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REVIEW

Exploring acceptability of AI-enabled voice assistants and digital AI humans in healthcare: a cross-sectional survey

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Abstract

Artificial intelligence, including Digital AI Humans (DHs) and Voice Assistants (VAs), offers new opportunities for healthcare delivery but may widen inequalities. This cross-sectional online survey examined factors influencing the acceptability of these technologies among 472 UK adults, considering demographics, digital literacy, healthcare access, familiarity with DHs and VAs, personality traits, and attitudes.

VA acceptability was assessed using logistic regression, with willingness to use VAs as the outcome variable. Lower acceptance was found among women, ethnic minorities, those with lower education levels, and individuals who infrequently searched for health information online. Conversely, higher acceptance was associated with engagement in online health discussions, greater awareness and use of VAs, perceived usefulness, fewer perceived barriers, and openness. DH acceptability was analysed through multiple regression, with attitudes toward DHs as the outcome variable. More positive attitudes were linked to White/Irish/European ethnicity, a greater perceived need for in-person care, participation in online health discussions, higher conscientiousness, and lower neuroticism, explaining 27.8% of the variance. Although 85.8% had used VAs and 82.2% owned one, only 25.8% reported daily use. Awareness of DHs was reported by 70.3% of participants, with attitudes generally positive (median score: 2.17/5, where lower scores indicate greater favourability). Institutional endorsement was a key factor, with 71.2% stating they would use VAs for healthcare if approved by the NHS. These findings support technology acceptance models, highlighting the roles of perceived usefulness, ease of use, and awareness. Culturally responsive design principles that address these factors may enhance adoption across diverse groups. Distinct personality traits influenced acceptance, with openness predicting VA acceptability, while conscientiousness and low neuroticism were associated with more positive attitudes toward DHs. While offering novel insights into human factors influencing AI adoption in healthcare, the study is limited by its reliance on proxy measures for acceptance.

Keywords Artificial intelligence · Acceptability · Digital health · Personality traits · Digital AI humans · Voice assistants

1 Introduction

Over the past 100 years, advances in medicine, such as the discovery of penicillin in 1928, have revolutionised healthcare. With the advent of newer technologies like artificial intelligence (AI), the potential for further improving health outcomes continues to grow. AI is defined as an unnatural object or entity that possesses the ability and capacity to meet or exceed the requirements of the task; it is assigned when considering cultural and demographic circumstances (Kelly et al. 2023). In healthcare, AI has the capacity to analyse extensive datasets, uncover intricate patterns, enhance financial management, forecast health outcomes, and support clinical decision-making (Shiwlani et al. 2024). These models can enhance healthcare delivery by streamlining

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patient management and triaging services, ultimately leading to improved patient outcomes (Alowais et al. 2023; Delshad et al. 2021). As a result, these applications are expected to profoundly impact the future of healthcare and how we interact with healthcare providers (Patil & Shankar 2023). Therefore, it is necessary to understand how users of these services are affected by the integration of AI into healthcare systems.

Conversational AI—including Digital AI Humans (DHs) and Voice Assistants (VAs)—utilises natural language processing, generative AI, and machine learning to mimic human conversation (Branting et al. 2004). The application of conversational AI in healthcare has attracted significant attention for its potential benefits, such as cost reduction, mediation of language barriers, and the provision of scalable health services (Ittarat et al. 2023; Luxton 2020; Wutz et al. 2023). Among the various forms of conversational AI, VAs and DHs stand out due to their distinct functionalities and interactions. VAs primarily focus on executing tasks and providing information via voice commands (Vogeley & Bente 2010), while DHs are designed to closely mimic human appearance and behaviour, offering more nuanced and engaging interactions than traditional text-based chatbots (Rzepka et al. 2022). Research by Cho (2019) has shown that VAs elicit more positive evaluations than chatbots in less sensitive conversations, primarily due to their enhanced social presence, which suggests that these improvements could be essential in the context of healthcare interactions.

In healthcare, VAs are often employed to facilitate self-management and promote healthy lifestyle behaviours through feedback and monitoring, shaping knowledge and self-beliefs, repetition and substitution, and goal-setting (Sezgin et al. 2020). DHs are regarded as a potential advancement over both chatbots and VAs, as the increased anthropomorphic experience has been shown to enhance users' willingness to follow recommendations (Abdi et al. 2022). In this context, anthropomorphism refers to the attribution of distinctively human-like feelings, mental states, and behavioural characteristics to AI (Salles et al. 2020). Research highlights those anthropomorphic features, such as human-like voices, behaviours, and personalities, significantly enhance perceived empathy and trust and are critical factors for user engagement and satisfaction with conversational AI systems (W. Li et al. 2024). However, excessive anthropomorphic traits may evoke discomfort due to the Uncanny Valley effect, as evidenced in both theoretical and empirical studies (Mori 1970; Kelly et al. 2023). For example, Thaler et al. (2020) further found that the more human-like an DH was perceived, the greater the feelings of eeriness elicited, demonstrating the delicate balance required in designing anthropomorphic systems. Seymour et al. (2021) provide further evidence of this balance, demonstrating that participants rated a 3D DH as more trustworthy than a 2D DH during a live discussion. This finding suggests that moderately human-like features can effectively build trust, provided they remain within an acceptable threshold of anthropomorphism for users. Therefore, balancing these features is an important consideration when designing these technologies.

DHs and VAs have been implemented in healthcare areas such as mental health support (Pauw et al. 2022; Philip et al. 2017), health advice (J. Kim et al. 2023; Nallam et al. 2020), and long-term health self-management (Baptista et al. 2020; Sezgin et al. 2020). For example, Jones et al. (2021) assessed the role of VAs in reducing loneliness among ageing adults and found a significant reduction in loneliness after 4 weeks due to anthropomorphic interactions, such as relational greetings. Additionally, a meta-analysis by Chattopadhyay et al. (2020) found that DH interventions were significantly more effective than traditional patient-facing systems that did not incorporate conversational AIs. Despite the advantages presented by DHs and VAs, there remains limited implementation and adoption of these technologies in healthcare, with much of the research focusing on assessing feasibility (Laumer et al. 2019; Wutz et al. 2023). Adoption is typically evaluated using the proxy measure of acceptability, which encompasses a multitude of factors influencing a person's willingness to use a technology (Laumer et al. 2019; Miles et al. 2021). Thus, understanding the factors that contribute to the acceptability of DHs and VAs is essential for facilitating their broader integration into healthcare settings.

