

Digital Health Literacy and Its Determinants among Adults Aged 45 Years and Above in Udupi Taluk, Coastal Karnataka, India: A Cross-Sectional Study

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Background and Objective: Digital health services increasingly require people to locate, understand, evaluate, and use health information through electronic platforms. Evidence on these competencies among middle-aged and older populations in coastal Karnataka remains limited. To assess digital health literacy and factors associated with eHEALS scores among adults aged ≥ 45 years in Udupi Taluk, coastal Karnataka, India.

Material and Methods: A community-based cross-sectional study was conducted among 385 adults aged ≥ 45 years recruited purposively outside community clinics in Udupi Taluk during January–February 2025. Digital health literacy was assessed using the eHealth Literacy Scale (eHEALS), and an investigator-developed structured questionnaire captured sociodemographic characteristics, morbidity, digital access, technology use, online health-information practices, and AI-related awareness. Data were analysed using descriptive statistics, group comparisons, and multivariable linear regression.

Results: The mean eHEALS score was 18.9 ± 9.63 . Smartphone ownership was reported by 62.6% of participants and 67.0% had internet access at home, whereas only 25.2% reported obtaining information about health conditions online. Among 251 participants who accessed online health information, 63.7% did not verify the information. In multivariable analysis, smartphone ownership ($B=7.11$; 95% CI:5.35–8.86; $p<0.001$) and confidence in internet use ($B=3.88$; 95% CI:1.92–5.84; $p<0.001$) were independently associated with higher eHEALS scores; frequency of digital-device use and higher educational attainment were also independently associated with eHEALS scores.

Conclusion: Digital health literacy among adults aged ≥ 45 years in Udupi Taluk was associated with smartphone ownership, internet-use confidence, frequency of digital-device use, and higher educational attainment. Interventions should therefore prioritize practical digital-health skills, confidence, and critical appraisal of online health information rather than access alone.

Keywords: Digital Divide, Health Information Seeking Behavior, India, Middle Aged, Older Adults, Telemedicine

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Introduction

Population ageing is accelerating globally. From 1974 to 2024, the proportion of people aged 65 years or older doubled from 5.5% to 10.3% and is projected to reach 20.7% by 2074 (1, 2). India is experiencing the same demographic transition: the United Nations Population Fund estimates that the population aged 60 years and above will rise from 149 million in 2022 to about 347 million by 2050 (2,3). At the same time, digital technologies are becoming increasingly embedded in health information, communication, and service delivery (4). These changes make digital competencies relevant not only after conventional old-age thresholds but also during midlife, when chronic disease risk and engagement with health services increase.

Digitalization has altered how health services and health information are delivered, accessed, and experienced (4). Digital health literacy refers to the competencies required to locate, understand, appraise, and apply health information obtained through electronic sources (5-7). These competencies are distinct from general literacy and from simple ownership of a mobile phone or internet connection. Recent evidence identifies age, education, income, internet use, perceived usefulness, and self-efficacy among important correlates of eHealth literacy (6).

Digital health literacy is shaped by sociodemographic, technological, and behavioural conditions. A recent study from Assam reported rural-urban differences in e-health utilisation among adults aged 60 years and above, with digital literacy, education, and income contributing to the observed gap (9). In coastal Karnataka, Krishna et al. reported variation in health literacy and eHealth literacy and noted that high health literacy did not necessarily translate into uniformly high eHealth literacy (10). Connectivity and conventional literacy cannot be assumed to represent the ability to use digital health resources effectively.

Increasing connectivity and access to digital technologies do not by themselves eliminate disparities in the skills required for meaningful digital participation.

Udupi Taluk provides an important setting in which to examine this distinction. The wider Udupi context has historically reported a relatively high general literacy rate according to Census 2011 data (11). Nevertheless, conventional literacy should not be assumed to correspond directly to digital health literacy, which additionally requires the ability to locate, evaluate, and apply health information obtained through digital sources.

This combination could be expected to favour digital engagement; however, the local evidence indicates that health literacy, eHealth literacy, and digital-health use may not develop in parallel (10). The unanswered question is therefore not simply whether adults have access to digital technology, but whether adults in midlife and later life can use that access to find, evaluate, and act on health information. Evidence specific to adults aged ≥ 45 years in Udupi Taluk, including information-verification practices, digital health use, and emerging awareness of AI-enabled health information, remains limited.

