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Nurses' perspectives on AI-Enabled wearable health technologies: opportunities and challenges in clinical practice

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Abstract

Background Wearable health technologies, such as smartwatches, biosensor patches, and fitness trackers, have evolved from basic monitoring tools to advanced medical-grade devices capable of continuous health tracking. The integration of artificial intelligence (AI) enhances their utility by enabling real-time data analysis, early diagnosis, and personalised disease management. Adoption accelerated during the COVID-19 pandemic, reinforcing their role in remote care. However, concerns regarding data privacy, accuracy, cost, and reduced human interaction persist. This study explores nurses' perceptions, awareness, and trust in AI-enabled wearable devices, identifies facilitators and barriers to adoption, and assesses demographic influences on attitudes.

Methods A total of 611 nurses were recruited using purposive sampling from educational hospitals in Saudi Arabia. Data were collected through an online structured questionnaire comprising demographic items, Likert-scale statements, and multiple-choice questions. Descriptive statistics and non-parametric tests (Kruskal-Wallis and Mann-Whitney U) were used to examine group differences.

Results Findings revealed generally positive attitudes toward AI-enabled wearables, with nurses acknowledging their potential to support personalised care, chronic disease management, and healthcare efficiency. However, data accuracy, affordability, and technical reliability emerged as prevalent concerns. Statistically significant differences were observed based on age ($p < 0.001$), education level ($p = 0.001$), and workplace setting ($p < 0.05$), with younger nurses and those in hospital settings expressing greater confidence in AI-driven health insights.

Conclusion While AI-enabled wearable devices are perceived as promising tools in nursing practice, concerns regarding data reliability, cost, and over-reliance on AI must be addressed. Structured training, institutional support, and clear guidelines are essential to ensure successful integration into clinical workflows and optimise their use in patient-centred care.

Clinical trial number Not applicable.

Keywords Wearable health technologies, Artificial intelligence in healthcare, Chronic disease management, AI-Enabled wearables, Patient-centred care, Remote monitoring

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Introduction

In recent years, the integration of digital health technologies into healthcare systems has brought about a profound transformation in the delivery, coordination, and personalisation of care [1–4]. This shift commonly referred to as digital transformation encompasses a range of innovations, including artificial intelligence (AI), telehealth, Electronic Health Records (HER), and wearable technologies, all aimed at improving efficiency, accessibility, and health outcomes [5]. Among these, wearable devices, such as smartwatches, fitness trackers, and biosensor patches, have become increasingly prominent due to their capacity for continuous, real-time monitoring of vital physiological parameters, including heart rate, glucose levels, blood pressure, and sleep patterns [6–10]. When integrated with AI, these devices can analyse large volumes of data to generate actionable insights, enhance clinical decision-making, and support proactive, patient-centred care [1, 11, 12]. International frameworks, including those developed by the World Health Organization and the European Commission, underscore the strategic importance of incorporating such digital tools into sustainable, equitable, and people-focused healthcare systems [13].

The advancement of wearable technology in healthcare

Wearable health technologies have advanced considerably, evolving from basic fitness trackers to complex medical-grade gadgets capable of continuous health monitoring. Recent breakthroughs in biosensor technology have facilitated the non-invasive monitoring of diverse biochemical and physiological signals. These advancements have established wearables as essential instruments in the management of chronic diseases, including diabetes, cardiovascular problems, and respiratory ailments [4, 14]. Wearable devices provide continuous data streams, enabling patients and clinicians to monitor illness progression, identify early warning signals, and modify treatment programs as necessary [4, 15, 16].

The COVID-19 pandemic expedited the deployment of wearable health devices, enabling remote monitoring and bolstering telemedicine initiatives. Throughout this timeframe, technologies like smartwatches and biosensors were extensively utilized to monitor symptoms, assess healing, and diminish the necessity for in-person healthcare consultations. This underscored the essential function of wearables in preserving healthcare continuity during crises [16].

Despite these advantages, AI-enabled wearable technologies are not without limitations. Technical challenges such as false alerts, device malfunctions, and user input errors can compromise the accuracy of data interpretation and lead to unnecessary patient anxiety or misdiagnoses [17–19]. Ethical considerations also arise, particularly regarding algorithmic bias where AI systems trained on non-representative datasets may disproportionately affect certain demographic groups, such as ethnic minorities or older adults [20–22]. Furthermore, although wearable devices offer continuous, real-time data, traditional health monitoring methods (e.g., in-clinic blood pressure checks, ECGs, and lab testing) continue to provide gold-standard diagnostic accuracy and human oversight that wearable devices cannot yet fully replicate [23, 24]. Understanding the trade-offs between AI-driven wearables and conventional monitoring is essential for their safe and equitable integration into nursing practice.

The function of artificial intelligence in wearable healthcare technology

Artificial Intelligence (AI) refers to the ability of computer systems to perform tasks typically requiring human intelligence, such as learning, reasoning, and pattern recognition [25, 26]. In healthcare, AI is applied in areas like diagnostic support, predictive analytics, and the analysis of complex health data [26]. When integrated into wearable technologies, AI enables continuous monitoring, early detection of health issues, and supports evidence-based clinical decisions with minimal human input [27].

Although wearable devices produce significant health data, the sheer volume and intricacy of this information can be daunting for both patients and practitioners. AI tools are essential in this context. Machine learning and deep learning algorithms can scrutinize extensive datasets from wearables, uncovering trends and patterns that may not be readily observable [3, 11, 28, 29]. AI-driven diagnostic models have exhibited significant precision in identifying illnesses such as atrial fibrillation, hypertension, and sleep disturbances. AI improves healthcare decision-making by analysing wearable data in real time, facilitating the early identification of potential health concerns and prompt actions [3].

AI-driven predictive analytics facilitates proactive care. For example, AI can evaluate continuous glucose monitoring data to forecast and avert diabetic crises or analyse electrocardiogram (ECG) signals from wearable devices to identify arrhythmias before to their manifestation [30, 31]. This transition from reactive to proactive treatment allows healthcare providers to intervene early, enhancing patient outcomes and alleviating the strain on healthcare systems.

While traditional health monitoring methods such as periodic in-clinic assessments, laboratory diagnostics, and manual charting remain the cornerstone of clinical evaluation, AI-enabled wearable devices offer continuous, real-time data collection and early detection capabilities that traditional methods cannot match [32, 33].

Wearables facilitate remote care, enable timely intervention, and empower patients through self-monitoring and personalised feedback. However, unlike conventional tools, wearable technologies may suffer from data noise, sensor errors, and lack of contextual interpretation leading to false alarms or overlooked clinical nuances [33, 34]. Moreover, traditional diagnostics often involve standardised protocols, clinician oversight, and validated benchmarks that enhance accuracy and clinical trust factors that are still evolving in wearable AI technologies [35]. Thus, while wearables enhance convenience and proactive monitoring, their effective use requires cautious integration alongside established clinical practices to avoid over-reliance or misapplication.

Nurses' perception about wearable devices

A growing body of research supports the perceived value of wearable technologies in promoting health monitoring and behavioural change from the perspective of nursing professionals. For instance, an empirical pilot study conducted in two emergency departments explored nurses' and patients' perceptions of wireless wearable sensor systems [36]. The devices tracked vital signs including heart rate, respiration rate, and oxygen saturation [36]. Results indicated that both nurses and patients perceived the system as highly useful and easy to use, with patients reporting slightly higher satisfaction. These perceptions suggest that wearable devices may be considered feasible for clinical integration and are generally well received by key stakeholders, which is critical for successful adoption in healthcare environments [36]. Recent studies further indicate that nurses particularly those in academic or educational hospital settings tend to hold favourable views of wearable health technologies, often perceiving them as useful tools for enhancing patient outcomes and streamlining clinical workflows [37]. As digital natives, many university-based nurses are familiar with mobile and wearable technologies, which has positively shaped their attitudes towards engaging with such innovations in clinical contexts. Wearable devices are also frequently perceived as effective instruments for promoting preventive health behaviours and monitoring physiological metrics. One survey, for example, found that 55% of nurses reported using wearable devices to track physical activity, while 34% indicated using them for broader health-related purposes underscoring their perceived relevance in both personal and professional settings [37, 38]. These attitudes are shaped by a range of factors, including individual confidence with technology, perceived ease of use, workplace culture, and prior training. Positive perceptions of wearables have been associated with increased patient engagement, enhanced chronic disease management, and improved nurse-patient communication [39, 40].

Notwithstanding these favourable evaluations, apprehensions about cost, data privacy, and sustained adherence continue to pose substantial obstacles to mainstream use. Resolving these difficulties may improve the acceptance and continued utilisation of wearable health technology in academic environments. Comprehending Nurses' perceptions of wearable devices offers essential insights into their perceived advantages and drawbacks, establishing a basis for the development of interventions designed to enhance Nurses health via technology. Despite the rapid growth of AI-integrated wearable health technologies and their documented benefits in chronic disease monitoring and self-management, limited empirical research has examined how nurses particularly those in educational hospital settings perceive and adapt to these tools in clinical contexts. Existing literature largely focuses on physicians or patients, leaving a gap in understanding nurses' unique experiences and attitudes toward AI-enabled wearables [41]. This study aims to address this gap by focusing on nurses' perspectives, thereby contributing valuable insights into the integration of such technologies into nursing-led care strategies.

Aim of the study

To explore nurses' perceptions, awareness, and trust in AI-enabled wearable health technologies for disease diagnosis, medication adherence, and clinical communication, among nurses working in educational hospitals.

- To investigate Nurses' views regarding the advantages and difficulties associated with the use of AI-enabled wearables for diagnosis and chronic disease management.
- To evaluate Nurses' perspectives on the impact of wearable technologies on enhancing medication adherence and prescription refills.
- To identify primary issues concerning data privacy, technical reliability, and human interaction in AI-enabled healthcare.
- To describe demographic variations (e.g., gender, educational background) in perceptions toward wearable health technologies.
- To explore how wearable technologies are perceived in terms of facilitating or limiting communication between patients and healthcare providers.

Methods

Study design

This study employed a cross-sectional descriptive survey design, which is particularly appropriate for capturing the perceptions, attitudes, and awareness levels of a defined population at a single point in time. Such a design is widely utilised in health informatics and nursing research to investigate responses to emerging technologies, including digital tools and AI-integrated systems. It enables the collection of a broad spectrum of data, facilitating the identification of patterns, demographic variations, and perceived barriers or enablers. The use of cross-sectional surveys in similar studies exploring healthcare professionals' perspectives on AI applications and wearable technologies further supports the suitability of this methodological approach for addressing the current research objectives.

Study population and setting

The study population consisted of nurses employed in educational hospitals across Saudi Arabia. These settings were deliberately selected to ensure representation from institutions engaged in both clinical service provision and healthcare education. Educational hospitals provide a particularly suitable context for investigating nurses' interactions with AI-enabled wearable technologies, as they are frequently at the forefront of implementing digital health innovations. The total accessible population encompassed 2,833 nurses across a range of departments and professional experience levels.