Research into conversational AIs in healthcare has identified numerous factors influencing acceptability, which are well-tested and outlined in the Technology Acceptance Model (TAM; Davis 1989) and the Unified Theory of Acceptance and Use of Technology (UTAUT; Venkatesh et al. 2003, 2012). TAM posits that two primary constructs—perceived usefulness (the degree to which a user believes that using the technology will enhance their performance) and perceived ease of use (the degree to which a user believes that using the technology will be free of effort)—significantly determine technology acceptance. UTAUT expands upon this by incorporating additional factors such as performance expectancy, effort expectancy, social influence, and facilitating conditions. A recent systematic review by Wutz et al. (2023) reinforces these theories by summarising factors that affect the acceptability of AI technologies in healthcare. The review identifies key constructs from UTAUT, including performance expectancy, effort expectancy, and social influence, while also highlighting additional factors like perceived risk and trust that are critical for understanding user engagement with conversational agents. Overall, this demonstrates that the acceptability of conversational AI in healthcare is a multi-faceted construct that is

influenced by numerous technical and broader individual and social factors.

Research into the acceptance of DHs and VAs in healthcare is not as extensive as that of conversational AIs, with much of the literature focusing on how the technical functionality of DHs and VAs influences acceptability. However, preliminary research has found both DHs and VAs to be acceptable modes of healthcare delivery, with factors such as ease of use, anonymity, and personability as influential at increasing their acceptability (Balaji et al. 2022; Baptista et al. 2020)—which complements factors identified in conversational AIs research (Nadarzynski et al. 2019). Notably, Wutz et al. (2023) identified anthropomorphism as a factor that increases acceptance of conversational AIs. It is plausible that the greater anthropomorphic experience provided by DHs and VAs contributes to their acceptance.

Acceptance is a useful construct to investigate, as it typically precedes the adoption of a technology. Research by J. Kim et al. (2023) supports this notion, finding that determinants of acceptability, such as perceived ease of communication and usefulness, positively predict favourable attitudes towards DHs and lead to strong intentions to adopt the technology. By understanding the factors that influence acceptability, healthcare providers and policymakers can anticipate and mitigate variables that affect the adoption and engagement of DHs and VAs in healthcare. This has significant implications, as non-acceptance and non-adoption of technology among certain groups can exacerbate healthcare inequalities. This is demonstrated in research by Litchfield et al. (2021), which found that the elderly and ethnic minorities struggled to adopt digital technology during the COVID-19 pandemic. This is significant because these groups have been found to have higher rates of chronic diseases, poorer health outcomes, and premature mortality due to reduced healthcare access compared to those who adopt and utilise technology (Song et al. 2021). Research should be undertaken to understand the reasons behind the non-acceptance of these technologies within these demographics to shape interventions that increase their adoption. In the context of AI, demographic factors such as age, gender, origin, and level of education have been shown to influence the acceptability of conversational AIs (Wutz et al. 2023); however, there is limited understanding of which specific demographic factors influence acceptance of DHs and VAs—this warrants further exploration.

Another notable factor influencing conversational AI acceptability is trust. In the context of VAs, trust has been found to play a critical role in how individuals accept the information conveyed by these technologies (Wienrich et al. 2021). Trust is a complex construct influenced by a multitude of factors, including the perceived reliability of the AI system, the transparency of its functioning, and the user's previous experiences with technology (Glikson & Woolley 2020). Research into AI has shown that trust can be shaped by both the capability of the AI itself and the AI literacy of the user (Jacovi et al. 2021; Long & Magerko 2020). Specifically, users need to feel confident in the responses provided by AI systems; this confidence relates to their trust in both the technology and its provider (Wutz et al. 2023). Furthermore, studies have indicated that individuals who are more adept at using AI technologies are better able to critically evaluate AI outputs, leading to more effective collaboration with these systems (Long & Magerko 2020).

Recent research by Beretta (2024) has also demonstrated that incorrect responses generated by AI can significantly diminish trust, highlighting the importance of accuracy in AI interactions. These findings suggest that to foster widespread adoption of DHs and VAs, it is essential to not only ensure the systems provide accurate information but also to enhance user understanding of how to effectively engage with AI. While trust has been identified as a crucial factor in the acceptance of conversational AIs, there is limited research specifically examining how trust influences the acceptance of DHs and VAs in healthcare contexts. Exploring this relationship is vital, as understanding how trust impacts user perceptions could inform the design and implementation of more effective AI-driven healthcare solutions.

Given the significant gaps in DHs and VAs research outlined above, the current study aims to explore participants' demographic, behavioural, and psychological factors that influence the acceptability of using DHs and VAs in healthcare. Through the analysis of previous literature, it is hypothesised that the acceptability of VAs in healthcare will be significantly associated with participants' ethnicity, gender, education, general digital literacy, and overall awareness of VAs (Wutz et al. 2023; Schiavo et al. 2024). It is also hypothesised that participants' personality traits will have an impact on the attitudes they hold towards the use of VAs in healthcare (Sharan & Romano 2020). The acceptability of DHs in healthcare is expected to have a similar correlation with the variables associated with the acceptability of VAs. Arguably, as DHs are more anthropomorphic than VAs, it might be assumed that DHs would elicit greater acceptance than VAs; however, as the use of VAs is more prominent, it is expected DHs to have a weaker acceptance than VAs as a result of familiarity bias.

