

Knowledge and Adoption of Digital Health Technologies Among Patients with Cardiovascular Disease Attending a Tertiary Hospital in Southwest Nigeria

A. I. OLUGBENGA-BELLO¹, R. O. IGE¹, A. A. AKINTUNDE², N.E. ANEGBE³, A.O OKE⁴, A.B IDOWU³, V.T AKIN-DOSUMU³, O.B BADA³, R.A ADEGOKE³

¹Department of Community Medicine, Ladoke Akintola University of Technology, Ogbomoso, Oyo State

²Department of Internal Medicine, , Ladoke Akintola University of Technology, Ogbomoso, Oyo State

³Department of Community Medicine, , Ladoke Akintola University of Technology Teaching Hospital, Ogbomoso, Oyo State

⁴Department of Computer Engineering, , Ladoke Akintola University of Technology, Ogbomoso, Oyo State

Correspondence:

Dr Roseline Olabisi Ige

Department of Community Medicine,

Faculty of Clinical Sciences,

Ladoke Akintola University of Technology,

Ogbomoso, Oyo State

Email: roige@lautech.edu.ng Phone: +2348035197609

Abstract

Background: Digital health technologies (DHTs) are increasingly used to support the prevention, monitoring, and self-management of cardiovascular disease (CVD). However, evidence regarding patients' knowledge and adoption of these technologies in Nigeria remains limited. This study assessed the knowledge and adoption of digital health technologies among patients with cardiovascular disease attending a tertiary hospital in Southwest Nigeria. **Methods:** A hospital-based cross-sectional study was conducted among 430 patients attending the Cardiology and General Outpatient Clinics of LAUTECH Teaching Hospital, Ogbomoso. Participants were selected using a systematic sampling technique, and data were collected using a pretested interviewer-administered questionnaire. Data were analysed using IBM SPSS Statistics version 22. Associations between sociodemographic characteristics and digital health technology utilization were assessed using the Chi-square test, with statistical significance set at $p < 0.05$. **Results:** The predominant age group was 51–60 years, and 80.0% of respondents demonstrated good knowledge of digital health technologies. More than half (54.7%) had used a digital health device for blood pressure monitoring. Utilization was significantly associated with age group ($p = 0.044$), sex ($p < 0.001$), religion ($p < 0.001$), educational level ($p < 0.001$), occupation ($p < 0.001$), and monthly income ($p = 0.003$). **Conclusion:** Although knowledge of digital health technologies was high, their adoption for cardiovascular self-management remained suboptimal. Targeted interventions to improve digital health literacy, affordability, and equitable access may enhance the utilization of these technologies among patients with cardiovascular disease.

Keywords: Digital Health, Telemedicine, Cardiovascular diseases, Mobile health

1. Introduction

Digital health technologies (DHTs) are transforming healthcare delivery by improving disease prevention, diagnosis, treatment, and long-term patient management [1]. Their rapid integration into clinical practice is redefining healthcare systems through enhanced diagnostic accuracy, real-time patient monitoring, improved communication between healthcare providers and

patients, and more personalized approaches to disease management [1, 2]. In cardiology, digital health technologies have become increasingly important in supporting clinical decision-making, facilitating remote monitoring, promoting treatment adherence, and improving the management of chronic cardiovascular conditions [2]. Consequently, these technologies have the potential to improve the quality, accessibility, and

efficiency of healthcare delivery while reducing the burden of cardiovascular disease.

Cardiovascular diseases (CVDs) comprise a group of disorders affecting the heart and blood vessels, including coronary heart disease, cerebrovascular disease, rheumatic heart disease, and other vascular disorders.[3] They remain the leading cause of mortality worldwide, accounting for an estimated 17.9 million deaths annually [3]. The growing burden of CVD represents a major global public health challenge, particularly in low- and middle-income countries, where increasing urbanization, population ageing, and lifestyle changes have contributed to rising disease prevalence [4.] Consequently, innovative, cost-effective, and patient-centred approaches to cardiovascular prevention and management are urgently needed.

Digital health technologies have emerged as valuable tools for addressing many of these challenges by supporting disease prevention, early diagnosis, continuous monitoring, treatment adherence, and patient self-management [5]. The increasing availability of smartphones, wearable devices, home monitoring equipment, and mobile health (mHealth) applications has shifted healthcare from a provider-centred model towards a more patient-centred approach that encourages active participation in disease management and shared decision-making [3]. Devices such as automated blood pressure monitors, ambulatory electrocardiography systems, wearable activity trackers, electronic thermometers, and implantable cardiac devices enable patients to monitor their health status while facilitating timely clinical intervention [3]. Furthermore, digital technologies improve communication among healthcare providers and between providers and patients, thereby enhancing continuity of care, patient safety, and overall healthcare quality [6].