Sampling strategy and sample size

A purposive sampling strategy was employed to recruit nurses with direct clinical exposure and demonstrable familiarity with wearable health technologies. This approach was chosen to ensure that participants possessed the necessary experiential and contextual knowledge to provide informed perspectives, thereby enhancing the reliability and validity of the study findings. Inclusion criteria comprised: (1) current employment as a registered nurse in an educational hospital in Saudi Arabia; (2) a minimum of one year of clinical practice; and (3) self-reported familiarity with digital health tools, particularly wearable technologies. Nurses in purely administrative or managerial roles, as well as those with limited or no exposure to wearable devices, were excluded from participation.

The required sample size was determined using Cochran's formula, based on a 95% confidence level and a 5% margin of error both widely recognised standards in quantitative survey research. The calculation yielded a minimum sample of 338 participants. However, to enhance representativeness and account for possible non-response, a larger sample was intentionally targeted. Ultimately, 611 valid responses were collected, resulting in a robust dataset and a notably high response rate. This increase not only improved the statistical power of the study but also enabled more reliable subgroup analyses across demographic variables.

To mitigate the risk of selection bias, participants were purposively drawn from a broad spectrum of hospital departments, varying levels of professional seniority, and diverse clinical specialisations. This sampling framework ensured that the final cohort captured the heterogeneity of nursing roles within educational hospital environments. Such diversity allowed the study to present a more nuanced and comprehensive understanding of nurses' perceptions of AI-enabled wearable technologies across differing healthcare contexts.

Data collection instrument

The study employed an online structured questionnaire to capture nurses' demographic characteristics, experiences, and perceptions regarding AI-integrated wearable technologies. The development of the questionnaire was informed by a comprehensive review of relevant literature on wearable health technologies, artificial intelligence in healthcare, and digital health adoption among clinicians. Existing validated instruments were consulted where applicable, and new items were constructed to address study-specific objectives, particularly in the context of AI-enabled wearables in nursing practice. Items were designed to capture key domains such as perceived benefits, challenges, trust, training needs, and clinical integration.

The development of the questionnaire was informed by an extensive review of the literature on artificial intelligence in healthcare, wearable health technologies, and digital adoption among clinical professionals [e.g. 6, 14, 32, 42]. Existing validated instruments were consulted where applicable, and additional items were developed to address the specific objectives of the study, with a focus on nursing perceptions of AI-enabled wearable devices. The items were designed to capture multiple domains, including perceived benefits, barriers to adoption, levels of trust, training needs, and integration into clinical workflows.

To ensure both content validity and reliability, the questionnaire underwent a rigorous validation process, comprising expert review and a pilot study. Four academic faculty members with expertise in health informatics and nursing practice conducted the expert review, evaluating the instrument for clarity, relevance, question sequencing, and alignment with the study's conceptual framework. Their feedback was used to revise the structure and refine item wording. A pilot study was subsequently carried out with 12 nurses from the target population. This phase assessed the readability, comprehensibility, and applicability of the questionnaire, resulting in further improvements to item clarity and response formatting.

Internal consistency of the questionnaire was evaluated using Cronbach's alpha (see Table 1). The overall Cronbach's alpha for the full instrument was 0.92, indicating excellent internal reliability. Subscale alpha values were also strong, including perceived benefits of AI wearables

Table 1 Internal consistency reliability of questionnaire subscales (Cronbach's Alpha)

Subscale	Cronbach's Alpha
Perceived Benefits of AI Wearables	0.91
Trust in AI-Driven Decisions	0.87
Barriers to Adoption	0.84
Integration into Clinical Practice	0.86
Nurses' perceptions & Attitudes Toward Patients' Use of Wearable Devices	0.90
Overall Questionnaire	**0.92**

(α = 0.89), trust in AI-driven decisions (α = 0.87), barriers to adoption (α = 0.84), and integration into clinical practice (α = 0.86).

Following this validation process, modifications were made to improve question clarity, terminology precision, and response scale effectiveness, ensuring that the instrument captured meaningful and interpretable data.

The final questionnaire was structured into five key sections, each designed to capture different dimensions of nurses' experiences and perceptions of AI-enabled wearable technologies. The first section comprised the participant information and assurance letter, which outlined the study's objectives, ethical safeguards, and voluntary participation requirements. It also included a consent form and assurances of confidentiality and anonymity, encouraging participants to respond openly and honestly.

The second section focused on demographic information, gathering data on age, gender, years of nursing experience, hospital affiliation, and prior exposure to wearable technologies. This enabled categorical comparisons during data analysis. The third section explored general awareness and professional experience with wearable devices, including self-reported usage and familiarity with AI-enabled applications in clinical contexts. The fourth section consisted of a series of Likert-type scale items aimed at assessing nurses' perceptions across key domains such as patient monitoring, personalised care, chronic disease management, clinical decision-making support, and perceived impact on physicians' workload. These items were measured on a five-point Likert scale ranging from "Strongly Disagree" to "Strongly Agree", allowing for a structured, quantitative evaluation of attitudes.

The final section included open-ended questions designed to elicit qualitative insights. Participants were invited to elaborate on perceived barriers to adoption, concerns regarding AI integration, and recommendations for improving the clinical usability of wearable technologies. This combination of closed- and open-ended question formats facilitated both statistical analysis and thematic exploration, enhancing the depth and reliability of the study's findings.

Data collection process

The data collection phase commenced in February 2024 and spanned five months, concluding in June 2024. The questionnaire was administered via Google Forms, which facilitated ease of access and ensured that nurses could complete the survey at their convenience.

To enhance response rates, a structured follow-up strategy was implemented:

- First Reminder (End of Month 1): Sent to participants who had not yet completed the survey, reinforcing the importance of their contribution.
- Second Reminder (End of Month 3): Included a brief summary of the study's relevance to clinical nursing practice, encouraging engagement.
- Final Reminder (Final Month): A last call for participation, ensuring maximum representation before closing data collection.

Nurses were given ample time to complete the survey, and data confidentiality was strictly maintained. Access to raw data was restricted to authorised researchers, with responses stored securely to prevent unauthorised access or misuse.

Data analysis

A comprehensive statistical analysis was conducted using SPSS (version 29) and R software, integrating descriptive and inferential techniques to provide a robust examination of the collected data. Descriptive statistics, including frequencies, percentages, means, and standard deviations, were computed to summarise participants' responses across different variables. To assess statistically significant differences in perceptions based on demographic characteristics such as gender, years of experience, and hospital affiliation, Kruskal-Wallis H and Mann-Whitney U tests were employed, given the non-parametric nature of the data. A significance level of 0.05 was applied to all inferential analyses to determine meaningful associations.

For data visualisation, R software was exclusively utilised to present findings from the demographic and multiple-choice questions. Bar charts were generated for demographic variables with three or more response categories, allowing for a clear comparison of distributions. Pie charts were used to represent binary demographic variables, effectively illustrating the proportional breakdown of responses. Additionally, UpSet plots were employed for multiple-choice questions, where participants could select more than one response, providing a structured visualisation of overlapping selections and common response patterns. These visual representations enhanced the interpretability of the findings, facilitating a more comprehensive understanding of nurses' perceptions of AI-enabled wearable devices within educational hospital settings.

In addition to the quantitative analysis, qualitative responses obtained from the open-ended questions were analysed using thematic analysis. Responses were reviewed and transcribed directly from the online survey platform. An initial phase of open coding was undertaken to identify salient concepts and recurring patterns within the data. These codes were subsequently organised into categories and refined into overarching themes aligned with the study's research objectives. To enhance the credibility and analytical rigour of the process, the sole researcher employed a reflexive approach, maintaining analytic memos to capture evolving interpretations and ensure consistency throughout the coding process. In addition, a peer debriefing session was conducted with an academic colleague experienced in qualitative research to review the thematic framework and mitigate potential interpretative bias.

Ethical considerations

Ethical approval

was obtained before study commencement, ensuring strict adherence to ethical research guidelines. Participants were fully informed about:

- The study's purpose and scope.
- Their voluntary participation and the right to withdraw at any stage.
- Confidentiality measures, with all responses remaining anonymous.

Data were securely stored and protected, with no identifying information linked to participant responses. The study was conducted in compliance with institutional research ethics standards to uphold integrity and participant rights.

Result

The demographic distribution illustrated in Fig. 1 provides an insightful overview of the participants' characteristics across several key variables, including age, education, workplace, work role, department, hospitals, and gender. The age distribution reveals a relatively balanced spread across different age groups, with the highest proportion in the 18–25 category (38.5%), followed by those aged 26–35 (26.6%), indicating a predominantly younger workforce. In terms of education, a significant majority hold a bachelor's degree (56.5%), while master's degree holders (23.2%) represent a notable proportion, suggesting a well-educated sample population. The workplace distribution is heavily skewed towards hospital settings (46.6%), with smaller proportions working in primary care (18.9%), private clinics (10%), and academic institutions (10.3%), reflecting a concentration of healthcare professionals in secondary care environments.

Further examination of occupational roles indicates that nurse practitioners (NPs) comprise the majority (72.2%), followed by acute care nurses (13.5%) and clinical nurse specialists (13.8%), highlighting the dominance of advanced nursing practice within the sample. Departmental representation is fairly diverse, with the largest groups working in medical wards (20.5%), general wards (17.6%), and critical care units (12.8%), reflecting a broad distribution of expertise across various clinical settings. Additionally, the hospital affiliation of participants shows an almost equal division, with 51.8% working in public hospitals and 48.2% in private hospitals, demonstrating a balanced representation of nurses across different healthcare sectors. Lastly, the gender distribution exhibits a pronounced female predominance (72.4% female, 27.6% male), which aligns with the broader global trend of nursing being a female-dominated profession. The overall demographic distribution suggests a representative sample of nursing professionals with varying levels of education, work experience, departmental affiliations, and hospital types, contributing to a comprehensive understanding of workforce composition.

Figure 2 presents an analysis of nurses' awareness, experiences, and perceptions regarding the use of wearable devices in clinical practice. The majority of respondents (80.9%) report having used a wearable device, suggesting widespread familiarity with the technology. However, only 29.7% indicate that wearables are integrated within their hospitals, reflecting a gap between personal use and institutional adoption. Similarly, 27.6% of nurses report working with patients using wearable devices, which suggests that while the technology is known, its application in patient care is still limited. The responses regarding recommending wearable devices to patients are more varied, indicating differing levels of confidence in their effectiveness, potentially influenced by institutional policies, workflow integration challenges, or the perceived benefits for patient management.