2 Methods

2.1 Design

This study utilised an exploratory cross-sectional online survey to investigate how demographic, behavioural, and psychological factors influence the acceptability of DHs

and VAs in healthcare. The survey was anonymous and took 10 min to complete.

2.2 Participants and recruitment

A total of 472 Participants over the age of 18, residing in the UK, and having good English literacy were recruited. The inclusion criteria required participants to be UK residents with adequate English literacy, while those under 18 or living outside the UK were excluded. An opportunity sampling method was used, leveraging the University of Westminster's student portal, research participation schemes, and targeted social media outreach via Facebook, Instagram, and WhatsApp. Specific UK-based Facebook groups, such as London Students and Psychology UK, were used to maximise reach.

To further extend recruitment, a snowball sampling approach was employed, encouraging participants to share the study within their networks. A dedicated Facebook page was created to promote the study through posts containing study details and an anonymous survey link. The University of Westminster's research participation scheme also facilitated recruitment by offering student credits, which could be accumulated for their own research participation needs. Additionally, a £75 prize draw was introduced as an incentive to encourage participation.

2.3 Survey measures

The survey comprised 96 items designed to assess demographic characteristics, digital literacy, healthcare engagement, awareness and attitudes toward VAs and DHs, and personality traits.

The survey began with demographic questions covering age, gender identity (male, female, non-binary), ethnicity, and highest level of education. General digital literacy was assessed through a question on daily internet usage, offering six frequency options from "less than one hour" to "over 12 h."

Participant behaviour was evaluated across three key areas: healthcare access, awareness of VAs, and awareness of DHs. The Healthcare Access section included four questions. Two items assessed the frequency of in-person doctor visits and health-related online searches over the past year, with response options ranging from "0 times" to "9 + times." Additional questions gauged the perceived importance of face-to-face consultations with healthcare professionals (five-point scale from "very important" to "not important") and prior engagement in online health discussions, with response options of "yes," "no," or "unsure." Awareness of VAs was measured through five questions assessing previous use, current ownership, likelihood of use if endorsed by the NHS (response options: "yes," "no," or "unsure"), frequency of use (from "never" to "every day"), and willingness to use VAs for healthcare (ranging from "definitely won't" to "definitely will"). Awareness of DHs was assessed with a single yes/no question.

Personality was measured using the Big Five Personality Inventory (BFI; John et al. 1991, 2008), a 44-item scale that evaluates extraversion, agreeableness, conscientiousness, neuroticism, and openness. The BFI was chosen for its high internal consistency and reliability (Arterberry et al. 2014), making it a robust measure of participants' personality traits.

To examine motivations and hesitations regarding VAs in healthcare, two custom questionnaires on Perceived Usefulness and Perceived Barriers were developed based on prior work (Nadarzynski et al. 2019; Sohn & Kwon 2020). Each questionnaire comprised 12 items rated on a five-point Likert scale. For instance, the Perceived Usefulness of VAs questionnaire included items like "to book medical appointments," with responses from "1—helpful" to "5—unhelpful," where lower scores indicated higher perceived usefulness. The Perceived Barriers questionnaire included items such as "my personal health data are safe when I use virtual assistants," with responses from "1—strongly agree" to "5—strongly disagree"; lower scores reflected fewer perceived barriers and, consequently, more positive attitudes toward VA use in healthcare. Both questionnaires demonstrated high internal consistency ($\alpha = 0.90$ for perceived usefulness; $\alpha = 0.79$ for perceived barriers).

Attitudes towards DHs in healthcare were measured using a separate 12-item Likert scale questionnaire. Items were positively framed, such as "An Digital AI Human could help me manage my health," with responses ranging from "1—strongly agree" to "5—strongly disagree." Lower scores indicated more positive attitudes toward DHs, and this scale also exhibited strong internal consistency ($\alpha = 0.88$).

2.4 Procedure

Ethical approval for the study was obtained from the University of Westminster College Ethics Committee. Participants accessed the survey via Qualtrics, starting with an information sheet and consent form that outlined the study's aim, eligibility criteria, ethical guidelines, and provided contact information for the research supervisor and principal investigator. Completion of the consent form confirmed participants' UK residency, age eligibility (over 18), and understanding of their right to withdraw at any time. Following consent, participants first provided demographic information before proceeding through the remaining survey sections, which covered behavioural factors, personality traits, and attitudes toward healthcare-related VAs and DHs. After completing the survey, participants received a debrief form, including a link to enter a £75 prize draw as a token

of appreciation for their time. Contact details were provided for any further inquiries.

2.5 Data analysis

This study focused on two primary outcomes: the acceptability of DHs and VAs in healthcare. To assess these outcomes, we employed two distinct statistical models: logistic regression for evaluating VA acceptability, where participants' willingness to use VAs served as the binary outcome variable, and multiple linear regression for examining DH acceptability, with participants' attitudes toward DHs as the continuous outcome variable. This approach allowed us to identify significant predictors influencing acceptability across demographic, behavioural, and psychological factors, providing a comprehensive understanding of the elements that shape users' willingness to engage with these technologies in healthcare settings. All data were analysed using SPSS.

For VA acceptability, participants' willingness to use VAs was categorised into "will use" and "will not use," allowing for logistic regression analysis as per the guidelines of Menard (2002). This approach adhered to reporting standards recommended by Peng et al. (2002). Predictor variables were dichotomised for clarity and ease of interpretation. Crosstabulations between these predictors and VA acceptability were first conducted to examine the frequency of willingness to use VAs within each category. Binary logistic regression was then performed to calculate odds ratios and 95% confidence intervals for each predictor, identifying significant associations with VA acceptability. Key predictors were subsequently adjusted within the model to refine the analysis, focusing on demographics, healthcare access, and VA awareness.