The present study therefore aimed The present study aimed to assess digital health literacy and factors associated with eHEALS scores among adults aged ≥ 45 years in Udupi Taluk, coastal Karnataka, India. A secondary objective was to characterise digital-device use, online health-information practices, information verification, and awareness and use of AI for health-related purposes.

Materials and Methods

Study design and setting: This community-based cross-sectional study was conducted in Udupi Taluk, coastal Karnataka, India, during a six-month study period from December 2024 to May 2025. The study population comprised adults aged 45 years and above residing in Udupi Taluk. The lower age threshold was selected to include both middle-aged and older adults and to permit examination of digital health literacy across the study predefined age categories (45-59 years, 60-79 years, and >79 years).

Study participants and sampling: Individuals aged ≥ 45 years who were residents of Udupi Taluk, willing to participate, and able to provide informed consent were eligible. Individuals with serious health conditions that prevented effective participation were excluded. Purposive community-based sampling was used. Recruitment was conducted outside community clinics:

eligible individuals encountered in these community settings were briefed about the study, invited to participate, and enrolled after providing written informed consent. Participants who could complete the questionnaire independently did so. For participants who were illiterate or otherwise unable to complete it independently, the investigator read each question and its response options aloud, recorded the participant-selected response, and verified the recorded response with the participant before proceeding.

Sample size: In the absence of a directly comparable prevalence estimate for the study population and setting, the sample size was calculated using a single-proportion formula with $p=0.50$, 95% confidence level ($Z=1.96$), and 5% absolute precision ($d=0.05$).

$$n = Z^2 \times p \times (1-p) / d^2$$

After allowing 10% for non-response or incomplete responses, the target sample size was 422 participants.

Study tools: Digital health literacy was measured using the eHealth Literacy Scale (eHEALS) developed by Norman and Skinner (6). Permission to use the scale was obtained from the copyright holders. The formal eHEALS comprises eight items rated on a 5-point Likert scale from strongly disagree to strongly agree, producing a total score from 8 to 40; higher scores indicate greater perceived eHealth literacy. The two supplementary items supplied with the instrument, concerning perceived usefulness and importance of internet health resources, are not included in the eHEALS total score. The eHEALS was translated into Kannada using forward and backward translation procedures, pilot tested among 30 participants, and showed high internal consistency in the study sample (Cronbach alpha=0.97).

An investigator-developed 31-item structured questionnaire was used alongside eHEALS. The questionnaire was developed to collect information relevant to the study objectives and covered sociodemographic characteristics (age, sex, religion, education, occupation, family structure and income), morbidity, ownership and recent use of phones and other digital devices, home internet and network access, email/text and social-media use, online shopping and banking, digital contact with healthcare providers, online prescription services, online health-information seeking, confidence and trust in digital platforms, awareness and use of AI for health-related purposes, digital-device use for health monitoring, and verification of online health information. The questionnaire was pilot tested among approximately 30 participants

to assess comprehensibility and feasibility of administration before the main study. No formal psychometric validation of the investigator-developed questionnaire was undertaken. As the items represented heterogeneous descriptive domains rather than a single underlying construct, responses were analysed as individual variables and no composite score was calculated.

Data analysis: Data analysis was performed using Jamovi version 2.3.28. Categorical variables were summarized using frequencies and percentages. Continuous variables were summarized using mean and standard deviation or median and interquartile range, as appropriate. The eHEALS total score was analysed as a continuous variable (range: 8–40); no low, moderate, or high categories were imposed. Differences in mean eHEALS scores between two groups were assessed using independent-samples t-tests; Welch's t-test was used when the assumption of homogeneity of variance was not met. For comparisons involving three or more groups, one-way ANOVA was used, with Welch's ANOVA applied when variances were unequal. Multivariable linear regression was performed to identify factors independently associated with eHEALS scores. The analysis was performed using complete-case analysis for variables included in the model. Model assumptions were evaluated using residual diagnostics, and heteroscedasticity-consistent (HC3) robust standard errors were used to account for heteroscedasticity. Education and area of residence were included in the adjusted model because of their conceptual relevance to digital health literacy. Statistical significance was set at $p < 0.05$.