The figure further explores nurses' comfort with digital health technologies, showing that while a substantial proportion express moderate to high confidence, a segment remains hesitant, possibly due to training gaps or concerns about usability. The most common patient age group using wearables skews toward younger and middle-aged adults, reinforcing the trend that digital health engagement is higher among tech-savvy populations. Finally, perceptions of wearables improving patient engagement vary, though there is a clear recognition of their potential benefits. Collectively, these findings highlight that while nurses are generally aware of and familiar with wearable technology, barriers to institutional integration and direct patient application remain, requiring

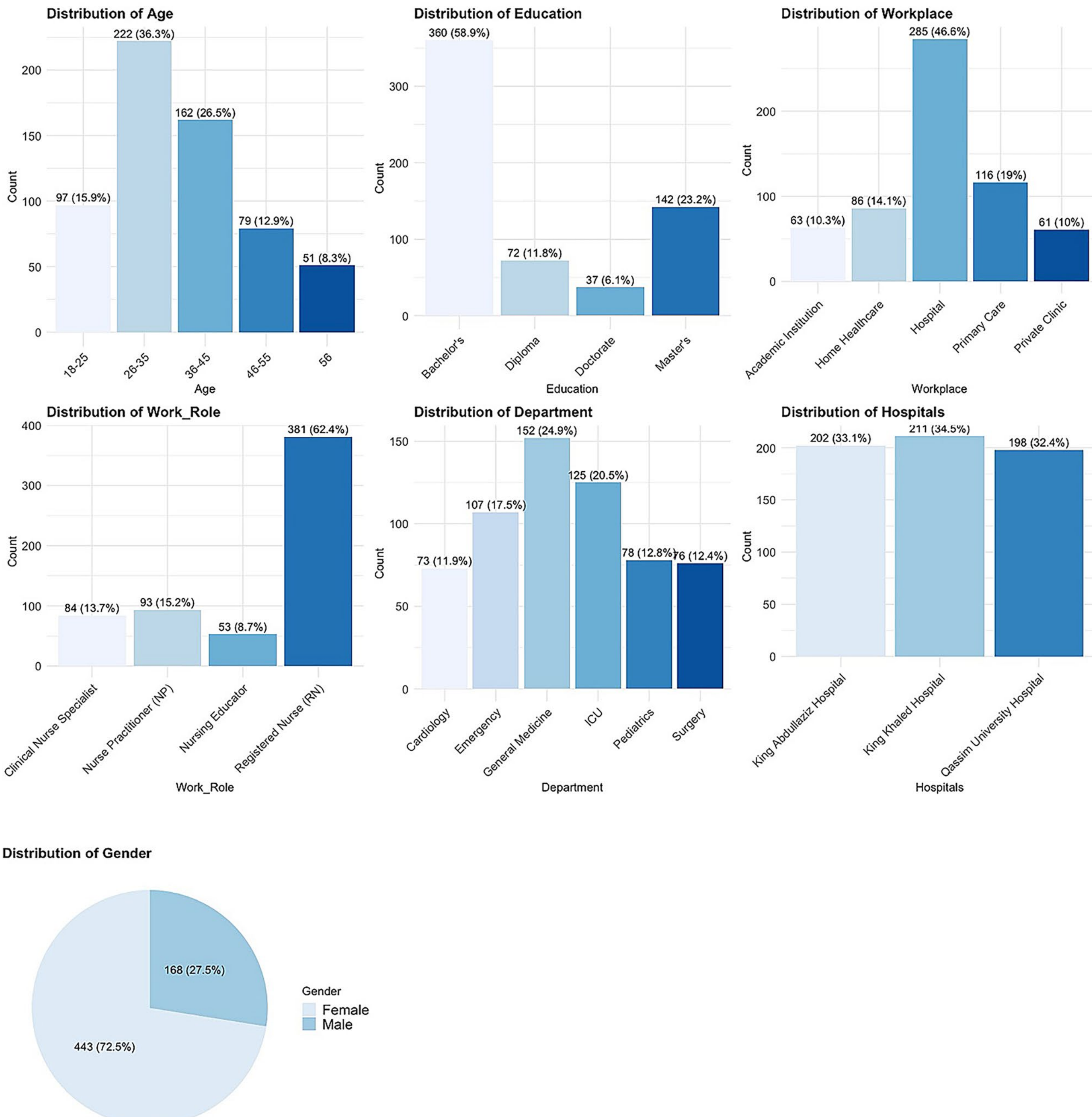

Fig. 1 Participants demographic information

further education, support, and evidence-based implementation strategies.

Table 2 summarises nurses' perceptions of the integration of AI-enabled tools with wearable device data to enhance clinical decision-making and patient care. The responses reflect moderate to strong agreement with the usefulness of AI, particularly in areas such as improving remote consultations (Mean = 3.65, SD = 1.06) and reducing physician workload (Mean = 3.64, SD = 1.16). Participants broadly acknowledged that AI systems are capable of interpreting large volumes of data more efficiently than humans (Mean = 3.54, SD = 1.09) and that such analysis could prevent disease-related complications (Mean = 3.62, SD = 1.03). However, a prevailing theme was the need for professional oversight, with high agreement that AI-generated interpretations must be supervised by healthcare professionals to ensure safety and accuracy (Mean = 3.56, SD = 1.05). Additionally, concerns regarding over-reliance on AI at the expense of human interaction in care delivery were notable, with the lowest

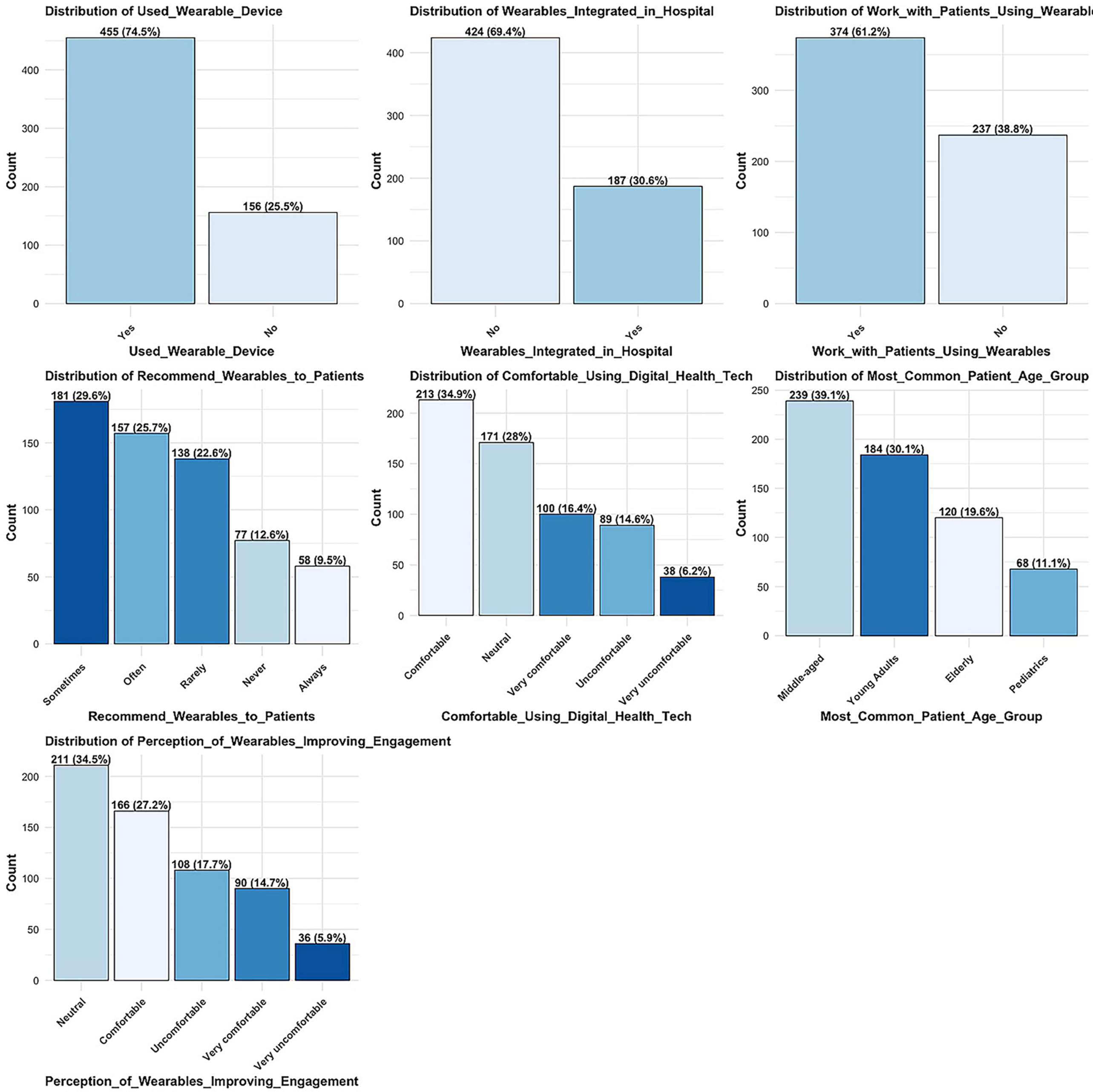

Fig. 2 Nurses' awareness and attitudes towards wearable devices in clinical practice

scoring item in this section being "loss of human touch" (Mean = 2.99, SD = 1.12), underscoring a cautious but open stance towards AI adoption.

Table 3 presents nurses' perspectives on the practical and clinical challenges associated with integrating wearable device data into patient care. A common concern was the inconsistency in patients' use of wearable technologies (Mean = 3.06, SD = 1.45), alongside anxiety induced by alarms and notifications (Mean = 3.01, SD = 1.38), which could lead to confusion or unnecessary clinical visits. Respondents also reported difficulties in interpreting the accuracy of health data generated by wearables (Mean = 3.03, SD = 1.44), and cited a lack of clinical guidelines (Mean = 3.08, SD = 1.42) as a critical barrier to effective usage. Notably, participants expressed concern that patients often misunderstand the data produced by their devices (Mean = 2.93, SD = 1.42), further complicating its integration into evidence-based care. These findings highlight a need for clearer frameworks and user education to reduce misinterpretation and support safer adoption of wearable technologies in clinical settings.