The second model examined DH acceptability in healthcare, using multiple linear regression to identify significant predictors of participants' attitudes toward DHs. Crosstabulations provided mean scores across categories, offering initial insights. The model included all relevant predictor variables (excluding VA-specific variables such as VA awareness, perceived usefulness of VAs, and perceived barriers to VAs) to predict attitudes toward DHs. The model's explanatory power was assessed through variance analysis, and both unstandardised (B) and standardised (β) beta coefficients were calculated to interpret the strength and direction of associations.

3 Results

A total of 472 participants completed the survey. The sample had a median age of 28 years (M = 29.69, SD = 8.22), with a slight majority being male (52.5% male, 47.2% female, 0.2% non-binary). Most participants identified as White/Irish/European/White Other (73.5%), 61% held a university degree or higher, and 42.2% reported spending 5–8 h online daily. Regarding healthcare engagement, 40.5% visited a doctor in person one to two times per year, and 37.1% conducted three to five health-related online searches annually. While 85.8% had used a VA and 82.2% owned one, only 25.8% used their VA daily. About 70.3% of participants were aware of DHs, expressing generally positive attitudes (median = 2.17; M = 2.19, SD = 0.69). Participants showed a high likelihood of using VAs for healthcare if endorsed by the NHS (71.2%), with positive perceptions of VA usefulness (median = 1.83; M = 1.91, SD = 0.71), despite recognising certain barriers (median = 2.79; M = 2.80, SD = 0.65). Personality traits scored closely, with agreeableness highest and neuroticism lowest. The mean scores for extraversion, agreeableness, conscientiousness, neuroticism, and openness were 3.28 (SD = 0.54), 3.55 (SD = 0.53), 3.42 (SD = 0.59), 2.96 (SD = 0.59), and 3.52 (SD = 0.57), respectively (Table 1).

3.1 Acceptability of voice assistants

Participants' willingness to use VAs in healthcare showed that 42.6% were likely ("probably will") to use VAs, and an additional 16.1% expressed a definite intent ("definitely will"). In contrast, 12.3% were firmly opposed ("definitely won't"), and 29% were unlikely ("probably won't") to use VAs for healthcare.

Logistic regression analysis identified significant demographic factors affecting VA acceptance, including gender, ethnicity, and education level. Women (OR = 0.68, 95% CI = 0.47–0.98), ethnic minorities (OR = 0.43, 95% CI = 0.28–0.65), and those with no formal qualifications or only O-levels (OR = 0.28, 95% CI = 0.16–0.52) showed significantly lower willingness to use VAs ($p < 0.01$). Infrequent online health-related searches ("twice or less") were negatively correlated with VA usage willingness (OR = 0.39, 95% CI = 0.24–0.63), whereas prior discussions with health professionals online increased willingness (OR = 3.39, 95% CI = 2.25–5.097).

VA awareness strongly correlated with willingness to use VAs in healthcare. Factors such as prior VA use (OR = 3.22, CI = 1.87–5.54), current VA ownership (OR = 3.25, CI = 1.18–8.97), and frequent VA use (OR = 0.15, CI = 0.084–0.28) positively influenced willingness. Endorsement by the NHS markedly increased willingness to use VAs (OR = 6.04, CI = 3.89–9.38). However, after including all four VA awareness variables in a binary logistic regression model, "previous use of VA" and "current VA ownership" were omitted.

Participants who were willing to use VAs scored lower on perceived usefulness of VAs (M = 1.69, SD = 0.61) than those not willing (M = 2.22, SD = 0.73). Binary logistic

Table 1 Variable characteristics—demographics, descriptives, and frequencies

Variable	N	(%) or [mean, SD]	Variable	N	(%) or [mean, SD]
Demographic variables			Not important	9	(1.9)
Age	471	[29.59, 8.22]	Discussed health online		
Gender			Yes	328	(69.5)
Female	223	(47.2)	Not Sure	36	(7.6)
Male	248	(52.5)	No	108	(22.9)
Non-Binary	1	(<1)	*Awareness of voice assistants*		
Ethnicity			Previous use of VA		
Black/Caribbean/African	44	(9.3)	Yes	405	(85.8)
White/Irish/European/white other	347	(73.5)	Not sure	27	(5.7)
Asian/Asian British/Indian	45	(9.5)	No	40	(8.5)
Mixed/Multiple Ethnicities	14	(3)	Currently own a VA device		
Other/Arab/Latin American	21	(4.4)	Yes	388	(82.2)
Prefer not to say	1	(<1)	No	13	(2.8)
Education			Unsure	4	(<1)
No qualifications	17	(3.6)	Frequency use of VA		
O Levels/GCSE	41	(8.7)	Never	27	(5.7)
A Levels	117	(24.8)	Once a month	88	(18.6)
University degree	288	(61)	Once a week	71	(15)
Other	9	(1.9)	Every other day	80	(16.9)
General digital literacy			Everyday	122	(25.8)
Time on Internet (hrs)			Willing to use VA for health		
<1	7	(1.5)	Definitely won't	58	(12.3)
1–2	63	(13.3)	Probably won't	137	(29)
3–4	125	(26.5)	Probably will	201	(42.6)
5–8	199	(42.2)	Definitely will	76	(16.1)
9–12	63	(13.3)	Use of VA if endorsed by NHS		
12+	15	(3.2)	Yes	336	(71.2)
Access to healthcare variables			Maybe	113	(23.9)
Physical visits to doctor			No	23	(23)
0 times	77	(16.3)	*Attitudes towards voice assistants*		
1–2 times	191	(40.5)	Perceived Usefulness of VA	472	[1.91, .71]
3–5 times	146	(30.9)	Perceived Barriers of VA	472	[2.80, .65]
6–8 times	52	(11)	*Digital AI Humans*		
9+ times	6	(1.3)	Awareness of Digital AI Humans		
Health-related searches			Yes	332	(70.3)
0 times	10	(2.1)	No	42	(8.9)
1–2 times	118	(25)	Attitudes towards DH Questionnaire	458	[2.19, .69]
3–5 times	175	(37.1)	*Personality traits*		
6–8 times	81	(17.2)	Extraversion	463	[3.28, .54]
9+ times	88	(18.6)	Agreeableness	463	[3.55, .53]
Importance of talking face-to-face with doctors			Conscientiousness	463	[3.42, .59]
Very important	191	(40.5)	Neuroticism	463	[2.96, .59]
Important	175	(37.1)	Openness	463	[3.52, .57]
Moderately important	70	(14.8)			
Slightly important	27	(5.7)			