Ethical approval and consent to participate: Ethical approval was obtained from the Institutional Ethics Committee (IEC2–625/2024). All participants were provided with a participant information sheet, and the study was explained to them prior to providing written informed consent. Confidentiality was maintained throughout the study, and no personal identifying information was collected or disclosed at any stage.

Results

Of the target sample of 422, 385 participants provided complete responses and were included in the analysis (response completion rate 91.2%). The mean age was 56.6 ± 10.9 years. Participants were grouped as 45–59 years (67.5%), 60–79 years (26.8%), and >79 years (5.7%).

Family size, members had Median (IQR): 4 (4–6); Range: 1–16. The mean eHEALS score was 18.9 ± 9.63 , with a median of 18 (IQR:8–27; range:8–40) (Table 1).

Table 1. Sociodemographic characteristics of the study population (n = 385)

Characteristics		Number	Percentage
Age in category	45-59 years	260	67.5
	60-79 years	103	26.8
	Above 79 years	22	5.7
Gender	Male	204	53
	Female	181	47
Religion	Hindu	319	82.9
	Christian	38	9.9
	Islam	24	6.2
	Sikhism	3	0.8
	Buddhism	1	0.3
Education	Illiterate	33	8.6
	Primary	70	18.2
	Middle	53	13.8
	Secondary	84	21.8
	Higher Secondary	62	16.1
	Diploma/Graduation	83	21.6
Occupation	Unemployed	32	8.3
	Homemaker	97	25.2
	Retired	26	6.8
	Employed	230	59.7
Type of Family	Nuclear	232	60.3
	Joint	145	37.7
	3 generation	8	2.1
Area	Rural	121	31.4
	Urban	264	68.6

A predominance of strongly disagree and disagree responses was observed across all eHealth literacy domains, indicating limited awareness, access, evaluation skills, and confidence in using online health information. Conversely, only a small proportion of respondents reported agree or strongly agree responses, indicating that a substantial proportion of participants reported limited perceived competence across several eHealth literacy tasks (Figure 1).

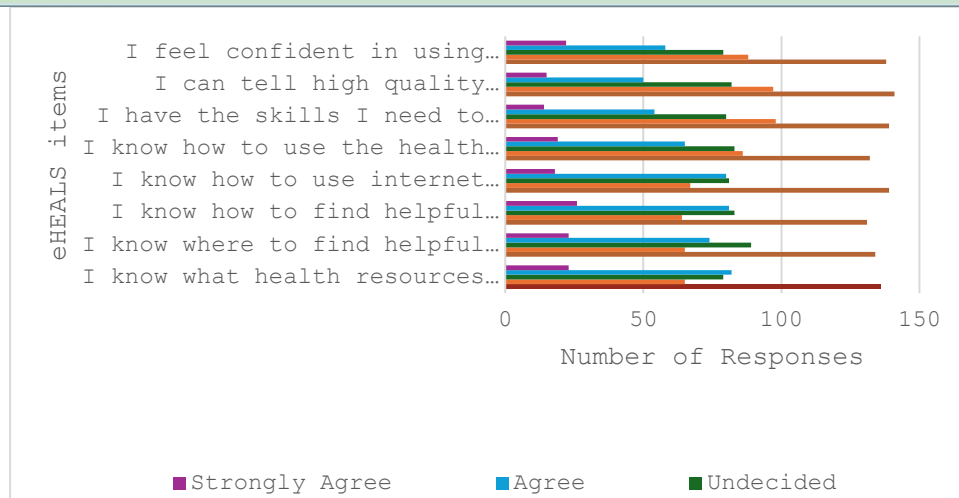


Figure 1: Distribution of responses to eHEALS items

Mean eHEALS scores differed significantly across age groups ($p < 0.001$), with participants aged 45–59 years having higher mean scores (21.5 ± 9.05) than those aged 60–79 years (14.1 ± 8.91) and >79 years (10.9 ± 5.68). Mean eHEALS scores were also higher among males than females (20.0 ± 9.39 vs 17.7 ± 9.77 ; $p = 0.021$) and differed significantly across educational categories ($p < 0.001$), with the highest mean score among participants with diploma/graduation education (28.92 ± 5.97). Smartphone owners (24.1 ± 8.02 vs 10.2 ± 4.34 ; $p < 0.001$) and participants with home internet access (21.7 ± 9.18 vs 13.4 ± 8.04 ; $p < 0.001$) also had higher mean eHEALS scores (Table 2).