Table 2 Perceptions of AI-Enabled integration in clinical decision-making

Item	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Mean	SD
AI-driven interpretations of wearable device data need to be supervised by healthcare professionals to ensure accuracy.	34 (5.56%)	56 (9.17%)	156 (25.53%)	265 (43.37%)	100 (16.37%)	3.56	1.05
AI-enabled tools can make sense of large volumes of wearable device data better than human healthcare providers.	36 (5.89%)	58 (9.49%)	176 (28.81%)	220 (36.01%)	121 (19.8%)	3.54	1.09
Integration of wearable device data with AI can make remote consultations more effective.	23 (3.76%)	67 (10.97%)	147 (24.06%)	237 (38.79%)	137 (22.42%)	3.65	1.06
I would trust an AI system to provide recommendations based on patients' wearable health data.	36 (5.89%)	72 (11.78%)	140 (22.91%)	244 (39.93%)	119 (19.48%)	3.55	1.11
AI-driven analysis of wearable data can prevent disease-related complications.	22 (3.6%)	65 (10.64%)	160 (26.19%)	241 (39.44%)	123 (20.13%)	3.62	1.03
AI-enabled tools can help reduce the workload of physicians.	43 (7.04%)	56 (9.17%)	130 (21.28%)	229 (37.48%)	153 (25.04%)	3.64	1.16
Wearable devices integrated with AI can improve personalized care for chronic disease patients.	31 (5.07%)	50 (8.18%)	148 (24.22%)	255 (41.73%)	127 (20.79%)	3.65	1.06
Helpfulness of AI-enabled tools.	22 (3.6%)	69 (11.29%)	145 (23.73%)	254 (41.57%)	121 (19.8%)	3.63	1.04
Wearable devices can replace some healthcare visits.	29 (4.75%)	61 (9.98%)	154 (25.2%)	256 (41.9%)	111 (18.17%)	3.59	1.04
I am concerned that reliance on AI for health decisions could lead to a loss of human touch in patient care.	65 (10.64%)	126 (20.62%)	232 (37.97%)	125 (20.46%)	63 (10.31%)	2.99	1.12

Table 3 Perceived challenges in using wearable device data

Item	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Mean score	SD
Wearable device alarms/notifications often cause unnecessary patient anxiety.	114 (18.66%)	124 (20.29%)	123 (20.13%)	141 (23.08%)	109 (17.84%)	3.01	1.38
Many patients do not use wearable devices consistently or correctly.	119 (19.48%)	123 (20.13%)	114 (18.66%)	113 (18.49%)	142 (23.24%)	3.06	1.45
Patients frequently ask for clinical interpretations of their wearable device data.	128 (20.95%)	114 (18.66%)	128 (20.95%)	103 (16.86%)	138 (22.59%)	3.01	1.45
Integrating wearable device data into electronic health records (I) is difficult.	126 (20.62%)	128 (20.95%)	120 (19.64%)	116 (18.99%)	121 (19.8%)	2.96	1.42
Patients sometimes become overly reliant on wearable device data instead of seeking medical advice.	132 (21.6%)	109 (17.84%)	129 (21.11%)	123 (20.13%)	118 (19.31%)	2.98	1.42
The accuracy of health data from wearable devices is a concern in clinical decision-making.	131 (21.44%)	109 (17.84%)	106 (17.35%)	143 (23.4%)	122 (19.97%)	3.03	1.44
There is a lack of guidelines on how to use wearable device data in patient care.	116 (18.99%)	110 (18.0%)	129 (21.11%)	121 (19.8%)	135 (22.09%)	3.08	1.42
Patients often misunderstand or misinterpret the data from their wearable devices.	137 (22.42%)	111 (18.17%)	139 (22.75%)	108 (17.68%)	116 (18.99%)	2.93	1.42

Table 4 focuses on nurses' views regarding the clinical impact of wearable devices on patient care and chronic disease management. Overall, participants recognised some benefits, particularly in improving medication adherence (Mean = 3.10, SD = 1.42) and aiding remote monitoring (Mean = 3.03, SD = 1.42). However, their confidence in wearables' ability to meaningfully reduce workload (Mean = 2.95, SD = 1.44) or improve clinical decision-making (Mean = 2.88, SD = 1.40) was relatively limited. Similar levels of cautious agreement were observed regarding the ability of wearable technologies to reduce unplanned hospital visits (Mean = 3.00, SD = 1.40) and enhance early detection of health issues (Mean = 2.98, SD = 1.42). These responses suggest that while wearables are valued for supporting routine monitoring and promoting adherence, their perceived impact on more complex clinical outcomes remains ambiguous, potentially due to inconsistent implementation or limited evidence in real-world practice.

Table 5 explores nurses' perceptions of institutional readiness, training, and confidence in using wearable devices within clinical workflows. While there was moderate agreement that wearable devices warrant greater institutional investment (Mean = 2.92, SD = 1.41), responses reflected limited confidence among nurses in interpreting wearable data (Mean = 2.99, SD = 1.38) and in receiving adequate training (Mean = 2.97, SD = 1.37). Encouragingly, there was stronger agreement that

Table 4 Clinical impact of wearables on patient monitoring and disease management

Item	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Mean	SD
Wearable devices can help in remote patient monitoring and telehealth interventions.	124 (20.29%)	110 (18.0%)	124 (20.29%)	131 (21.44%)	122 (19.97%)	3.03	1.42
Wearable devices reduce the workload by providing continuous patient monitoring.	133 (21.77%)	123 (20.13%)	124 (20.29%)	103 (16.86%)	128 (20.95%)	2.95	1.44
Data from wearable devices helps in making more informed clinical decisions.	132 (21.6%)	135 (22.09%)	120 (19.64%)	121 (19.8%)	103 (16.86%)	2.88	1.4
Wearable devices contribute to improved medication adherence in patients.	112 (18.33%)	113 (18.49%)	127 (20.79%)	120 (19.64%)	139 (22.75%)	3.1	1.42
Patients using wearable devices provide more useful health data during consultations.	119 (19.48%)	133 (21.77%)	118 (19.31%)	110 (18.0%)	131 (21.44%)	3.0	1.43
Wearable devices help in managing chronic conditions (e.g., diabetes, hypertension, heart disease).	115 (18.82%)	130 (21.28%)	108 (17.68%)	133 (21.77%)	125 (20.46%)	3.04	1.42
Patients using wearable devices require fewer unplanned hospital visits.	120 (19.64%)	120 (19.64%)	128 (20.95%)	126 (20.62%)	117 (19.15%)	3.0	1.4
Wearable health devices improve the early detection of health issues in my patients.	124 (20.29%)	130 (21.28%)	115 (18.82%)	119 (19.48%)	123 (20.13%)	2.98	1.42

Table 5 Institutional readiness and nurse training for wearable device integration

Item	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Mean	SD
My hospital/clinic should invest more in wearable device technology for patient care.	134 (21.93%)	121 (19.8%)	131 (21.44%)	111 (18.17%)	114 (18.66%)	2.92	1.41
More standardized protocols are needed for incorporating wearable device data into nursing practice.	120 (19.64%)	109 (17.84%)	120 (19.64%)	127 (20.79%)	135 (22.09%)	3.08	1.43
I have received adequate training on how to use and interpret wearable device data.	123 (20.13%)	109 (17.84%)	151 (24.71%)	122 (19.97%)	106 (17.35%)	2.97	1.37
Training on wearable devices should be included in nursing education and professional development.	119 (19.48%)	107 (17.51%)	121 (19.8%)	113 (18.49%)	151 (24.71%)	3.11	1.46
There is sufficient institutional support for integrating wearable devices into patient care.	113 (18.49%)	119 (19.48%)	129 (21.11%)	119 (19.48%)	131 (21.44%)	3.06	1.41
I feel confident in interpreting and utilizing wearable device data for patient care.	116 (18.99%)	127 (20.79%)	121 (19.8%)	140 (22.91%)	107 (17.51%)	2.99	1.38
My healthcare facility supports the use of wearable devices for patient monitoring.	123 (20.13%)	122 (19.97%)	107 (17.51%)	122 (19.97%)	137 (22.42%)	3.05	1.45
I encourage patients to use wearable devices to monitor their health.	121 (19.8%)	125 (20.46%)	120 (19.64%)	103 (16.86%)	142 (23.24%)	3.03	1.45

training on wearable technology should be formally integrated into nursing education and professional development programmes (Mean = 3.11, SD = 1.46), and that more standardised protocols are needed for wearable device use in nursing practice (Mean = 3.08, SD = 1.43). These findings suggest that while nurses are receptive to wearable integration, there is a pressing need for enhanced institutional support and targeted training initiatives to ensure readiness and effective implementation.

Table 6 summarises nurses' attitudes towards how patients engage with wearable devices and the influence of these tools on health behaviours. Although participants agreed that wearable technologies promote treatment adherence (Mean = 2.99, SD = 1.40) and increased self-monitoring (Mean = 3.04, SD = 1.41), there was notable scepticism regarding whether these devices lead to meaningful patient empowerment. For instance, responses were divided on whether wearable users are more engaged in managing their health (Mean = 2.88, SD = 1.40) or make health decisions independently without clinician input (Mean = 3.04, SD = 1.37). Additionally, while many agreed that patients trust wearable data (Mean = 3.07, SD = 1.44), concerns persisted regarding over-reliance on technology in place of professional guidance. Overall, these findings suggest that nurses perceive wearables as a useful complement to patient care but stress the importance of maintaining clinical oversight and enhancing patient education to ensure safe and informed use.

The UpSet plot in Fig. 3 illustrates nurses' perceptions of the primary benefits of wearable devices in managing chronic diseases, highlighting the interconnected advantages of this technology. The set size bar chart indicates that the most frequently recognised benefits include

Table 6 Nurses' perceptions & attitudes toward patients' use of wearable devices

Item	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Mean	SD
Patients who use wearable devices report fewer health concerns due to increased self-monitoring.	114 (18.66%)	124 (20.29%)	129 (21.11%)	114 (18.66%)	130 (21.28%)	3.04	1.41
Wearable devices motivate patients to maintain a healthier lifestyle.	135 (22.09%)	128 (20.95%)	96 (15.71%)	124 (20.29%)	128 (20.95%)	2.97	1.46
Patients with wearable devices are more likely to monitor their health conditions regularly.	129 (21.11%)	117 (19.15%)	132 (21.6%)	117 (19.15%)	116 (18.99%)	2.96	1.41
Patients often make health decisions based on wearable device data without consulting a healthcare provider.	104 (17.02%)	131 (21.44%)	133 (21.77%)	122 (19.97%)	121 (19.8%)	3.04	1.37
Patients trust the health data collected by wearable devices.	120 (19.64%)	108 (17.68%)	132 (21.6%)	109 (17.84%)	142 (23.24%)	3.07	1.44
Wearable devices help patients adhere to their prescribed treatments.	121 (19.8%)	125 (20.46%)	117 (19.15%)	136 (22.26%)	112 (18.33%)	2.99	1.4
Patients with wearable devices are more engaged in managing their health.	129 (21.11%)	143 (23.4%)	122 (19.97%)	109 (17.84%)	108 (17.68%)	2.88	1.4
Patients who use wearable health devices have better health awareness.	124 (20.29%)	129 (21.11%)	119 (19.48%)	105 (17.18%)	134 (21.93%)	2.99	1.44

enhanced patient-provider communication, better tracking of vital signs, and early detection, underscoring the role of wearables in improving clinical interactions and facilitating real-time monitoring. The intersection bar chart reveals the most common combinations of these benefits, with the highest intersection size reaching 18 responses, suggesting that nurses view these advantages as complementary rather than isolated. The matrix visualisation further demonstrates how different benefits overlap, with multiple connections reflecting diverse yet recurring patterns in nurses' perspectives. Additionally, benefits such as improved medication adherence, reduced workload, and increased patient engagement were frequently co-selected, reinforcing the view that wearable technology enhances both patient-centred care and clinical efficiency. This analysis suggests that while individual benefits are acknowledged, nurses predominantly perceive wearable devices as a holistic tool that integrates various aspects of healthcare to optimise chronic disease management.