Physical visits to doctor and health-related online searches both within last 12-months; 'Currently own a device' was only displayed to participants who answered, 'Yes' to 'Previous use of VA', and 'Frequency use of VA' only displayed to participants who answered 'Yes' to 'Currently own a VA device'; VA—Voice assistance; DH—Digital AI Human

regression showed that lower perceived usefulness scores were associated with greater willingness to use VAs (OR = 0.33, CI = 0.24–0.44). Similarly, lower perceived barriers were linked to VA willingness (M = 2.54, SD = 0.58), with fewer perceived barriers increasing willingness to use VAs (OR = 0.12, CI = 0.073–0.19). Both perceived usefulness and perceived barriers remained significant after adjusting the model (Table 2).

Higher levels of extraversion (OR = 2.11, CI = 1.46–3.04), agreeableness (OR = 1.87, CI = 1.30–2.70), conscientiousness (OR = 1.78, CI = 1.28–2.48), and openness (OR = 2.32, CI = 1.63–3.30) were associated with increased willingness to use VAs, while higher neuroticism (OR = 0.70, CI = 0.51–0.96) was associated with less willingness. However, when all personality traits were entered into an adjusted model, only openness showed a significant association with VA willingness (OR = 1.75, CI = 1.15–2.65) (Table 3).

3.2 Acceptability of digital AI humans

Attitudes toward using DHs in healthcare showed a median score of 2.17 (M = 2.19, SD = 0.69). Multiple regression analysis explored the relationship between demographics, digital literacy, DH awareness, and personality traits with attitudes toward DHs. The final model, which incorporated all predictors, explained 27.8% of the variance in attitudes toward DHs ($F(15, 338) = 10.07$, $p < 0.001$).

Significant predictors within this model included ethnicity ($\beta = -0.096$, $t = -1.97$, $p = 0.049$), the perceived importance of face-to-face doctor interactions ($\beta = 0.21$, $t = 4.40$, $p < 0.001$), and online health discussion behaviours ($\beta = 0.14$, $t = 2.85$, $p = 0.005$). Personality traits also played a significant role: high conscientiousness ($\beta = -0.21$, $t = -3.22$, $p = 0.001$) and low neuroticism ($\beta = 0.15$, $t = 2.70$, $p = 0.007$) predicted more positive attitudes toward DHs (Table 4).

4 Discussion

This study examined the demographic, behavioural, and psychological factors influencing the acceptance of DHs and VAs in healthcare, revealing unique predictors for each technology. For VAs, lower acceptability was associated with being female, identifying as part of an ethnic minority group, having lower educational attainment, and infrequent online health searches. These findings suggest that certain demographic groups may perceive VAs as less accessible or beneficial, which aligns with existing literature highlighting differences in technology acceptance based on demographic characteristics. In contrast, higher VA acceptability was linked to engagement in online health discussions—particularly when endorsed by the NHS—more frequent VA use, perceived usefulness, fewer perceived barriers, and higher openness. These results highlight the significant role of prior exposure and institutional endorsement in promoting VA acceptance, consistent with the principles of the TAM. For DHs, positive attitudes were significantly associated with identifying as White/Irish/European, valuing face-to-face interactions with healthcare providers, engaging in online health discussions, and exhibiting personality traits such as high conscientiousness and low neuroticism. These findings indicate that personality traits and cultural backgrounds may shape perceptions of DHs differently from VAs, reflecting varying comfort levels with AI-driven interactions that simulate human engagement. The study's results contribute to the growing body of evidence indicating that DHs and VAs can be acceptable technologies in healthcare (Bérubé et al. 2021; Burbach et al. 2019; Philip et al. 2017; Zhong & Ma 2022). Moreover, the findings align with previous research on conversational AIs, identifying consistent factors such as gender, ethnicity, education level, and digital literacy that influence acceptability (Wutz et al. 2023).

Identifying as White/Irish/European emerged as a significant predictor of willingness to use both DHs and VAs. This observation supports previous research by Apergi et al. (2021), which found that Black patients demonstrated lower engagement with DHs and VAs for heart failure self-management compared to their White counterparts. Additionally, Cooks et al. (2022) highlighted that the appearance of DHs significantly influences their acceptability, particularly among Black patients. Specifically, Black adults with a strong sense of rural belonging rated virtual healthcare characters (VHCs) as more attractive when they matched their ethnic backgrounds. These findings suggest that attributes such as ethnicity and visual representation in DHs can enhance trustworthiness and engagement, indicating that careful consideration of appearance is crucial in the design of DHs and VAs. Supporting this notion, J. Li and Kim (2024) found that features such as character settings, cultural cues, dynamic design, visual imagery, and voice interaction all influence the social acceptance of VAs. This highlights the importance of integrating culturally diverse design principles in the development of DHs and VAs to ensure the technology is inclusive and appealing to a broader demographic, thereby increasing overall acceptability.