Several studies have demonstrated the effectiveness of digital health interventions in reducing modifiable cardiovascular risk factors and improving disease outcomes.[7] Lifestyle modification remains the cornerstone of cardiovascular disease prevention, and digital technologies have become increasingly useful in promoting healthier dietary habits, increasing physical activity, supporting smoking cessation, reducing harmful alcohol consumption, and improving medication adherence.[7,8] Mobile health applications, in particular, have shown considerable promise in facilitating behavioural change and supporting self-management among individuals with chronic diseases.[8] In hypertension management, dietary mobile applications have been developed to promote adherence to the Dietary Approaches to Stop Hypertension (DASH) eating plan, thereby improving blood pressure control and cardiovascular health outcomes.[9]

The successful implementation of digital health technologies depends not only on their availability but also on patients' willingness to accept and use them. The Technology

Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT) are among the most widely applied theoretical frameworks for understanding technology adoption [10, 11]. The TAM proposes that perceived usefulness and perceived ease of use are the primary determinants of technology acceptance, whereas the UTAUT extends this framework by incorporating additional factors, including social influence and facilitating conditions [10, 11]. Together, these models provide a useful conceptual basis for understanding patients' adoption of digital health technologies and identifying factors that may facilitate or hinder their utilization in clinical practice.

Although digital health technologies have demonstrated considerable potential for improving treatment adherence and clinical outcomes among patients with chronic diseases, including cardiovascular disease [12], evidence regarding patients' knowledge and adoption of these technologies in Nigeria remains limited. Most existing studies have focused on healthcare providers or digital health infrastructure, with relatively few examining patients' awareness, acceptance, and utilization of digital health technologies for cardiovascular self-management. Understanding these factors is essential for designing interventions that promote equitable access to digital health services and improve cardiovascular outcomes in resource-limited settings. Therefore, this study assessed the knowledge and adoption of digital health technologies among patients with cardiovascular disease attending LAUTECH Teaching Hospital, Ogbomoso, Southwest Nigeria.

2. Materials and Methods

2.1 Study Area

The study was conducted at the Cardiology Unit and the General Outpatient Department (GOPD) of Ladoke Akintola University of Technology (LAUTECH) Teaching Hospital, Ogbomoso, Oyo State, Nigeria. Ogbomoso is the second-largest city in Oyo State after Ibadan and is strategically located within the Guinea Savannah region of southwestern Nigeria, serving as a major commercial and educational centre linking the northern and southwestern parts of the country. The city has an estimated population of approximately 602,000 (2022 estimate) and lies at an elevation of about 347 m above sea level. The climate is characterized by a tropical wet-and-dry pattern with a mean annual temperature of approximately 26.2°C, an average annual rainfall of about 1,200 mm, and relative humidity ranging from 75% to 95%. Agriculture and commerce constitute the predominant occupations, although the service and industrial sectors have expanded considerably in recent years.[13].

Ladoke Akintola University of Technology (LAUTECH) Teaching Hospital is a tertiary healthcare institution located along the Ilorin–Ibadan Expressway in Ogbomoso North Local

Government Area. The hospital comprises more than 14 clinical departments and provides specialist healthcare services to residents of Oyo State and neighbouring states. The Cardiology Unit of the Department of Internal Medicine has been fully operational since 2011 and provides comprehensive cardiovascular services, including transthoracic echocardiography, resting and ambulatory electrocardiography, exercise stress testing, 24-hour ambulatory blood pressure monitoring, and point-of-care cardiac biomarker assays. The Cardiology and General Outpatient clinics manage an average of 65 and 40 patients per week, respectively.

2.2 Study Design

This study employed a hospital-based descriptive cross-sectional design to assess the knowledge and adoption of digital health technologies among patients with cardiovascular disease attending LAUTECH Teaching Hospital, Ogbomoso.

2.3 Study Population

The study population comprised adult patients diagnosed with cardiovascular disease who attended follow-up clinics at the Cardiology Unit and the General Outpatient Department of LAUTECH Teaching Hospital during the study period.

Eligible participants were adults aged 18 years and above with a confirmed diagnosis of cardiovascular disease who had attended at least two previous clinic visits, thereby ensuring adequate exposure to routine cardiovascular care and opportunities to interact with digital health technologies. Patients who were critically ill, haemodynamically unstable, cognitively impaired, or otherwise unable to provide reliable responses during the interview were excluded. In addition, patients with severe comorbid conditions that significantly impaired communication or participation in the study were excluded.

2.4 Sample size determination:

The minimum sample size was calculated using Leslie Fischer's formula for the population less than 10,000 as shown below:

$$NF = n/1 + (n/N), \quad n = \frac{z^2pq}{d^2}$$

Where: NF = required sample size

N = exact figure <10,000

n = desired sample size (when population is greater than 10,000)

z = standard normal deviate, usually set at 1.96, which corresponds to the 95% confidence level.