The UpSet plot in Fig. 4 illustrates the primary challenges nurses encounter when incorporating patient-generated data from wearable devices into clinical practice, highlighting the complexity of integrating such technology into existing workflows. The set size bar chart reveals that the most frequently reported challenges include a lack of guidelines, patient misinterpretation of data, and limited EHR integration, indicating significant barriers related to standardisation and data interoperability. The intersection bar chart further demonstrates the most common combinations of challenges, with the largest intersection size reaching 48 responses, suggesting that nurses often experience multiple obstacles simultaneously. The matrix visualisation illustrates overlapping concerns, with notable intersections among accuracy issues, time constraints, inconsistent patient use, and increased patient anxiety, reflecting the broader difficulties associated with the reliability, usability, and clinical applicability of wearable-generated data. These findings underscore the need for clear clinical guidelines, improved EHR integration, and enhanced patient education to facilitate the effective utilisation of wearable technology in healthcare settings.

The UpSet plot in Fig. 5 presents an analysis of how nurses encourage and support patients in using wearable devices for chronic disease management, revealing the most common strategies adopted in clinical practice. The set size bar chart highlights that the most frequently reported approaches include providing training, educating patients, and monitoring and validating data, suggesting a strong emphasis on patient empowerment and data accuracy. The intersection bar chart further illustrates the most prevalent combinations of strategies, with the highest intersection size reaching 58 responses, indicating that multiple supportive actions are often employed simultaneously. The matrix visualisation demonstrates overlapping methods, particularly among training, discussing data during consultations, and recommending devices, reinforcing the role of healthcare professionals in guiding patients through the adoption and effective use of wearable technology. Interestingly, a smaller subset of responses indicates a lack of encouragement for device use, highlighting potential concerns or hesitancy in certain clinical settings. These findings underscore the importance of structured education, data validation, and ongoing clinical discussions in enhancing patient engagement with wearable devices for chronic disease self-management.

The UpSet plot in Fig. 6 illustrates nurses' perspectives on the key improvements needed to enhance the effectiveness of wearable devices in chronic disease management, highlighting the most frequently

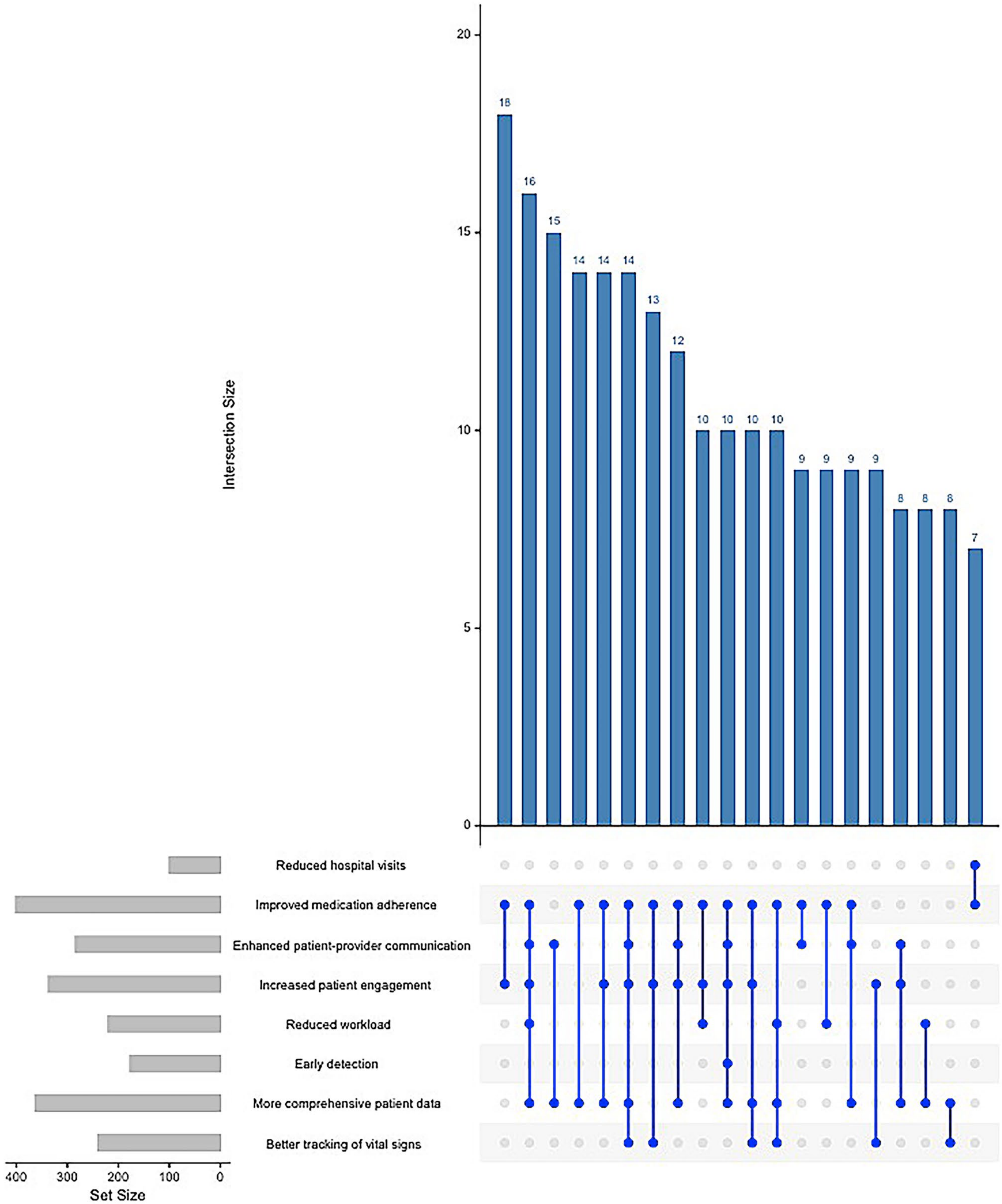

Fig. 3 Nurses' perceptions of the primary benefits of wearable devices in chronic disease management: An UpSet plot pnalysis

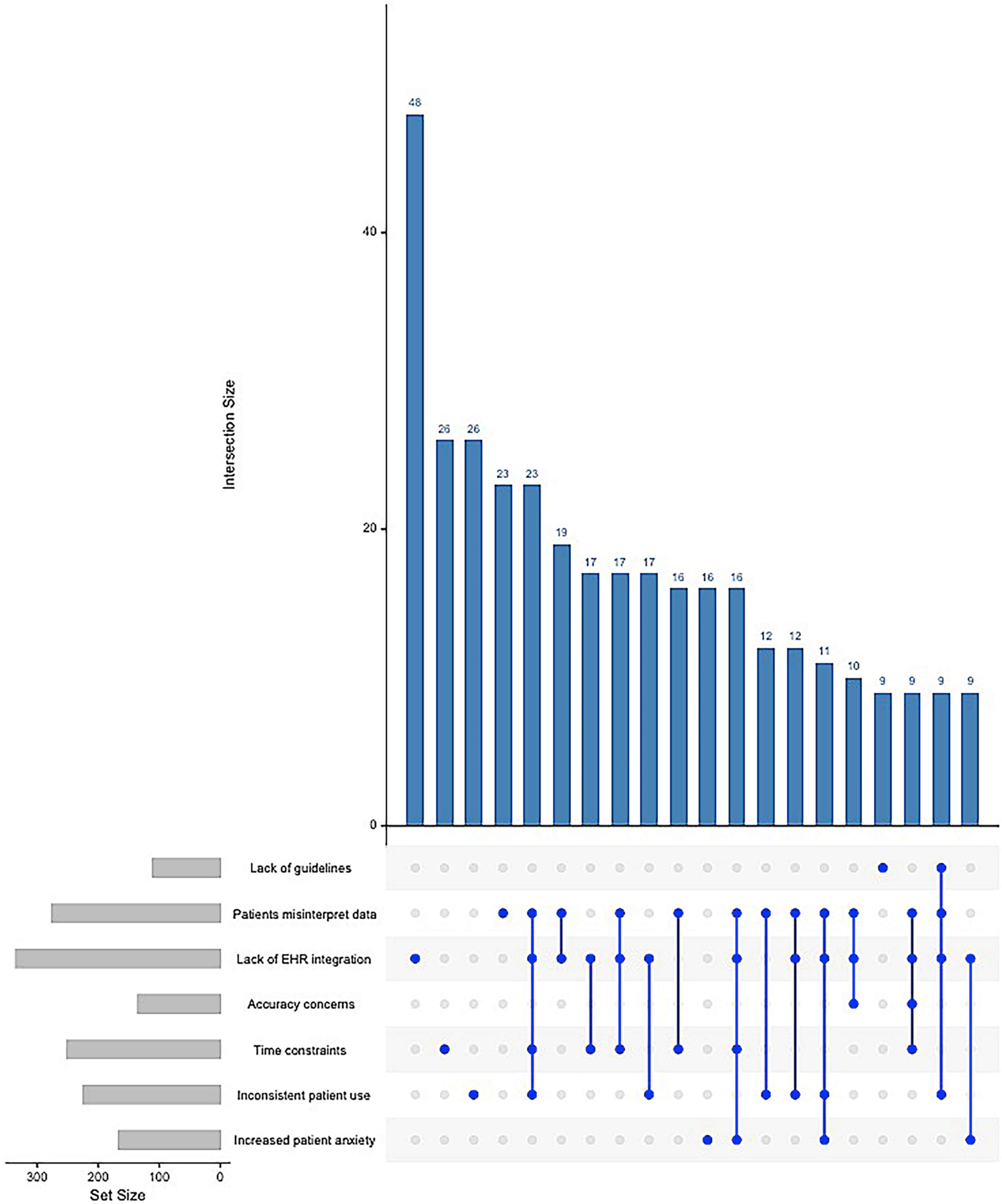

Fig. 4 Challenges in integrating patient-generated data from wearable devices into clinical practice: An UpSet plot analysis

