs and information seeking behaviour of rural dwellers in Sarawak, Malaysia. Malaysian J Libr Inf Sci. 2020;25(2):77–94.
33. Harris R, Bala P, Songan P, Guat Lien EK, Trang T. Challenges and opportunities in introducing information and communication technologies to the Kelabit community of north central Borneo. New Media Soc. 2001;3(3):270–95.
34. Malaysian Communications and Multimedia Commission (MCMC). Internet Users Survey 2020. The Internet Users Survey 2020. 2020.
35. Malaysian Communication and Multimedia Commission (MCMC). Internet users survey 2018 [Internet]. Internet users survey 2018. 2018. Available from: https://www.mcmc.gov.my/skmmgovmy/media/General/pdf/Internet-Users-Survey-2018.pdf
36. Department of Statistics (DOSM) M. Census 2020. 2020 [cited 2024 Nov 16]. Vital statistics, Malaysia, 2020. Available from: https://www.mycensus.gov.my/
37. Ministry of Local Government Sarawak. Department and agencies in Sarawak [Internet]. 2024 [cited 2023 Mar 12]. Available from: https://mphlg.sarawak.gov.my/web/home/index/
38. Cochran WG. Sampling Technique. 2nd Editio. New York: John Wiley and Sons Inc.,; 1963.
39. Abu Bakar AB. Information seeking behaviours of rural women in Malaysia. Libr Philos Pract. 2011;2011(JAN).
40. Bryman A. Social Research Method. Fourth Edi. Social Research Method. Great Clarendon Street,

Oxford, OX26DP, United Kingdom: Oxford University Press; 2016.
41. Michie S, van Stralen MM, West R. The behaviour change wheel: A new method for characterising and designing behaviour change interventions. Implement Sci [Internet]. 2011;6(1):42. Available from: http://www.implementationscience.com/content/6/1/42
42. George, D., & Mallery P. SPSS for Windows Step by Step: A Simple Guide and Reference. Fourth Edi. Boston: Allyn & Bacon; 2003.
43. Koo TK, Li MY. A Guideline of Selecting and Reporting Intraclass Correlation Coefficients for Reliability Research. J Chiropr Med. 2016;15(2):155–63.
44. Ramayah T, Cheah J, Chuah F, Ting H, Mumtaz MA. Partial Least Squares Structural Equation Modeling (PLS) using SmartPLS3.0. Second Edi. Kuala Lumpur: Pearson Malaysia Sdn Bhd; 2018.
45. Hair J, Alamer A. Partial Least Squares Structural Equation Modeling (PLS-SEM) in second language and education research: Guidelines using an applied example. Res Methods Appl Linguist. 2022;1(3).
46. Hair JF, Hult GTM, Ringle CM, Sarstedt M. A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM). 2nd Editio. Sage Publications Inc., Thousand Oaks, CA; 2017.
47. Hair JF, Ringle CM, Sarstedt M. PLS-SEM: Indeed a silver bullet. J Mark Theory Pract. 2011;19(2):139–52.
48. Hair JF, Black WC, Babin BJ, Anderson RE. Multivariate Data Analysis (7th Edition). 7th editio. Pearson Prentice Hall; 2010.
49. Cohen J. Statistical power analysis for the behavioral sciences. Second Edi. Lawrence Erlbaum Associates, Publishers; 1988.
50. Shmueli G, Sarstedt M, Hair JF, Cheah JH, Ting H, Vaithilingam S, et al. Predictive model assessment in PLS-SEM: guidelines for using PLSpredict. Eur J Mark. 2019;53(11):2322–47.
51. Hair JF, Sarstedt M, Ringle CM, Sharma PN, Liengaard BD. Going beyond the untold facts in PLS–SEM and moving forward. Eur J Mark. 2024;58(13):81–106.
52. Christalle E, Zill JM, Frerichs W, HΔrter M, Nestoriuc Y, Dirmaier J, et al. Assessment of patient information needs: A systematic review of measures. PLoS One. 2019;14(1):1–15.
53. Horn C, Rennie E, Gifford S, Riman RM, Wee GLH. Digital Inclusion and Mobile Media in Remote Sarawak. Swinburne Univ Technol Melbourne [Internet]. 2018; Available from: http://apo.org.au/system/files/128041/apo-nid128041-572516.pdf
54. Johny AK, Cheah WL, Razitasham S. Disclosure of traditional and complementary medicine use and its associated factors to medical doctor in primary care clinics in Kuching division, Sarawak, Malaysia. Evidence-based Complement Altern Med. 2017;2017.
55. Froze S, Arif MT, Saimon R. Does health literacy predict preventive lifestyle on metabolic syndrome? a population-based study in Sarawak, Malaysia. Open J Prev Med. 2018;08(06):169–82.
56. Obaremi OD, Olatokun WM. A survey of health information source use in rural communities identifies complex health literacy barriers. Health Info Libr J. 2021;(October 2020):1–9.
57. Tusubira AK, Ssinabulya I, Kalyesubula R, Nalwadda CK, Akiteng AR, Ngaruiya C, et al. Self-care and healthcare seeking practices among patients with hypertension and diabetes in rural Uganda. PLOS Glob Public Heal [Internet]. 2023;3(12):1–14. Available from: http://dx.doi.org/10.1371/journal.pgph.0001777
58. Kim K, Shin S, Kim S, Lee E. The Relation Between eHealth Literacy and Health-Related Behaviors : Systematic Review and Meta-analysis Corresponding Author : 2023;25.
59. Nutbeam D. Health literacy as a public health goal: a challenge for contemporary health education and communication strategies into the 21st century. Health Promot Int. 2000;15(3):259–67.
60. (DOSM) D of SM. Household Income Malaysia 2022. 2022.
61. Gupta S, Virk A, Mittal A, Agarwal BK. Patterns and determinants of healthcare - seeking behavior among hypertensive patients in a rural population of north India : A mixed - method study. 2020;
62. Schmidt H, Wild EM, Schreyugg J. Explaining variation in health information seeking behaviour – Insights from a multilingual survey. Health Policy (New York). 2021;(February).
63. Tiefenbeck V, Goette L, Degen K, Tasic V, Fleisch E, Lalive R, et al. Overcoming salience bias: How real-time feedback fosters resource conservation. Manage Sci. 2018;64(3):1458–76.