P = proportion of hypertensive patients willing to receive mobile health services for prevention, treatment and information on hypertension in a previous similar study was 48.7%.[14]

P = 0.487, q = 1 - p;

= 1 - 0.487 = 0.513

d = degree of accuracy, set at 0.05 for this study

Therefore: $n = \frac{(1.96)^2 (0.487) (0.513)}{(0.05)^2}$

$$= \frac{0.9598}{0.0025}$$

= 383.92. Approximately 384.

$$N = n/1 + (n/N)$$

$$NF = 384/1 + (384/5460) = 384/1 + 0.07 = 384/1.07$$

$$NF = 358$$

A non-response rate of 10% is anticipated;

$$= 358 / 1 - 0.1 = 397$$

To enhance the representativeness of the study population and improve the precision of the estimates, the calculated sample size was increased to 430 participants.

2.5 Sampling Technique

Systematic sampling was used, total number of patients attending the clinics in a week is 105 patients

Sample size = 430 patients, using proportionate allocation,

$$\text{for Cardiology clinic} = \frac{65 \times 430}{105} = 266 \text{ patients}$$

$$\text{For GOPD clinic} = \frac{40 \times 430}{105} = 164 \text{ patients}$$

Using systematic random sampling, the total number of patients presenting on each clinic day was collected from the record unit. This formed the sampling frame for each clinic day; each patient was given a serial number. Sampling frame for each clinic day was divided by the allocated sample size per clinic day to get the k^{th} (k is the interval between one respondent and the other). The first eligible patient was randomly selected using balloting while other patients were selected using the k^{th} interval based on the serial numbering.

2.6 Research Instruments

Data were collected using a semi-structured, interviewer-administered questionnaire on knowledge and adoption of digital health technologies among cardiovascular patients. To ensure face and content validity, the questionnaire was reviewed by experts in Cardiology, Biostatistics and Computer engineering to ensure that the instrument was set to measure what it was supposed to measure before it was administered. Internal consistency was evaluated using Cronbach's alpha, with values ≥ 0.70 considered acceptable.

Knowledge of digital health technologies: The section was made up of 24 questions with scoring of 1 for correct answer and 0 for incorrect answer. It informed the classification into good knowledge for mean scores ≥ 12 and poor knowledge for scores < 12 .

Pattern of Adoption of digital health devices: The first out of 14 questions were used to classify respondents on usage of digital health technology and presented as percentage. The other 13 questions assessed the pattern of adoption of digital health technologies.

Pre-testing of Research Instruments: The questionnaire was pre-tested among 30 patients with cardiovascular diseases at Osun State University Teaching Hospital, Osogbo, Osun State. This helped to address some areas of ambiguity in the questionnaire. Necessary modifications and corrections which included rephrasing of certain sentences for clarity were made

before the final administration of the questionnaires to the study participants.

2.7 Data Collection Methods

Interviewer-administered, semi-structured questionnaire was used to obtain the required data from 430 respondents. This was administered by five research assistants that were recruited and trained by the researcher.

2.8 Data Analysis

Data collected was edited daily so as to ensure that all the required items on the questionnaire were appropriately answered. Data entry and analysis were done using IBM SPSS version 22.0. Categorical variables were summarized using simple proportions, while mean and standard deviation was used to summarize continuous variables. Level of significance was set at $p < 0.05$.

2.9 Ethical Consideration

Ethical approval was obtained from the Ethical Review Committee of LAUTECH Teaching Hospital, Ogbomoso, with number LTH/OGB/EC/2023/342, on 13th of June, 2023. The respondents were informed about the objectives of the study and that their participation was voluntary. The study participants were assured of confidentiality and all questionnaires were coded without names or addresses of respondents. Signed informed consent forms were obtained from the respondents before being recruited into the study.

3 Results

3.1 Socio-demographic Characteristics of the Respondents

A total of 430 patients with cardiovascular disease participated in the study. The largest proportion of respondents was aged 51–60 years (27.9%), followed by those aged over 60 years (22.8%), while participants aged 31–40 years constituted the smallest age group (8.8%). Females accounted for 56.3% of the respondents. Most participants were Christians (54.0%), belonged to the Yoruba ethnic group (96.7%), and were married (68.4%). Half of the respondents (50.2%) had attained tertiary education, while 32.6% were professionals and an equal proportion were skilled workers. Furthermore, 41.9% reported an average monthly income exceeding ₦50,000 (Table 1).

3.2 Clinical Characteristics of the Respondents

The majority of respondents (77.2%) reported attending fewer than three clinic visits prior to enrolment. Slightly more than half (51.6%) had normal systolic blood pressure (<140 mmHg), whereas 29.3% had borderline systolic blood pressure (140–159 mmHg). The most common diastolic blood pressure categories were 71–80 mmHg (29.3%) and 61–70 mmHg (28.4%). Regarding nutritional status, 51.1% of respondents had a normal body mass index (BMI), while 39.2% were overweight and 7.2% were obese. More than half (56.3%) had a waist-to-hip ratio consistent with overweight. The mean systolic blood pressure, diastolic blood pressure, and BMI were 158 ± 9

mmHg, 68 ± 5 mmHg, and 23.9 ± 6.9 kg/m², respectively (Table 2).