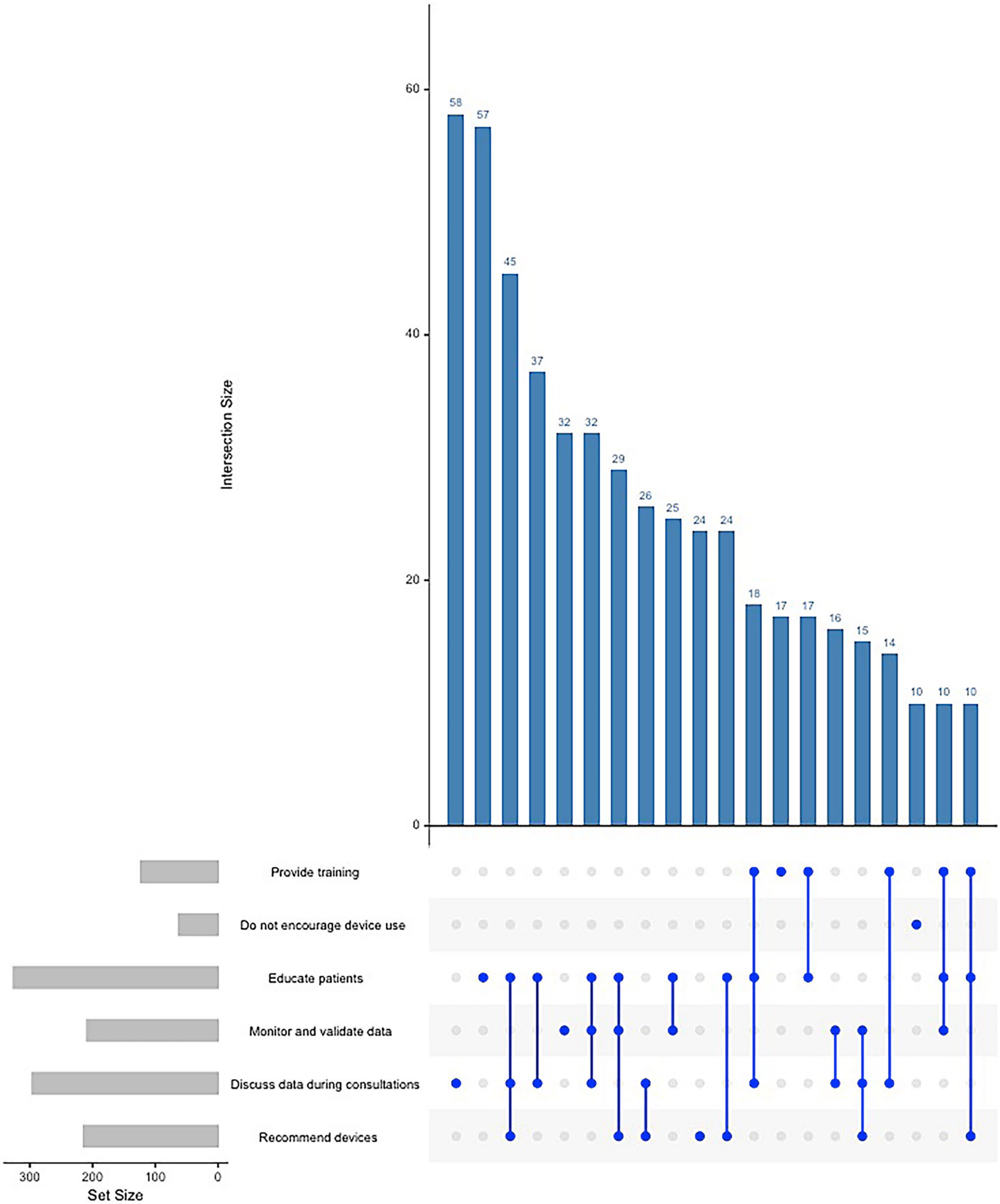

Fig. 5 Nurses' strategies for supporting patients in using wearable devices for chronic disease management: An UpSet plot analysis

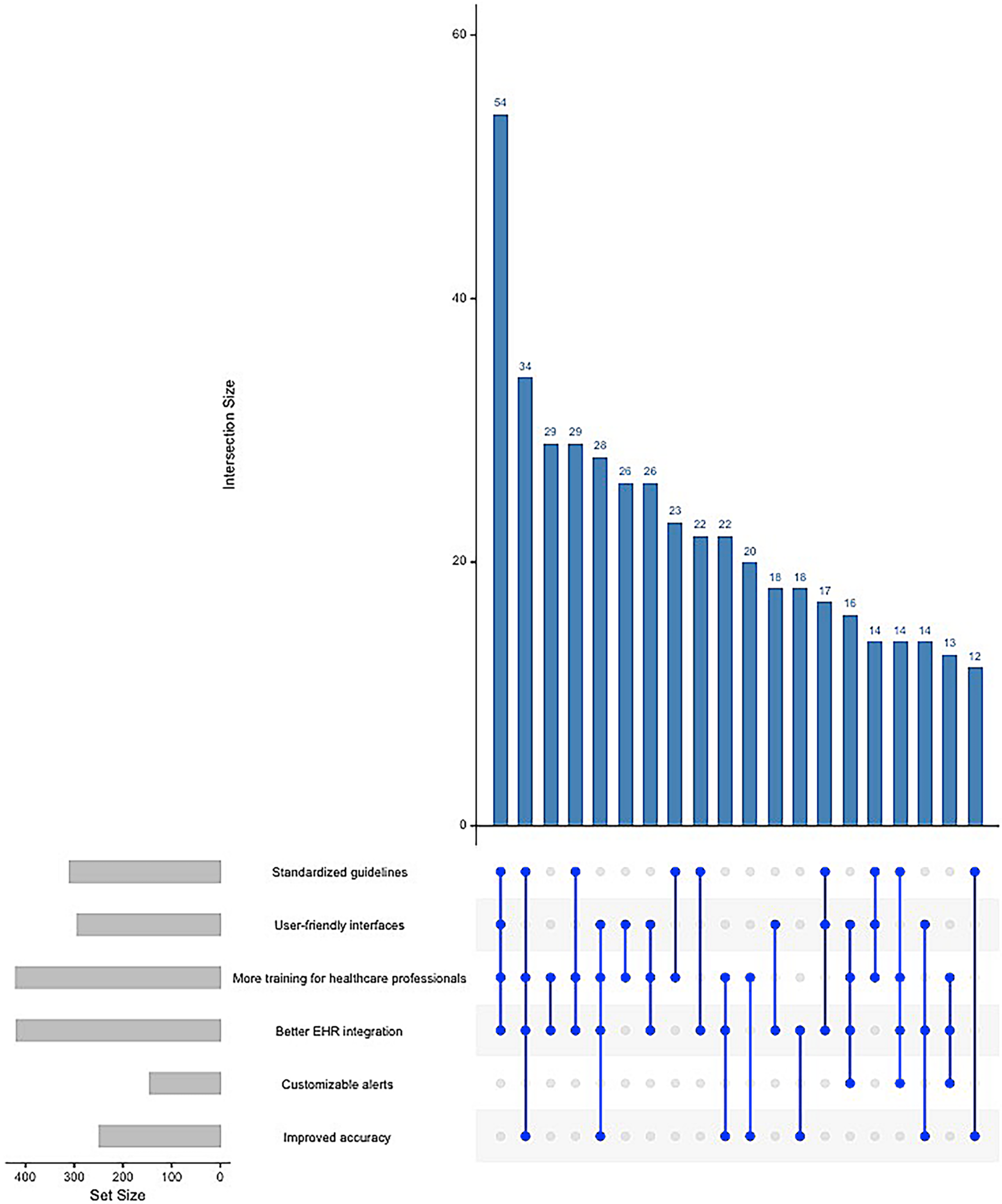

Fig. 6 Recommended improvements to enhance the usefulness of wearable devices in chronic disease management: An UpSet plot analysis

suggested modifications. The set size bar chart indicates that the most commonly cited improvements include standardised guidelines, more training for healthcare professionals, and better EHR integration, emphasising the necessity for clearer protocols and improved interoperability between wearable technology and existing healthcare infrastructure. The intersection bar chart reveals that the most frequent combination of suggested improvements, reported by 54 respondents, involves multiple enhancements being required simultaneously, indicating that nurses view these changes as interconnected rather than standalone solutions. The matrix visualisation further illustrates the overlap between different improvement areas, with frequent intersections among user-friendly interfaces, customisable alerts, and improved accuracy, suggesting that both usability and data precision are critical factors in enhancing the clinical utility of wearable devices. These findings highlight the urgent need for institutional support, structured training, and seamless integration into clinical workflows to maximise the potential benefits of wearable technology in managing chronic conditions.

The UpSet plot in Fig. 7 presents an analysis of nurses' perceptions regarding the role of artificial intelligence (AI) in analysing wearable device data to support chronic disease management, highlighting key concerns and barriers to AI adoption in clinical settings. The set size bar chart reveals that the most frequently cited concerns include AI bias, limited training, and ethical considerations, indicating widespread apprehension about the reliability, fairness, and ethical implications of AI-driven decision-making in healthcare. The intersection bar chart demonstrates that 52 respondents reported multiple concerns simultaneously, suggesting that nurses perceive these challenges as interrelated rather than isolated issues. The matrix visualisation further illustrates the overlap among integration difficulties, healthcare professional resistance, and lack of trust in AI, highlighting systemic challenges that may hinder AI adoption in clinical practice. These findings underscore the need for improved AI training, transparent integration frameworks, and ethical safeguards to build trust and enhance the clinical utility of AI-driven wearable data analysis in chronic disease management.

The UpSet plot in Fig. 8 illustrates the key challenges nurses identify in integrating artificial intelligence (AI) for analysing wearable device data in clinical practice, highlighting concerns related to both automation and clinical reliability. The set size bar chart indicates that the most frequently reported challenges include concerns about AI replacing human decisions, the necessity of AI supervision, and the reliability of AI-generated alerts, reflecting a widespread apprehension about the potential loss of clinical autonomy and decision-making authority. The intersection bar chart shows that 61 respondents reported multiple concerns simultaneously, demonstrating the interconnected nature of these challenges. The matrix visualisation further reveals overlapping concerns among AI's role in improving data interpretation, detecting early signs, and reducing workload, suggesting that while AI is recognised for its potential benefits, its integration remains hindered by issues of trust, supervision, and reliability. These findings underscore the importance of establishing clear oversight mechanisms, ensuring AI augments rather than replaces clinical judgment, and fostering confidence in AI-driven decision support to enhance its effectiveness in wearable data analysis.

Demographic variations in nurses' perceptions of patient engagement, AI benefits, and trust

The Mann-Whitney U test was conducted to examine differences in nurses' perceptions of AI-enabled wearable devices based on gender (see Table 7). The results indicate that none of the comparisons reached statistical significance, with all p-values exceeding 0.05. This suggests that male and female nurses hold relatively similar views regarding the integration, challenges, and impact of AI-enabled wearables in clinical practice. While the test for AI-enabled tools yielded the lowest p-value ($p = 0.083$), indicating a potential trend towards a difference, it remains non-significant at the conventional 0.05 threshold. This suggests that further research with a larger sample or additional contextual factors may be necessary to determine whether gender plays a role in shaping attitudes toward AI-enabled wearables. Similarly, perceptions of challenges associated with wearable devices ($p = 0.788$), impact on patient care ($p = 0.840$), integration in clinical practice ($p = 0.885$), and overall perceptions of wearables ($p = 0.435$) showed no significant differences, reinforcing the notion that gender does not substantially influence these attitudes.

The Kruskal-Wallis test results revealed several statistically significant differences in nurses' perceptions of AI-enabled wearable technologies across demographic variables (see Table 8). Age and education level were particularly influential, with younger nurses and those with higher educational attainment demonstrating more favourable or critical views (both $p < 0.001$), suggesting that training strategies may need to be tailored to accommodate varying levels of digital familiarity and clinical experience. Significant differences were also observed based on workplace setting, work role, and departmental affiliation (all $p < 0.05$), indicating that nurses' exposure to, and engagement with, wearable technologies may differ depending on their clinical environment or professional responsibilities.