Table 2. Associations between participant characteristics and eHEALS scores

Variable	Subcategory	Mean score	SD	p-value
Age group*	60-79 Years	14.1	8.91	<0.001
	45-59 Years	21.5	9.05	
	Above 79 Years	10.9	5.68	
Gender†	Male	20	9.39	0.021
	Female	17.7	9.77	
Education level*	Illiterate	9.21	3.39	<0.001
	Primary	13.94	7.75	
	Middle	13.74	6.01	
	Secondary	18.38	8.87	
	Higher Secondary	21.65	8.77	
	Diploma/Graduation	28.92	5.97	
Smartphone ownership‡	No	10.2	4.34	<0.001
	Yes	24.1	8.02	
Internet access at home‡	No	13.4	8.04	<0.001
	Yes	21.7	9.18	

*Welch's ANOVA; †Independent-samples t-test; ‡Welch's independent-samples t-test

Although smartphone ownership (62.6%) and home internet access (67.0%) were relatively common, health-related digital use was limited, with only 25.2% seeking health information online. Overall, 34.9% of participants reported confidence in using the internet. Confidence was concentrated in familiar platforms: WhatsApp (51.2%), YouTube (34.3%), and Facebook (25.7%). Awareness (23.9%) and health-related use (9.9%) of artificial intelligence were also low. Among participants accessing online health information, 63.7% did not verify its reliability, while 68.8% of participants never used digital devices to monitor their health (Table 3).

Table 3. Digital access and selected digital-health practices among participants (n =385 unless specified)

Variable	n	%
Keypad phone	123	31.9
Smartphone	241	62.6
Internet access at home	258	67.0
Communicate through social media	194	50.4
Online shopping	118	30.6
Online payments/net banking	158	41.0
Contact/find healthcare provider online	44	11.4
Order/refill prescription online	43	11.2
Obtain health-condition information online	97	25.2
Heard of AI	92	23.9
Used AI for health-related purposes	38	9.9
Never use digital devices to monitor health	265	68.8
Do not verify online health information (among n=251)	160	63.7

The multivariable linear regression included 384 participants with complete data for all variables entered into the model. Smartphone ownership was independently associated with a 7.11-point higher eHEALS score ($B = 7.11$; 95% CI: 5.35–8.86; $p < 0.001$), while confidence in internet use was associated with a 3.88-point higher score ($B = 3.88$; 95% CI: 1.92–5.84; $p < 0.001$). Compared with participants who never used digital devices for health monitoring, higher eHEALS scores were observed across several frequency categories. Higher educational attainment was also independently associated with eHEALS scores. The model explained 70.2% of the variance in eHEALS scores ($R^2 = 0.702$; adjusted $R^2 = 0.682$) (Table 4).

Table 4. Multivariable linear regression model of factors associated with eHealth Literacy Scale (eHEALS) scores among adults aged ≥45 years (Complete case n = 384)

Predictor	Comparison	B	Robust SE	95% CI	p-value
Age, years	Per 1-year increase	-0.03	0.04	-0.11 to 0.05	0.439
Sex	Male vs female	0.61	0.77	-0.90 to 2.13	0.428
Smartphone ownership	Yes vs no	7.11	0.90	5.35 to 8.86	<0.001