Table 1. Sociodemographic Characteristics of the Respondents (N = 430)

Variable	Category	n (%)
Age group (years)	<30	112 (26.0)
	31–40	38 (8.8)
	41–50	62 (14.4)
	51–60	120 (27.9)
	>60	98 (22.8)
Sex	Male	188 (43.7)
	Female	242 (56.3)
Religion	Islam	198 (46.0)
	Christianity	232 (54.0)
Ethnicity	Hausa	14 (3.3)
	Yoruba	416 (96.7)
Marital status	Single	136 (31.6)
	Married	294 (68.4)
Educational attainment	No formal education	54 (12.6)
	Primary	84 (19.5)
	Secondary	76 (17.7)
	Tertiary	216 (50.2)
Occupational status	Unemployed	40 (9.3)
	Skilled	140 (32.6)
	Semi-skilled	110 (25.6)
	Professional	140 (32.6)
Average monthly income (₦)	None	40 (9.3)
	<30,000	90 (20.9)
	30,000–50,000	120 (27.9)
	>50,000	180 (41.9)

3.3 Knowledge of Digital Health Technologies

Overall, respondents demonstrated a high level of awareness of digital health technologies. Most respondents (85.6%) reported having heard that computers and related digital technologies could be used for disease prevention, diagnosis, and treatment.

Friends (70.2%), television (55.3%), and healthcare workers (47.4%) were the most common sources of information. Awareness of the use of digital health technologies in the management of cardiovascular disease was reported by 60.5% of respondents. Smartphone applications (72.1%) were the most widely recognized form of digital health technology, followed by automated blood pressure monitors (29.3%) and ambulatory electrocardiography devices (22.8%). The principal perceived benefit of digital health technologies was their ability to facilitate health status monitoring (86.0%), while the requirement for education or training before use (59.5%) was the most frequently reported limitation (Table 3). Overall, 344 respondents (80.0%) demonstrated good knowledge of digital health technologies, whereas 86 (20.0%) had poor knowledge (Figure 1).

3.4 Adoption of Digital Health Technologies

Overall, 234 (54.4%) respondents had used a digital health device for blood pressure management. Among these users, most reported using the devices in the hospital (82.1%), while 11.1% used them at home. Digital blood pressure monitors (81.4%) and smartphones (61.7%) were the most commonly used technologies for blood pressure monitoring, whereas ambulatory electrocardiography devices were used by 27.4% of respondents (Table 4). Overall, 356 (82.8%) respondents had used at least one digital health device within the preceding year. Among these users, 42.7% had last used a device within the previous few months, 32.6% within the preceding weeks, and 13.5% within the preceding days. Nearly half (48.3%) reported weekly use, while 16.3% reported daily use. Most users (62.9%) considered the devices very easy to use. Smartphone ownership was high, with 380 (88.4%) respondents owning a smartphone. However, only 102 (26.8%) smartphone owners reported using a health-related mobile application for health monitoring. Half of all respondents (50.2%) were very satisfied with digital health technologies, and 57.2% believed that their use should be encouraged. The principal reasons for encouraging digital health technologies were their perceived accuracy and time-saving advantages (43.1%) and ease of use (33.3%) (Table 4).

3.5 Factors Associated with Knowledge of Digital Health Technologies

Knowledge of digital health technologies was significantly associated with age ($\chi^2 = 13.400, p = 0.009$) and sex ($\chi^2 = 3.459, p = 0.045$). No statistically significant associations were observed between knowledge and religion, ethnicity, marital status, educational attainment, occupational status, or average monthly income (Table 5).

Table 2. Clinical Characteristics of the Respondents (N = 430)

Variable	Category	n (%)
Number of clinic visits	<3	332 (77.2)
	4–6	32 (7.4)
	7–9	42 (9.8)
	>10	24 (5.6)
Systolic blood pressure (mmHg)	<140 (Normal)	222 (51.6)
	140–159 (Borderline)	126 (29.3)
	160–189 (Stage 2 hypertension)	64 (14.9)
	≥190 (Severe hypertension)	18 (4.2)
Diastolic blood pressure (mmHg)	≤50	18 (4.2)
	51–60	106 (24.7)
	61–70	122 (28.4)
	71–80	126 (29.3)
	81–90	40 (9.3)
	>90	18 (4.2)
Body mass index (kg/m²)	Underweight (<18.5)	11 (2.5)
	Normal (18.5–24.9)	220 (51.1)
	Overweight (25.0–29.9)	168 (39.2)
	Obese (≥30.0)	31 (7.2)
Waist-to-hip ratio	Normal	77 (17.9)
	Overweight	242 (56.3)
	Obese	111 (25.8)
Continuous variables		Mean ± SD
Systolic blood pressure (mmHg)		158 ± 9
Diastolic blood pressure (mmHg)		68 ± 5
Body mass index (kg/m²)		23.9 ± 6.9

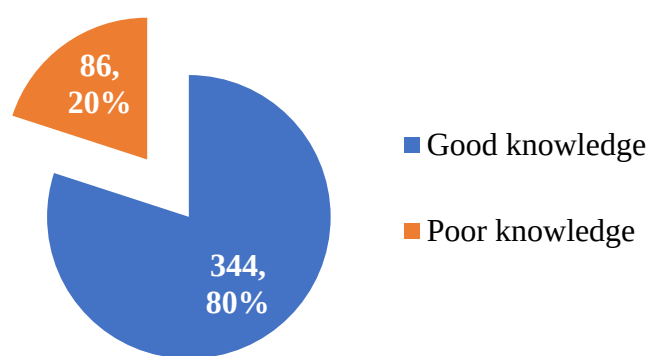


Figure 1. Overall Level of Knowledge of Digital Health Technologies Among Respondents. Overall, 344 (80.0%) respondents demonstrated good knowledge, while 86 (20.0%) had poor knowledge of digital health technologies.