A key difference between DHs and VAs was the perceived importance of face-to-face interactions with healthcare providers. The ability to engage in face-to-face dialogue significantly influenced the acceptability of DHs but not VAs. These differences may stem from the more anthropomorphic interactions that DHs provide, which mimic the experience of face-to-face conversations (K. Kim et al. 2018). Research by Brinkel et al. (2017) supports this by highlighting participants' concerns about

Table 2 Factors associated with willingness to use VA in healthcare

Variable	N (%)	N (%) of willing to use VA	Unadjusted OR [95% CI]	Adjusted OR [95% CI]
Demographic variables				
Age				
< 25	175 (37.2)	86 (49.1)	0.63 [0.37–1.067]	
26–35	210 (44.6)	138 (65.7)	1.25 [0.75–2.10]	
36 +	86 (18.3)	52 (60.5)	Ref	
Gender				
Female	223 (47.3)	120 (53.8)	**0.68 [0.47–0.98]** *	**0.58 [0.39–0.86]** **
Male	248 (52.7)	157 (63.3)	Ref	Ref
Ethnicity				
Ethnic minority	124 (26.3)	54 (43.5)	**0.43 [0.28–0.65]** **	**0.45 [0.29–0.70]** **
White/Irish/European/white other	347 (73.7)	223 (64.3)	Ref	Ref
Education				
No qualifications or O level	58 (12.5)	19 (32.8)	**0.28 [0.16–0.52]** **	**0.37 [0.18–0.63]** **
A-Levels	117 (25.3)	72 (61.5)	0.93 [0.60–1.45]	1.041 [0.66–1.64]
Uni-Degree	288 (62.2)	182 (63.2)	Ref	Ref
General digital literacy				
Time spent on internet (hrs/day)				
1–4	188 (40.4)	106 (56.4)	1.052 [0.62–1.79]	
5–8	199 (42.8)	125 (62.8)	1.38 [0.81–2.34]	
9 +	78 (16.8)	43 (55.1)	Ref	
Access to healthcare variables				
Physical visits to doctors (within year)				
twice or less times	268 (56.8)	145 (54.1)	0.62 [0.34–1.12]	
3–5 times	146 (30.9)	94 (64.4)	0.95 [0.50–1.80]	
Over 6 times	58 (12.3)	38 (65.5)	Ref	
Health-related searches (within year)				
Twice or less times	128 (27.1)	58 (45.3)	**0.39 [0.24–0.63]** **	**0.37 [0.23–0.61]** **
3–5 times	175 (37.1)	104 (59.4)	0.69 [0.44–1.070]	0.63 [0.40–1.002]
Over 6 times	169 (35.8)	115 (68)	Ref	Ref
Importance of talking face-to-face with doctors				
Important	366 (77.5)	214 (58.5)	0.96 [0.62–1.49]	
Less or no important	106 (22.5)	63 (59.4)	Ref	
Discussed health online with a doctor/healthcare professional				
Yes	328 (69.5)	222 (67.7)	**3.39 [2.25–5.097]** **	**3.50 [2.30–5.31]** **
No	144 (30.5)	55 (38.2)	Ref	Ref
Awareness of VA				
Previously used VA				
Yes	405 (85.8)	254 (62.7)	**3.22 [1.87–5.54]** **	
No	67 (14.2)	23 (34.3)	Ref	
Currently own a VA device				
Yes	388 (95.8)	248 (63.9)	**3.25 [1.18–8.97]** *	
No	17 (4.2)	6 (35.3)	Ref	
Frequency use of VA				
Rarely/Never	115 (29.6)	47 (40.9)	**0.15 [0.084–0.28]** **	**0.20 [0.11–0.37]** **
Fairly Often	151 (38.9)	101 (66.9)	**0.44 [0.25–0.79]** **	**0.48 [0.27–0.87]** *
Everyday	122 (31.4)	100 (82)	Ref	Ref
Use of VA if endorsed by the NHS				
Yes	336 (71.2)	238 (70.8)	**6.040 [3.89–9.38)** **	**4.93 [2.83–8.60]** **
No	136 (28.8)	39 (28.7)	Ref	Ref

*Significant at $p < 0.05$, **significant at $p < 0.01$; VA—Voice Assistant

Table 3 Psychological correlates of willingness to use VA

Variable	Mean (SD)		Unadjusted OR (95% CI)	Adjusted OR [95% CI]
	Willing to use VA	Not willing to use VA		
Attitudes Towards VA				
Perceived Usefulness of VA (PUVA)	1.69 (0.61)	2.22 (0.73)	**0.33 [0.24–0.44]** **	**0.66 [0.47–0.94]** *
Perceived Barriers of VA (PBVA)	2.54 (0.58)	3.16 (0.57)	**0.12 [0.073–0.19]** **	**0.15 [0.091–0.25]** **
personality traits				
Extraversion	3.37 (0.52)	3.16 (0.55)	**2.11 [1.46–3.040]** **	1.42 [0.92–2.18]
Agreeableness	3.63 (0.48)	3.46 (0.57)	**1.87 [1.30–2.70]** **	1.31 [0.85–1.99]
Conscientiousness	3.50 (0.63)	3.31 (0.51)	**1.78 [1.28–2.48]** **	1.14 [0.76–1.71]
Neuroticism	2.90 (0.60)	3.028 (0.58)	**0.70 [0.51–0.96]** *	0.90 [0.62–1.31]
Openness	3.63 (0.51)	3.37 (0.61)	**2.32 [1.63–3.30]** **	**1.75 [1.15–2.65]** **

*Significant at $p < 0.05$, **significant at $p < 0.01$; VA—Voice Assistant; PUVA and PBVA both total N = 472. PUVA and PBVA Willing to use VA, N = 277, Not willing to use VA, N = 195. All Personality traits, N = 463. All personality trait variables Willing to use VA, N = 270, Not willing to use VA = 193

losing the doctor–patient interaction, suggesting a preference for more personal engagement in healthcare contexts. The findings of this study indicate that DHs might be more favourably received by individuals who prioritise maintaining direct interactions with healthcare providers.