Occupation	Unemployed vs retired	1.59	1.73	-1.80 to 4.97	0.358
	Employed vs retired	1.23	1.57	-1.84 to 4.30	0.433
	Homemaker vs retired	2.13	1.53	-0.86 to 5.12	0.163
Family size	Per additional member	-0.03	0.20	-0.43 to 0.36	0.868
Disease count	Per additional morbidity	-0.20	0.32	-0.82 to 0.42	0.531
Laptop ownership	Yes vs no	0.44	1.43	-2.36 to 3.25	0.757
Tablet/iPad ownership	Yes vs no	-0.46	1.66	-3.71 to 2.78	0.780
Computer ownership	Yes vs no	-1.95	1.63	-5.13 to 1.24	0.231
Computer use in past month	Yes vs no	0.61	1.31	-1.95 to 3.17	0.641
Internet access at home	Yes vs no	0.02	0.69	-1.34 to 1.38	0.973
Confidence using internet	Yes vs no	3.88	1.00	1.92 to 5.84	<0.001
Digital-device use	Rarely vs never	3.91	1.58	0.80 to 7.01	0.014
	Monthly vs never	6.13	1.08	4.02 to 8.25	<0.001
	Weekly vs never	6.55	1.94	2.74 to 10.35	<0.001
	Daily vs never	4.16	1.66	0.90 to 7.42	0.012
Education	Primary vs illiterate	-0.20	0.90	-1.97 to 1.57	0.824
	Middle vs illiterate	-0.73	1.02	-2.74 to 1.27	0.475
	Secondary vs illiterate	1.78	1.04	-0.25 to 3.82	0.086
	Higher secondary vs illiterate	3.61	1.32	1.02 to 6.20	0.006
	Diploma/graduation vs illiterate	5.33	1.53	2.34 to 8.33	<0.001
Area of residence	Urban vs rural	0.41	0.77	-1.10 to 1.93	0.592

B, unstandardized regression coefficient; CI, confidence interval; SE, standard error. Robust standard errors were calculated using the HC3 estimator. Reference categories are indicated in the comparison column. Model $R^2 = 0.702$; adjusted $R^2 = 0.682$

Discussion

This study identified a marked separation between access to digital technology and health-directed digital use among adults aged ≥ 45 years in Udupi Taluk. Although smartphones and home internet access were relatively common, health-information seeking and digital healthcare activities were substantially less frequent. The principal local challenge therefore appears to extend beyond connectivity to the conversion of access into confident, purposeful, and critical health use.

The mean eHEALS score was 18.9 ± 9.63 , while the item-level response distribution showed substantial disagreement with statements concerning several eHealth-literacy competencies, particularly evaluation of online health resources and discrimination between high- and low-quality information. Item-level responses reinforce this interpretation: more than 60% disagreed or strongly disagreed that they had the skills to evaluate online health resources or distinguish high-quality from low-quality resources. This is notable in a setting known for relatively high general literacy. General literacy may support reading and comprehension, but eHealth literacy additionally requires search skills, platform familiarity, appraisal of source credibility, and confidence in applying digital information. Recent evidence from coastal

Karnataka similarly found that comparatively favourable health-literacy profiles do not necessarily correspond to uniformly high eHealth literacy (9). A 2025 global meta-analysis also identified internet use, education, perceived usefulness, and self-efficacy as important correlates of eHealth literacy (8).

Smartphone ownership remained strongly associated with eHEALS scores after adjustment for sociodemographic, educational, access-related, and digital-use characteristics. Confidence in internet use and frequency of digital-device use were also independently associated with higher eHEALS scores, suggesting that access alone may be insufficient without the confidence and experience required to use digital technologies effectively for health-related purposes. The pattern is consistent with evidence from Assam, where digital literacy contributed substantially to rural–urban differences in e-health utilisation among older adults (9), and with broader evidence identifying internet use and self-efficacy as important correlates of eHealth literacy (8). In Udupi Taluk, familiar communication platforms may provide an entry point for health communication, but local programmes should not assume that routine WhatsApp or YouTube use automatically confers the ability to judge health-information quality.

Education demonstrated a pronounced graded relationship with eHEALS scores in the bivariate analysis and remained relevant after multivariable adjustment. Compared with participants who were illiterate, those with higher-secondary and diploma/graduation education had independently higher eHEALS scores. This finding supports that technological access operates alongside foundational educational competencies required to navigate, understand, and critically appraise digital health information.

Among participants who accessed online health information, 63.7% reported that they did not verify it. This finding is particularly important because health misinformation is widely represented across social-media platforms, making the ability to evaluate source credibility an essential component of meaningful digital health literacy (12). This finding is especially relevant because item-level eHEALS responses also showed limited confidence in evaluating health resources and distinguishing high- from low-quality information. In the local context, health information may be encountered incidentally through messaging and video platforms that are already familiar for social communication, rather than through deliberate searches of clinical or government sources. Consequently, interventions should pair basic digital

navigation with practical source-checking skills, such as comparing information across credible sources and discussing uncertain information with healthcare professionals.