3.6 Factors Associated with Adoption of Digital Health Technologies

Utilization of digital health devices for blood pressure management was significantly associated with age group ($\chi^2 = 9.816$, $p = 0.044$), sex ($\chi^2 = 35.035$, $p < 0.001$), religion ($\chi^2 = 11.719$, $p < 0.001$), educational attainment ($\chi^2 = 18.894$, $p < 0.001$), occupational status ($\chi^2 = 26.237$, $p < 0.001$), and average monthly income ($\chi^2 = 14.071$, $p = 0.003$). However, ethnicity and marital status were not significantly associated with utilization of digital health technologies (Table 6).

3.7 Predictors of Knowledge and Adoption of Digital Health Technologies

Binary logistic regression analysis demonstrated that none of the sociodemographic variables independently predicted respondents' knowledge of digital health technologies after adjustment for potential confounding variables (Table 7). Similarly, no independent sociodemographic predictors of digital health technology utilization for blood pressure management were identified in the multivariable logistic regression model (Table 8).

Discussion

This study assessed the knowledge and adoption of digital health technologies (DHTs) among patients with cardiovascular disease attending LAUTECH Teaching Hospital, Ogbomosho. Overall, most participants demonstrated good knowledge of digital health technologies, suggesting that awareness of digital health interventions is increasing among patients receiving specialist cardiovascular care. This finding is consistent with that of Owoye et al [15], who reported that 96.2% of healthcare workers in Benin City, Nigeria, had good knowledge of e-health services, with approximately two-thirds reporting previous use of these technologies [15]. Although healthcare workers are

expected to demonstrate higher levels of knowledge because of their professional training, the relatively high level of awareness observed among patients in the present study may reflect increasing public exposure to digital technologies, improved educational attainment, and the urban and semi-urban setting of the study population. Similarly, Okeke et al. reported marked disparities in digital health awareness between healthcare professionals and rural community members in Oyo State, emphasizing the influence of educational and geographical factors on digital health literacy [16].

Despite the high level of knowledge observed in this study, adoption of digital health technologies remained relatively low, particularly regarding the use of mobile health applications for cardiovascular self-management. This disparity between awareness and utilization highlights an important implementation gap. Similar findings have been reported by Belachew et al. among patients with chronic diseases in Northwest Ethiopia, where favourable perceptions of telemedicine coexisted with low levels of actual utilization [17]. In the present study, although smartphone ownership was high, only a small proportion of smartphone owners reported using health-related applications. Furthermore, more than half of respondents who had used digital health devices did so primarily within the hospital setting rather than independently at home. These findings suggest that awareness alone is insufficient to promote sustained adoption and that structural barriers—including affordability, limited access to personal monitoring devices, inadequate digital skills, and insufficient patient support—continue to limit the integration of digital technologies into routine self-care.

Smartphones were the most widely recognized digital health tool among respondents, reflecting the rapid expansion of mobile technology across Nigeria. Similar observations were reported by Dele-Ojo et al. in Ekiti State, where all participants owned mobile phones, approximately half owned smartphones, and almost all expressed willingness to use and pay for mobile health services [14]. However, willingness and device ownership do not necessarily translate into meaningful utilization. In the present study, television and interpersonal networks, particularly friends, were the principal sources of information on digital health technologies, highlighting the continued importance of traditional media and social interactions in disseminating health information despite increasing internet penetration. This finding is consistent with previous reports from Nigeria demonstrating that digital health information is frequently obtained through informal social networks and conventional mass media rather than through dedicated digital health platforms [18,19].

Table 3. Knowledge of Digital Health Technologies Among Respondents (N = 430)