To our knowledge, this is the first study to specifically examine the relationship between the Big Five personality traits and the acceptance of DHs and VAs in healthcare, addressing a notable gap in the existing literature. Previous research has highlighted that traits such as extraversion, openness, and agreeableness are positively associated with technology acceptance (Keeton 2008). The present study provides moderate support for these findings, revealing that higher levels of openness emerged as a significant predictor of willingness to use VAs within an adjusted model. However, these findings were inconsistent regarding attitudes towards DHs, where participants with higher neuroticism and lower conscientiousness reported less acceptance. These discrepancies may arise from differing outcome measures explored in prior literature. Further investigation is required to fully understand the role of the Big Five personality traits in the acceptance of DHs and VAs in healthcare. Notably, the results suggest that users' psychological factors significantly influence acceptance, offering valuable insights for healthcare providers and policymakers. Understanding these influences may help tailor interventions aimed at enhancing acceptance and engagement with DH and VA technologies, particularly among individuals who may be predisposed to accept or reject these innovations.

According to the TAM (Davis 1989), users' perceived usefulness and ease of use are fundamental constructs in determining technology adoption. The findings from this study support the TAM, as participants expressed greater willingness to use VAs when they perceived higher usefulness and fewer barriers to usage in healthcare. These results are consistent with previous literature, which emphasises that perceived barriers and usefulness are critical determinants of user intentions (Estacio et al. 2019). However, as noted by Arifin (2020), TAM does not adequately address users' awareness of the technology in question. Increased levels of awareness may enhance users' perceived ease of use and usefulness, contributing to higher intentions to adopt these technologies (Mutahar et al. 2018). This is evident in the present findings, where participants who had previously used, currently used, and frequently used VAs exhibited significant positive associations with their willingness to use VAs for healthcare purposes. This highlights the necessity of acknowledging users' levels of awareness when seeking to improve the acceptance of DHs and VAs in healthcare.

4.1 Implications

The findings from this study provide important insights into the factors influencing the acceptance of DHs and VAs in healthcare, with several implications for practice, policy, and theory.

Practically, the results suggest that designing AI technologies to be culturally responsive may enhance their acceptability among diverse user groups. The significant role of demographic factors, such as ethnicity and educational attainment, indicates that developers should consider these variables when creating DHs and VAs. Incorporating features that reflect cultural sensitivity—such as customisable avatars or language options—may improve user engagement and trust in these technologies.

From a policy perspective, the association between NHS endorsement and increased willingness to use VAs suggests that institutional support could play a vital role in promoting technology adoption. Healthcare organisations may wish to implement strategies that include endorsements of

Table 4 Mean digital AI human attitude scores across all predictors alongside multiple linear regression analysis

Variable	Mean Attitudes towards DH (SD)	β	B [95% CI]	p-values
			(Constant) = 2.14 [1.00 to 3.28]	
Demographic variables				
Age		.071	.007 [− .002 to .016]	.14
Gender		.010	.015 [− .122 to .15]	.83
Male	2.16 (.70)			
Female	2.23 (.68)			
Ethnicity		**− .096**	**− .16 [− .32 to− .001]**	**.049***
Ethnic minority	2.36 (.65)			
White/Irish/European/white other	2.13 (.70)			
Education		.029	.029 [− .078 to .14]	.59
No qualifications or O level	2.37 (.61)			
A-Levels	2.25 (.59)			
Uni-Degree	2.13 (.74)			
General digital literacy				
Time spent on internet (hrs/day)		.013	.013 [− .088 to .12]	.80
1–4	2.23 (.65)			
5–8	2.11 (.73)			
9 +	2.25 (.70)			
Access to healthcare variables				
Physical visits to doctors (within year)		− .081	− .082 [− .19 to .023]	.13
Twice or less times	2.22 (.73)			
3 to 5 times	2.22 (.63)			
Over 6 times	2.00 (.67)			
Health-related searches (within year)		− .021	− .020 [− .12 to .077]	.69
Twice or less times	2.23 (.64)			
3 to 5 times	2.31 (.61)			
Over 6 times	2.037 (.78)			
Importance of talking face-to-face with doctors		**.21**	**.44 [.24 to .64]**	**< .001****
Important	2.11 (.68)			
Less or no important	2.48 (.67)			
Discussed health online with a doctor/health professional		**.014**	**.25 [.078 to .43]**	**.005****
Yes		2.064 (.68)		
No		2.49 (.64)		
Awareness of DH				
Heard of DH		.067	.16 [− .060 to .38]	.15
Yes		2.10 (.72)		
No		2.50 (.67)		
Personality traits				
Extraversion		.070	.11 [− .069 to .29]	.23
Agreeableness		− .10	− .14 [− .31 to .025]	.095
Conscientiousness		**− .21**	**− .26 [− .42 to − .10]**	**.001****
Neuroticism		**.15**	**.20 [.055 to .35]**	**.007****
Openness		− .095	− .13 [-.29 to .036]	.13

*Significant at $p < 0.05$, **significant at $p < 0.01$; DH—Digital AI Human

AI technologies as part of their integration plans. Such support could help mitigate user hesitance, particularly among demographics that displayed lower acceptability, such as women and ethnic minorities.

Theoretically, this study contributes to the understanding of technology acceptance by identifying the influence of personality traits and cultural background on attitudes towards DHs and VAs. While models such as the TAM highlight the importance of perceived usefulness and ease of use, the findings suggest that additional constructs, including personality factors and cultural perceptions, may also play a significant role. This highlights the potential value of integrating these dimensions into future research models to enhance the understanding of technology acceptance in healthcare settings.

4.2 Limitations

This study has several methodological limitations that may affect the interpretation and generalisability of the findings. Firstly, the primary outcome variables for VA acceptability were measured through participants' willingness to use VAs. As a proxy measure, willingness may not fully capture the nuanced dimensions of acceptability, potentially limiting the accuracy of the findings in reflecting genuine acceptance. A more comprehensive measure incorporating specific acceptability criteria, such as trust, perceived usefulness, and anticipated barriers, may yield a more accurate portrayal.

Secondly, the sample was predominantly composed of participants identifying as White/Irish/European, with approximately 73.7% falling into this demographic. Although the study used a dichotomous approach to categorise other ethnicities as 'ethnic minorities,' this limited representation constrains the generalisability of the findings across more diverse ethnic backgrounds. The predominance of a single demographic group may have influenced results and highlights the need for future studies to sample more equitably across ethnic groups to gain insights that are more broadly applicable.