AI-related findings also require interpretation beyond awareness alone. Only 23.9% had heard of AI in healthcare and 9.9% had used an AI-based application for a health-related purpose. Among those aware of AI, almost half were neutral about trusting AI-generated health information. This pattern may reflect unfamiliarity, uncertainty about accuracy, limited perceived usefulness, low digital self-efficacy, language and interface barriers, or preference for established interpersonal sources of health advice. These mechanisms were not directly measured and therefore cannot be confirmed by the present study. Nevertheless, the Technology Acceptance Model and recent eHealth-literacy evidence identify perceived usefulness and self-efficacy as relevant determinants of digital engagement (8), providing a plausible framework for future qualitative or mixed-methods research on AI acceptance in this population.

The observed disconnect between access to digital devices and their health-directed use is consistent with Indian evidence indicating that ICT availability and routine technology use do not necessarily translate into adequate digital health literacy or purposeful digital health engagement (13). This suggests that local inequities may operate through access, experience, and confidence rather than demographic characteristics in isolation. Similar Indian evidence shows that digital literacy, education, income, and place of residence can structure e-health utilisation (9). Locally realistic responses could therefore include brief assisted digital-health sessions linked to community clinics, Kannada-language demonstrations, family-supported digital navigation where desired by participants, and source-verification prompts delivered through familiar platforms.

Study Limitations and Strengths: Strengths include use of the established eHEALS instrument with permission from the copyright holders, Kannada translation and pilot testing, inclusion of adults across middle and later life, assessment of both access and health-directed digital behaviours, and multivariable analysis. Several limitations should be acknowledged. The cross-sectional design precludes causal inference. Purposive sampling outside community clinics in Udupi Taluk limits generalisability beyond the sampled communities and may over-represent people who are sufficiently mobile or engaged to attend these settings. Self-

reported measures are susceptible to recall and social-desirability bias. In addition, the investigator-developed questionnaire was pilot tested for comprehensibility and feasibility but did not undergo formal psychometric validation; therefore, findings derived from these descriptive items should be interpreted accordingly. eHEALS measures perceived rather than objectively demonstrated competence and was originally developed in an earlier internet environment (6). Interviewer administration for participants unable to complete the questionnaire independently improved inclusion but may have introduced interviewer or response bias. The study did not directly measure psychological constructs such as technology acceptance, perceived usefulness, trust formation, or reasons for non-use, and it did not assess clinical outcomes.

Implications for future research: Future studies should use probability-based or multicentre sampling, include objective performance-based measures alongside eHEALS, and examine how language, family support, trust, perceived usefulness, and digital self-efficacy influence health-directed technology use. Qualitative or mixed-methods research would be particularly useful for explaining why high general literacy and device ownership coexist with limited online health-information use and for understanding acceptance of AI-enabled health tools. Intervention studies should test locally adapted digital-literacy approaches rather than infer effectiveness from the present cross-sectional associations. Recent meta-analytic evidence indicates that tailored eHealth-literacy interventions can improve measured eHealth literacy, but their effectiveness and feasibility require local evaluation (14).

For Udupi Taluk, feasible approaches for future evaluation include digital-navigation sessions linked to community clinics, short modules on identifying credible health sources, assisted use of government or provider portals, and training that uses familiar smartphone applications as a bridge to health-specific tasks. Such strategies should be co-designed with adults across the study age groups and evaluated for usability, uptake, eHealth-literacy outcomes, and unintended exclusion of people with limited access or confidence.

Conclusion

Digital health literacy among adults aged ≥ 45 years in Udupi Taluk was associated with smartphone ownership, internet-use confidence, frequency of digital-device use, and higher educational attainment. Despite relatively common digital access, health-related digital use and verification of online health information were limited. Interventions should therefore

prioritize practical digital-health skills, confidence, and critical appraisal of online health information rather than access alone.

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Conflicts of interest: The authors declare that there is no conflict of interest in this article.

Consent for publication: Not applicable.

Ethics Approval and Consent to Participate: This study received ethical approval from the Ethics Committee of Kasturba Medical College (IEC2–625/2024). The study was conducted in accordance with the principles of the Declaration of Helsinki. Participants completed the questionnaires anonymously and were assured of the confidentiality of their responses.

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