Table 3. Knowledge of Digital Health Technologies Among Respondents (N = 430)			Variable	Category	n (%)
Variable	Category	n (%)			
Awareness that digital technologies can be used for disease prevention, diagnosis, and treatment	Yes	368 (85.6)	Perceived barriers to digital health technologies†	Improves self-awareness of health status	248 (57.7)
				Can be used at any time	242 (56.3)
	No	62 (14.4)		Promotes patient autonomy	198 (46.0)
				Affordable	192 (44.7)
Source of information†	Friends	302 (70.2)		Encourages patient involvement in care	186 (43.3)
	Television	238 (55.3)		No side effects	156 (36.3)
	Health workers	204 (47.4)		Reduces hospital visits	148 (34.4)
	School	114 (26.5)		No training required	86 (20.0)
	Newspaper	112 (26.0)	Requires education/training to use	256 (59.5)	
	Radio	64 (14.9)	Exposure to radiation	222 (51.6)	
	Social media	62 (14.4)	Not reliable for patient care	208 (48.4)	
Awareness of the use of digital health technologies in the management of cardiovascular disease	Yes	260 (60.5)	Gives false confidence about health status	202 (47.0)	
	No	170 (39.5)	Expensive	200 (46.5)	
Digital health technologies recognized†			Smartphone applications	310 (72.1)	Requires smartphone ownership
	Variability in device accuracy	146 (34.0)			
	Automatic blood pressure monitor (digital sphygmomanometer)	126 (29.3)	Devices are not readily available	98 (22.8)	
	Ambulatory electrocardiography (ECG)	98 (22.8)	Lacks clinical validation	78 (18.1)	
	Others	22 (5.1)	Time-consuming	76 (17.7)	
Perceived benefits of digital health technologies†	Facilitates health status monitoring	370 (86.0)	† Multiple responses were permitted; therefore, percentages do not total 100%.		
	Convenient to use	274 (63.7)			
	Portable and easy to use	264 (61.4)			

Table 4. Adoption and Utilization of Digital Health Technologies Among Respondents

Variable	Category	n (%)		Indifferent	8 (2.2)
Ever used a digital health device for blood pressure management (N = 430)	Yes	234 (54.4)	Smartphone ownership (N = 430)	Yes	380 (88.4)
	No	194 (45.1)		No	50 (11.6)
	Not sure	2 (0.5)			
Place of use among users (n = 234)	Hospital	192 (82.1)	Use of a health-related application among smartphone owners (n = 380)	Yes	102 (26.8)
	Home	26 (11.1)		No	278 (73.2)
	Other settings	16 (6.8)			
Digital health technologies used for blood pressure monitoring† (N = 430)	Digital blood pressure monitor	350 (81.4)	Perceived positive effect of health applications‡ (n = 102)	Yes	Not internally consistent in source data
	Smartphone	266 (61.7)		No	Not internally consistent in source data
	Ambulatory ECG	118 (27.4)			
	Other devices	42 (9.8)			
Use of any digital health device within the previous year (N = 430)	Yes	356 (82.8)	Overall satisfaction with digital health technologies (N = 430)	Very satisfied	216 (50.2)
	No	74 (17.2)		Satisfied	136 (31.6)
				Not satisfied	38 (8.8)
Time since last use (n = 356)	Days	48 (13.5)	Should digital health technologies be encouraged? (N = 430)	Indifferent	40 (9.3)
	Weeks	116 (32.6)		Yes	246 (57.2)
	Months	152 (42.7)		No	184 (42.8)
	Years	40 (11.2)			
Frequency of use (n = 356)	Daily	58 (16.3)	Reasons for encouraging digital health technologies† (n = 246)	Accurate and time-saving	106 (43.1)
	Weekly	172 (48.3)		Easy to use	82 (33.3)
	Monthly	100 (28.1)		Facilitates health monitoring	44 (17.9)
	Occasionally	26 (7.3)		Promotes healing	14 (5.7)
Ease of use (n = 356)	Very easy	224 (62.9)	† Multiple responses were permitted; therefore, percentages do not total 100%.		
	Easy	124 (34.8)	Although more than half of the respondents reported using digital health devices for blood pressure monitoring, utilization		

† Multiple responses were permitted; therefore, percentages do not total 100%.

Although more than half of the respondents reported using digital health devices for blood pressure monitoring, utilization remained predominantly hospital-based rather than patient-

initiated within the home environment. This observation is consistent with the systematic review by Stokes et al., which demonstrated that while digital technologies for hypertension management are increasingly available in sub-Saharan Africa, their use remains largely health facility-driven, with limited integration into home-based self-monitoring and long-term self-management [20]. Similar ownership-utilization gaps have also been reported in high-income countries. Langford et al., in a nationally representative survey of hypertensive adults in the United States, observed that although smartphone ownership was widespread, only a minority of participants used health-related applications, with adoption being particularly low among older adults [21]. Collectively, these findings suggest that device availability alone does not ensure utilization. Rather, digital health literacy, perceived usefulness, confidence in technology, ease of use, and integration into routine clinical care appear to be more important determinants of sustained adoption. Likewise, Kassaw et al [22]. reported that ownership of mobile phones significantly increased willingness to adopt remote patient monitoring among cardiovascular patients in Ethiopia [22].