In contrast, no significant differences were found with respect to hospital affiliation or perceptions of integration

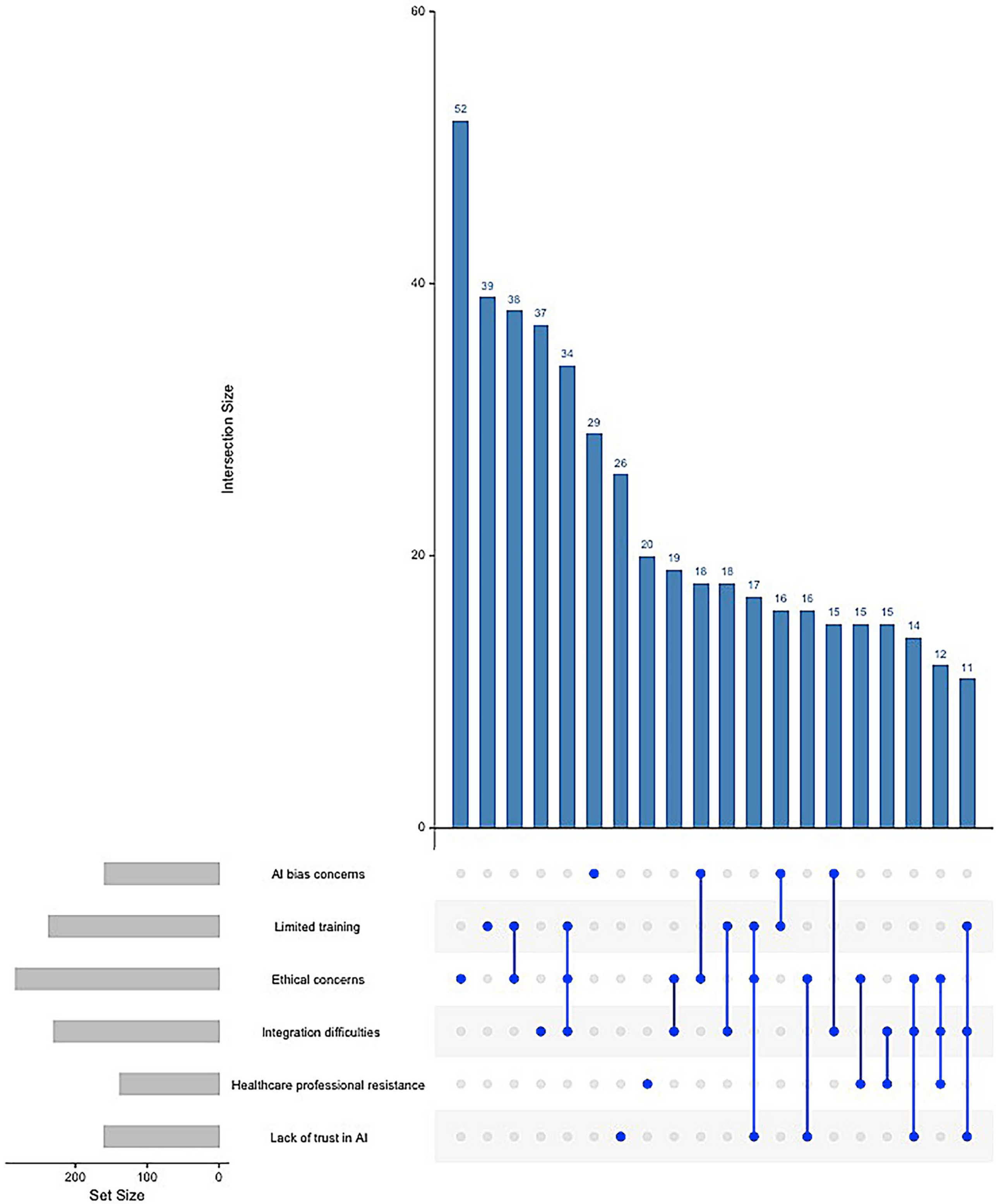

Fig. 7 Nurses' perceptions of AI in analysing wearable device data for chronic disease management: An UpSet plot analysis

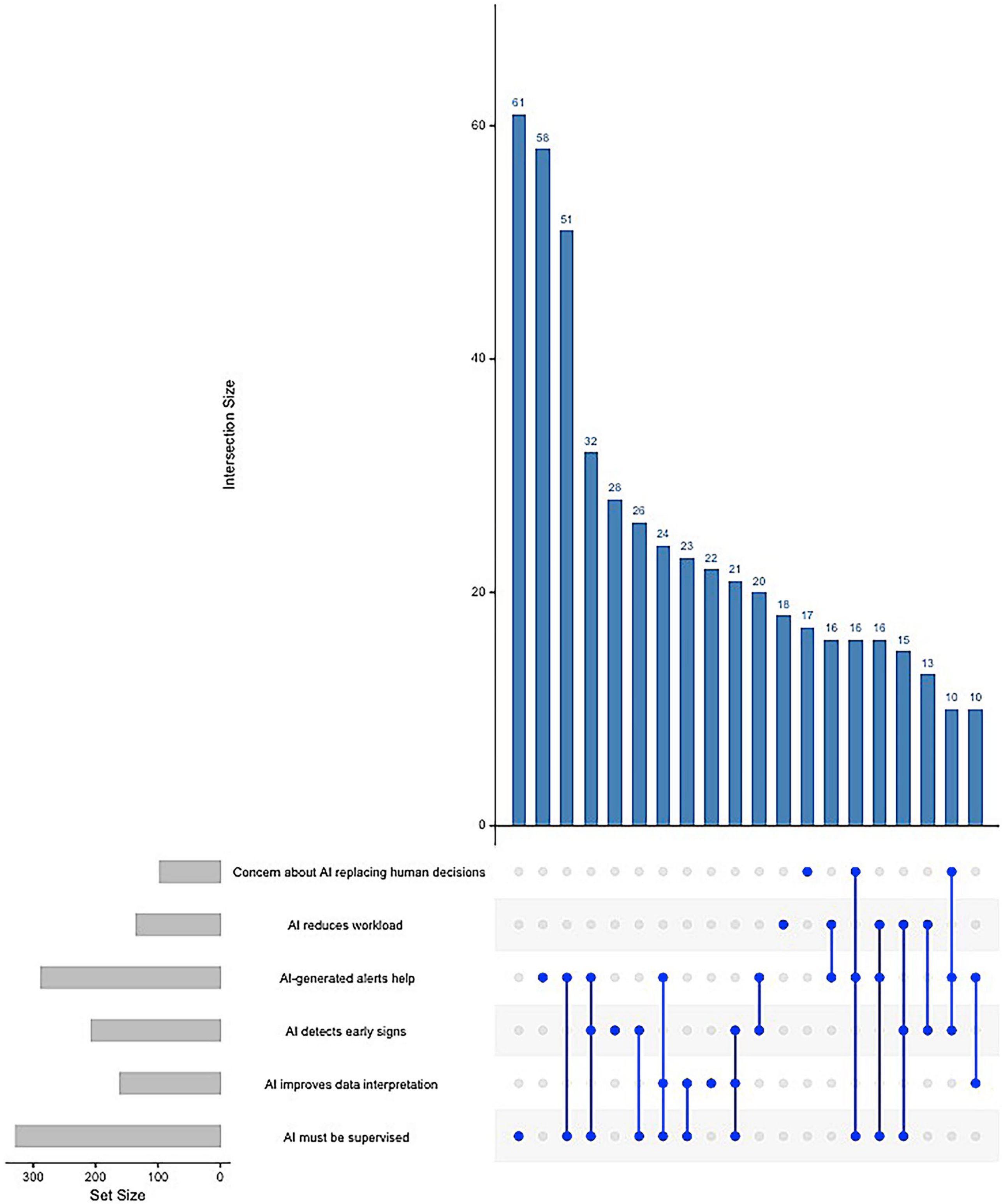

Fig. 8 Key Challenges in integrating AI for analysing wearable device data in clinical practice: An UpSet plot analysis

Table 7 Mann-Whitney U test results for Gender-Based differences in nurses' perceptions of AI-enabled wearable device

Dependent variable	Statistic	*P*_Value
AI Powered Tools	40580.0	0.083
Challenges Using Wearables	37736.0	0.788
Impact on Patient Care	37604.0	0.84
Integration in Clinical Practice	36930.5	0.885
Nurses Perception Wearables	38730.5	0.435

Table 8 Kruskal-wallis test results for differences in nurses' perceptions of AI-enabled wearable tools across demographic groups

Dependent variable	Statistic	*P*_value
Age		
AI Powered Tools	35.883	0.001
Challenges Using Wearables	3.095	0.542
Impact on Patient Care	2.335	0.674
Integration in Clinical Practice	2.168	0.705
Nurses Perception Wearables	0.851	0.931
Education		
AI Powered Tools	22.373	0.001
Challenges Using Wearables	2.089	0.554
Impact on Patient Care	2.679	0.444
Integration in Clinical Practice	1.681	0.641
Nurses Perception Wearables	0.834	0.841
Workplace		
AI Powered Tools	42.256	0.001
Challenges Using Wearables	10.135	0.038
Impact on Patient Care	11.763	0.019
Integration in Clinical Practice	0.844	0.933
Nurses Perception Wearables	4.231	0.376
Work Role		
AI Powered Tools	20.153	0.001
Challenges Using Wearables	0.986	0.805
Impact on Patient Care	8.374	0.039
Integration in Clinical Practice	2.166	0.539
Nurses Perception Wearables	2.164	0.539
Department		
AI Powered Tools	51.727	0.001
Challenges Using Wearables	3.212	0.667
Impact on Patient Care	1.575	0.904
Integration in Clinical Practice	3.784	0.581
Nurses Perception Wearables	3.671	0.598
Hospitals		
AI Powered Tools	0.33	0.848
Challenges Using Wearables	0.411	0.814
Impact on Patient Care	0.963	0.618
Integration in Clinical Practice	4.149	0.126
Nurses Perception Wearables	0.527	0.768

into clinical practice ($p > 0.05$), implying that institutional setting and broader implementation frameworks may exert less influence on nurses' attitudes. Similarly, concerns related to the usability, reliability, and accuracy of wearable technologies appeared to be consistent across demographic subgroups, reflecting a shared set of practical and technical challenges among nursing professionals.

Thematic analysis of the open-ended responses revealed that nurses generally acknowledged the clinical potential of AI-enabled wearable technologies (see Table 9), particularly in enhancing diagnostic accuracy ($n = 22$) and supporting chronic disease monitoring ($n = 13$). These devices were seen as useful for detecting early warning signs and enabling timely interventions. Nonetheless, concerns were raised regarding data privacy ($n = 14$), overreliance on AI in clinical decision-making ($n = 9$), and the lack of technical support ($n = 13$). A substantial number of participants reported limited exposure ($n = 20$) and insufficient knowledge ($n = 15$) of such technologies, highlighting the importance of targeted training and professional development to ensure confident and effective use in clinical practice.