Thirdly, there were differences in the outcome measures used to assess the acceptability of VAs and DHs, which may limit the comparability of findings across these two technologies. While both measures demonstrated internal consistency, variations in question phrasing and focus could influence responses, potentially skewing the comparative analysis. These inconsistencies raise questions about the comparability of the results, as one measure may more accurately capture acceptability than the other.

Finally, this study did not incorporate longitudinal measures, which would allow for observing changes in acceptability over time as users become more familiar with DH and VA technologies. Future research should consider longitudinal approaches and the development of refined, standardised questionnaires to assess both DH and VA acceptability in healthcare contexts, allowing for a more nuanced understanding of user acceptance.

4.3 Future research

The findings from this study highlighted that a major difference between the acceptability of VAs and DHs in healthcare was the perceived importance of face-to-face interactions, a factor that significantly influenced DH acceptability but not VA acceptability. This suggests that DHs could offer a more authentic replication of the doctor–patient interaction, potentially reducing user concerns about the impersonality of digital healthcare (Nadarzynski et al. 2019; Brinkel et al. 2017). However, further research is needed to validate this assumption through rigorous studies that examine how DHs impact perceived interaction quality in specific healthcare settings.

Emerging evidence from studies, such as Wienrich et al. (2021), indicates that giving a VA an identity or personalised introduction can improve user trust and perception. Future research could explore whether similar enhancements—such as identity customisation or culturally relevant features—might influence DH acceptance and perceived interpersonal value in healthcare. Additionally, investigating the potential benefits of AI personalisation, such as adaptive responses or tailored reminders based on interaction history, could enhance perceived usefulness and engagement. Understanding which personalisation features are most effective could inform design choices for both DHs and VAs.

Digital literacy was found to be an insignificant predictor for VA acceptance in this study, contrary to prior research suggesting a relationship between digital proficiency and chatbot acceptability (Nadarzynski et al. 2019). Methodological variations, such as differences in digital literacy measures, may account for these discrepancies. Future studies should establish a more objective measure of digital literacy, potentially exploring how it mediates the relationship between prior technology exposure and acceptance. Additionally, examining how digital literacy moderates the impact of demographic factors, such as age or gender, on VA and DH acceptance could provide valuable insights into user engagement pathways. These analyses could clarify how digital familiarity and literacy shape the use and perception of healthcare AI technologies.

It would also be beneficial to examine cultural sensitivity and inclusivity in DH and VA design. Future research could explore the impact of culturally adaptive features, such as avatar appearance, language options, and culturally specific health information, to make healthcare AI more inclusive for diverse demographic groups. Qualitative studies could provide deeper insight into how cultural nuances shape interactions with healthcare AI. This approach is further supported by recent findings on how cultural factors, such as avatar ethnicity, impact trust and engagement among users (Apergi et al. 2021; Cooks et al. 2022; J. Li & Kim 2024).

Additionally, a longitudinal approach could yield valuable insights by tracking user attitudes toward DHs and VAs over time. Such studies would help assess whether acceptance, perceived usefulness, and trust in healthcare AI shift with prolonged exposure, familiarity, or advancements in AI capabilities. Understanding these long-term effects would provide a more comprehensive picture of AI adoption dynamics in healthcare.

Future research should also examine AI acceptability across different healthcare applications, such as mental health, chronic illness management, and preventive care, as user expectations and attitudes may vary widely depending on the specific healthcare context. For example, Nadarzynski et al. (2020) found that users preferred human healthcare providers over AI for sensitive services, such as sexual health, suggesting that the application and purpose of AI are critical factors in user acceptance.

Testing alternative theoretical models, such as the Value-based Adoption Model (VAM), could enhance our understanding of AI acceptance beyond TAM's traditional focus on perceived usefulness and ease of use (Sohn & Kwon 2020). VAM incorporates dimensions like perceived enjoyment and technicality, which may better capture user expectations and barriers to AI adoption. Furthermore, validating both TAM and VAM across diverse healthcare contexts could help identify factors that most strongly influence users' intentions to adopt DHs and VAs. This aligns with Venkatesh and Davis's (1996) TAM enhancement, which emphasised the importance of recognising external influences on perceived usefulness and ease of use.

5 Conclusion

In conclusion, this study offers valuable insights into user acceptance of DHs and VAs in healthcare, emphasising the need for culturally responsive and trust-building strategies in technology adoption. Furthermore, this study not only contributes to understanding the acceptability of DHs and VAs but also emphasises the need for targeted research into psychological factors that impact technology adoption. The focus on personality traits provides a unique lens through which to explore acceptability, as previous studies have often overlooked these factors in the context of healthcare technology. Future efforts should focus on refining these approaches to bridge gaps in technology acceptance across diverse populations. The findings indicate that the acceptability of these technologies is significantly shaped by users' awareness, perceived usefulness, and perceived barriers. However, to fully comprehend the nuances of user willingness to engage with these technologies in healthcare, more methodologically rigorous research is necessary to explore the specific contexts in which users are inclined to use DHs and VAs. To our knowledge, this study is the first to quantitatively assess the acceptance of DHs and VAs in healthcare through the lens of the TAM, while also examining the relationship between personality traits and acceptance. Given the increasing integration of these technologies in healthcare, the insights derived from this research can inform the development of targeted interventions and policies aimed at facilitating their implementation within healthcare services. Future research should extend beyond the current findings by investigating the practical applications of these technologies and assessing whether the identified factors and interventions are applicable across diverse cultural contexts and healthcare systems. Such research will contribute to a more comprehensive understanding of the dynamics of AI acceptance in healthcare, ultimately supporting the effective integration of these technologies to improve patient care.

Author Contribution All authors designed the study and contributed to the interpretation of findings and the final report write-up.

Data Availability Data is provided within the manuscript or supplementary information files.

Declarations

Competing Interests The authors declare no competing interests.

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