Among respondents who used health-related mobile applications, perceived benefits included improved knowledge of cardiovascular disease and increased awareness of personal cardiovascular health. These findings support evidence from Kassavou et al. [23], whose systematic review and meta-analysis demonstrated that app-based self-monitoring interventions produce modest but clinically meaningful reductions in systolic blood pressure among individuals with hypertension [23]. Nevertheless, respondents in the present study identified several barriers to adoption, including inadequate knowledge of device operation, high cost, concerns regarding safety, and doubts about device reliability. Similar barriers have been documented in Nigeria by Oke et al [18], who identified poor digital literacy, inadequate infrastructure, unreliable internet connectivity, and financial constraints as major impediments to digital health implementation [18]. Furthermore, Echieh et al [24]. demonstrated that low literacy levels, sedentary lifestyles, and infrastructural limitations reduced the effectiveness of telehealth interventions among hypertensive patients in Nigeria and Ghana, even when digital devices were provided [24]. These findings suggest that successful implementation of digital health programmes requires more than technology provision; comprehensive patient education, user-centred device design, and improvements in digital infrastructure are equally important. Sociodemographic characteristics significantly influenced both knowledge and adoption of digital health technologies.

Table 5: Association between respondents' sociodemographic characteristics and overall knowledge about digital health technology

Socio-demographic information		Knowledge about Digital Health Technology		X^2	df	p -value
		Good knowledge	Poor knowledge			
Age (years)						
<30	96(85.7)	16(14.3)	13.400	4	0.009*	
31 – 40	24(63.2)	14(36.8)				
41 – 50	48(77.4)	14(22.6)				
51 – 60	110(91.7)	10(8.3)				
>60	68(69.4)	30(30.6)				
Sex						
Male	162(86.2)	26(13.8)	3.459	1	0.045*	
Female	184(76.0)	58(24.0)				
Religion						
Islam	178(76.7)	54(23.3)	2.243	1	0.092	
Christianity	168(84.8)	30(15.2)				
Ethnicity						
Hausa	334(79.8)	82(20.2)	1.757	1	0.213	
Yoruba	12(99.3)	2(0.7)				
Marital status						
Single	100(73.5)	36(26.5)	3.044	1	0.061	
Married	246(83.7)	48(16.3)				
Educational status						
No formal education	44(81.5)	10(18.5)	7.676	3	0.053	
Primary	78(92.9)	6(7.1)				
Secondary	52(68.4)	24(31.6)				
Tertiary	172(79.6)	44(20.4)				
Occupational status						
Unemployed	36(90.0)	4(10.0)	7.679	3	0.053	
Skilled	122(87.1)	18(12.9)				
Semiskilled	76(69.1)	34(30.9)				
Professional	112(80.0)	28(20.0)				
Average monthly Income						
None	36(90.0)	4(10.0)	3.575	3	0.311	
<30000	76(84.4)	14(15.6)				
30,000 – 50,000	88(73.3)	32(26.7)				
>50,000	146(81.1)	34(18.9)				

*Statistically significant <0.05

Younger participants and males demonstrated significantly better knowledge, while age, sex, educational attainment, occupation, religion, and monthly income were significantly associated with the utilization of digital health devices. These findings are consistent with previous studies showing that younger age, higher educational attainment, and greater socioeconomic status facilitate digital technology adoption [14, 21, 22]. Individuals with higher levels of education and income are more likely to possess the digital literacy, technological confidence, and financial resources required to access and effectively utilize digital health tools. The observed association between sex and technology utilization may reflect broader gender differences in access to digital technologies and patterns of health-seeking behaviour. Importantly, despite relatively low utilization, most respondents expressed satisfaction with digital health technologies and supported their wider implementation. Similar positive attitudes towards telemedicine despite low levels of use have been reported by Belachew et al. [17]. Collectively, these findings suggest that limited adoption of digital health technologies among patients with cardiovascular disease is driven primarily by structural, socioeconomic, and health system constraints rather than unwillingness to use technology.

Conclusion

This study found that patients with cardiovascular disease attending LAUTECH Teaching Hospital had good knowledge of digital health technologies, with smartphone applications and automated blood pressure monitors being the most recognized tools. However, despite high awareness and smartphone ownership, adoption of digital health technologies for cardiovascular self-management remained low and was largely hospital-based rather than home-based. Knowledge was significantly associated with age and sex, while utilization was influenced by age, sex, religion, educational attainment, occupation, and monthly income.

These findings suggest that awareness alone is insufficient to promote digital health adoption. Improving digital health literacy, affordability and access to monitoring devices, expanding reliable internet connectivity, and integrating digital health education into routine cardiovascular care may enhance patient engagement and improve cardiovascular disease management in Nigeria.

Table 6: Association between respondents' sociodemographic characteristics and utilization of a digital health device to manage blood pressure

Socio-demographic information		Utilization of digital health device to manage your blood pressure		X ²	df	p-value
		Yes	No			
Age (years)						
<30		46(41.8)	64(58.2)	9.816	4	0.044*
31 – 40		18(47.4)	20(52.6)			
41 – 50		34(54.8)	28(45.2)			
51 – 60		84(70.0)	36(30.0)			
>60		52(53.1)	46(46.9)			
Sex						
Male		60(31.9)	128(68.1)	35.035	1	<0.001*
Female		174(72.5)	66(27.5)			
Religion						
Islam		132(67.3)	64(32.7)	11.719	1	<0.001*
Christianity		102(44.0)	130(56.0)			
Ethnicity						
Haus		4(28.6)	10(71.4)	1.989	1	0.153
Yoruba		230(55.6)	184(44.4)			
Marital status						
Single		64(47.1)	72(52.9)	2.332	1	0.084
Married		170(58.2)	122(41.8)			
Educational status						
No formal education		48(88.9)	6(11.1)	18.894	3	<0.001*
Primary		30(35.7)	54(64.3)			
Secondary		40(54.1)	34(45.9)			
Tertiary		116(53.7)	100(46.3)			
Occupational status						
Unemployed		8(20.0)	32(80.0)	26.237	3	<0.001*
Skilled		74(53.6)	64(46.4)			
Semi-skilled		88(80.0)	22(20.0)			
Professional		64(45.7)	76(54.3)			
Average monthly Income				14.071	3	0.003*
None		8(20.0)	32(80.0)			
<30000		62(68.9)	28(31.1)			
30,000 – 50,000		60(50.8)	58(49.2)			
>50,000		104(57.8)	76(42.2)			

*Statistically significant <0.05

Table 7: Predictors of knowledge about digital health technology

Variable	Knowledge about Digital Health Technology		Odd Ratio	Confidence interval	p-value
	Good knowledge	Poor knowledge			
Age (years)					
<30 (R)	96(85.7)	16(14.3)	1		
31 – 40	24(63.2)	14(36.8)	0.434	0.134 - 2.628	0.724
41 – 50	48(77.4)	14(22.6)	0.592		0.422
51 – 60	110(91.7)	10(8.3)	0.611	0.002 - 1.905	0.927
>60	68(69.4)	30(30.6)	0.659	0.942 - 2.823	0.628
				0.004 – 1.761	
Sex					
Male (R)	162(86.2)	26(13.8)	1		
Female	184(76.0)	58(24.0)	0.645	0.202 – 3.516	0.142

Study Limitations

This cross-sectional study cannot establish causal relationships between knowledge, sociodemographic characteristics, and digital health technology adoption. The use of self-reported questionnaires may have introduced recall and social desirability bias, although standardized interviewer administration and assurances of confidentiality were used to minimize these effects. Furthermore, as the study was conducted in a single tertiary healthcare facility, the findings may not be generalizable to other healthcare settings or regions of Nigeria. Future multicentre longitudinal studies are recommended to validate these findings and assess changes in digital health adoption over time

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Table 8: Predictors of the utilization of a digital health device to manage blood pressure

Variable	Utilization of digital health device to manage your blood pressure		Odd Ratio	Confidence interval	p-value
	Yes	No			
Age (years)					
<30(R)	46(41.8)	64(58.2)	1		
31 – 40	18(47.4)	20(52.6)	0.492	0.134 - 2.628	0.724
41 – 50	34(54.8)	28(45.2)	0.434		0.422
51 – 60	84(70.0)	36(30.0)	0.611	0.002 - 1.905	0.927
>60	52(53.1)	46(46.9)	0.659	0.942 - 2.823	0.628
				0.004 - 1.761	
Sex (R)					
Male	60(31.9)	128(68.1)	1		
Female	174(72.5)	66(27.5)	1.017	0.136 - 2.18	0.192
Religion					
Islam (R)	132(67.3)	64(32.7)	1		
Christianity	102(44.0)	130(56.0)	1.603	0.191 - 1.356	0.647
Educational status					
	48(88.9)	6(11.1)	1		
No formal education (R)	30(35.7)	54(64.3)	1.882	0.002 - 1.602	0.801
Primary	40(54.1)	34(45.9)	1.064		0.444
Secondary	116(53.7)	100(46.3)	1.924	0.602 - 3.471	0.611
Tertiary				0.072- 1.897	
Occupational status					
	8(20.0)	32(80.0)	1		
Unemployed (R)	74(53.6)	64(46.4)	1.529	0.204 - 1.703	0.352
Skilled	88(80.0)	22(20.0)	1.094	0.542 - 3.182	0.244
Semi-skilled	64(45.7)	76(54.3)	1.164		0.503
Professional				0.004 - 1.761	
Average monthly Income					
	8(20.0)	32(80.0)	1		
None (R)	62(68.9)	28(31.1)	1.912	0.146 - 1.088	0.761
<30000	60(50.8)	58(49.2)	1.311		0.822
30,000 – 50,000	104(57.8)	76(42.2)	1.904	0.049 - 2.031	0.664
>50,000				0.194 - 1.606	

Authors' Contributions

Olugbenga-Bello A.I - Conception, design, supervision, analysis and critical review. Ige R.O - Design, supervision, data collection, interpretation, literature review and writing. Akintunde A.A - Design, supervision, data collection, interpretation and critical review. Anegebe N.E - Design, supervision, interpretation, literature review and writing. Oke A.O - Design, interpretation, literature review and writing. Idowu A.B - Design, literature review and writing. Akin-Dosumu V.T - Design, literature review and writing. Bada O.B - Design, literature review and writing. Adegoke R.A - Design, literature review and writing.

Competing interests

All authors of this paper declare that there is no conflict of interest related to the content of this manuscript.

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