In relation to medication adherence and communication, personalised medication reminders ($n = 28$) and automated prescription refills ($n = 19$) were among the most frequently cited benefits. However, participants also expressed concerns about device malfunctions ($n = 14$), inconsistent AI recommendations ($n = 11$), and the absence of adequate physician follow-up ($n = 9$). Affordability was mentioned as a barrier by some respondents ($n = 8$), especially in relation to patients from lower-income backgrounds. Regarding communication outcomes, nurses noted the value of real-time health insights ($n = 25$) and a reduction in unnecessary follow-up appointments ($n = 19$). At the same time, worries about diminished face-to-face interaction ($n = 15$) and a loss of the human element in care ($n = 11$) were evident. Still, several nurses ($n = 8$) viewed wearables as a valuable complement to traditional care, and a smaller group ($n = 6$) highlighted their role in promoting patient autonomy and self-management.

Discussion

The findings of this study offer valuable insights into nurses' perceptions, awareness, and trust in AI-enabled wearable health technologies, particularly in relation to disease diagnosis, medication adherence, and patient–clinician communication. Participants broadly recognised the potential benefits of these technologies, especially their role in enhancing diagnostic accuracy, supporting chronic disease management, and delivering personalised medication reminders. AI-integrated wearables were viewed as tools that could improve patient engagement and enable real-time, data-driven clinical decision-making. However, notable concerns emerged regarding data privacy, device reliability, and the potential reduction in human interaction, all of which present barriers to broader adoption.

Table 9 Thematic analysis of nurses' Open-Ended responses on AI-Enabled wearable technologies: perceived benefits, challenges, and future considerations

Theme	Code	Sample Responses		Frequency
Question 1: Perceptions of AI-Enabled Wearable Technologies for Diagnosis and Disease Management				
Theme	**Code**	**Sample Responses**		**Frequency**
Positive Perceptions	Improved diagnostic accuracy	"Wearable devices with AI provide early warning signs, which helps prevent complications."	"AI-enabled wearables make it easier to detect early-stage health issues."	22
	Enhanced chronic disease monitoring	"I believe wearable devices help track chronic conditions more efficiently."	"The continuous data helps both me and my doctor keep track of progress."	13
Concerns and Barriers	Data privacy concerns	"I'm worried about who has access to my personal health data collected by wearables."	"It's unclear how wearable data is protected especially in case of a breach."	14
	Overreliance on AI	"Relying solely on AI could lead to missed diagnoses without human oversight."	"Sometimes AI-based diagnostics seem overconfident and might mislead users."	9
	Lack of technical support	"If the app or device fails, I wouldn't know how to get proper technical assistance."	"If it breaks, I don't know who to contact for support it's frustrating."	13
Neutral/Unsure	Limited exposure	"I haven't used AI-based wearables much, so I can't form an opinion."	"I've heard of these devices, but I'm not confident enough to use them."	20
	Insufficient knowledge	"I don't fully understand how these devices work or their diagnostic capabilities."	"There's too much technical jargon around how wearables collect and process data."	15
Mixed Optimism	Balanced perspective	"These devices can be helpful but shouldn't be treated as a replacement for doctors."	"I think they're useful but need professional oversight for major decisions."	12
Question 2: Potential Advantages and Challenges in Managing Medication Adherence and Prescription Refills				
Theme	Code	Sample Responses		Frequency
Benefits of Wearables	Personalized reminders	"The reminders from wearables keep patients informed about their next medication dose."	"It's helpful to get personalized alerts, especially for older adults."	28
	Streamlined prescription refills	"The AI system auto-orders refills before the medication runs out this is convenient."	"I like that I don't have to manually reorder my medications AI handles it."	19
Challenges	Device malfunctions	"Sometimes the device glitches and stops sending reminders."	"There have been times when notifications stop working completely."	14
	Inconsistent AI recommendations	"The AI sometimes provides conflicting advice, which makes me hesitant to trust it."	"Sometimes two different devices give different readings it's confusing."	11
	Lack of physician follow-up	"Without a follow-up from the physician, I would be unsure whether the recommendation is accurate."	"A doctor's confirmation helps me feel reassured, especially for big changes."	9
Mixed Perceptions	Good for routine cases	"Wearables are great for simple cases, but for anything serious, you need a doctor."	"For routine prescriptions, it's convenient, but for complex medication, I need human input."	8
Concerns About Cost	Affordability concerns	"The cost of advanced AI-enabled wearables is too high for some patients."	"The subscription fees for these wearables are often out of reach for many patients."	8
Question 3: Impact of AI-Enabled Wearables on Communication and Healthcare Outcomes				
Theme	Code	Sample Responses		Frequency
Improved Communication	Real-time health insights	"These devices provide real-time feedback that improves communication with doctors."	"The real-time data helps both doctors and patients catch issues early."	25
	Reduced appointment burden	"I don't need as many follow-up appointments because I get regular updates from my wearable."	"It helps reduce unnecessary visits and saves time."	19
	Early intervention	"Wearables alert me before my condition worsens, so I can reach out to my doctor early."	"I appreciate how wearables notify me in time to make proactive choices."	18
Risk of Decreased Interaction	Less face-to-face communication	"I miss the face-to-face interaction with my doctor because everything is now automated."	"It feels like the human connection is lost with all the automation."	15
	Loss of human touch	"The chatbot is helpful, but it feels impersonal compared to talking to a real person."	"I prefer seeing a doctor for complex concerns rather than relying on a chatbot."	11
Balanced View	Supportive but supplementary	"I think wearables are useful as long as they supplement not replace real doctor visits."	"They're great as an additional tool, but human expertise is still necessary."	8
Perceived Patient Autonomy	Greater patient control	"Some patients told us wearables give me more control over my own health by tracking my progress."	"Some of my patients told us it gives me confidence to manage my health independently."	6

Some findings require deeper interpretation in the context of the Saudi healthcare environment. The lack of significant gender differences, for instance, may reflect standardised clinical roles and uniform digital training across staff, diminishing gender-based variation in technology engagement. Similarly, muted perceptions of AI's impact on decision-making and workload likely stem from limited practical exposure to such tools, as AI adoption in Saudi hospitals remains in its early stages. The absence of differences across hospital affiliations may point to broader systemic issues, including uneven digital infrastructure and underdeveloped policy frameworks. These results highlight the need for further research into organisational readiness, national digital health strategies, and the integration of AI competencies within nursing education, to support the effective and equitable implementation of wearable technologies in clinical practice.

A key finding was that AI-enabled wearables were generally perceived as valuable tools for disease diagnosis and chronic condition management, with many nurses acknowledging their ability to provide real-time health insights and detect early warning signs. This aligns with previous research demonstrating that these technologies facilitate early disease detection and risk stratification, particularly for conditions such as cardiovascular disease and diabetes [1, 4, 15]. However, despite this enthusiasm, limited exposure to AI-enabled wearables among some nurses contributed to uncertainty and hesitation, with many participants indicating a lack of technical knowledge and training. Similar concerns have been documented in earlier studies, where limited digital literacy among healthcare professionals was identified as a major obstacle to the effective integration of AI-driven healthcare technologies [28, 43].

The findings also underscored the perceived impact of AI-enabled wearables on medication adherence and prescription refills. Many nurses viewed these technologies as useful for routine medication management, with features such as automated prescription refills and personalised reminders enhancing adherence, particularly for patients with complex medication regimens. These findings align with prior studies indicating that AI-driven medication management systems improve adherence rates and reduce the likelihood of missed doses [12, 44]. However, concerns about device malfunctions, inconsistent AI-generated recommendations, and the need for physician oversight emerged as significant barriers. These concerns reflect broader discussions in the literature regarding the reliability of AI-based decision-making in healthcare and the necessity for human oversight to validate AI-driven prescriptions and treatment recommendations [3, 29].

A further key theme in the study was the impact of AI-enabled wearables on patient-physician communication. Many nurses recognised that real-time health insights from wearables could enhance communication between patients and healthcare providers, enabling earlier interventions and reducing unnecessary follow-up visits. However, a substantial number of participants expressed concerns that increased automation might lead to a decline in face-to-face interactions and a loss of human connection in healthcare. These findings are consistent with previous studies highlighting that while AI-enabled technologies improve efficiency, they may also contribute to a sense of depersonalisation in patient care [14, 30]. This suggests the need for a balanced approach in which AI-driven wearables support, rather than replace, human interactions in clinical practice.

The study identified significant demographic variations in nurses' perceptions of AI-enabled wearable technologies. Age and education level emerged as key determinants, with younger and more highly educated nurses exhibiting greater acceptance and confidence in AI-driven wearables. These findings are consistent with previous research suggesting that digital literacy and technological exposure strongly influence healthcare professionals' attitudes towards AI integration [38, 43]. Similarly, workplace setting and departmental affiliation played a role in shaping perceptions, with nurses working in hospital environments reporting higher engagement with wearable technologies compared to those in primary care settings.

Although the Mann-Whitney U test indicated no statistically significant differences in nurses' perceptions of AI-enabled wearable devices based on gender, this outcome merits further contextual interpretation. Both male and female nurses in the present study may have had broadly equal access to digital health training and similar levels of exposure to wearable technologies within their clinical environments. Moreover, the increasingly technology-oriented nature of modern nursing practice may be fostering a more consistent level of digital competence across genders. These factors could account for the convergence in perceptions observed. While this finding contrasts with some previous studies that reported gender-based differences in technology adoption often suggesting that male healthcare professionals exhibit greater confidence in digital health tools [21], the absence of such variation here suggests that the adoption and acceptance of AI-enabled wearables may be shaped more by professional exposure, institutional culture, and training opportunities than by inherent gender-related differences. Future research should explore whether more nuanced gender-based variations emerge in specific domains, such as trust in AI or readiness to engage with emerging technologies, particularly when accounting for role, experience, or departmental affiliation.

This study's findings align with existing literature on AI-driven wearable technologies in healthcare, reinforcing the consensus that these devices offer significant clinical benefits while also posing ethical and technical challenges. Previous research has highlighted that AI-integrated wearables improve early diagnosis, patient monitoring, and adherence to treatment plans [4, 11, 30], findings that were echoed by participants in this study. However, concerns regarding data privacy, AI reliability, and the potential depersonalisation of healthcare interactions have also been raised in prior studies, indicating a persistent gap in trust and confidence among healthcare professionals [12, 28].

A notable contribution of this study is its focus on nurses' perceptions, rather than those of physicians or patients, providing a unique perspective on the integration of AI-enabled wearables in clinical practice. While prior research has predominantly examined patients' trust in AI-driven healthcare [9, 15], fewer studies have explored how nurses who play a pivotal role in patient care perceive and interact with these technologies. This study highlights that nurses are generally receptive to these technologies but require greater technical support, structured training programmes, and institutional guidelines to optimise their implementation in practice.

It is important to acknowledge that the findings related to patient engagement, usage patterns, and perceived benefits of wearable technologies are derived from nurses' professional observations rather than direct patient-reported data. While these perspectives offer valuable clinical insight, they may be subject to interpretative bias and shaped by individual experience. Consequently, statements regarding patient demographics or levels of engagement with digital health tools should be interpreted as reflective of nurses' perceptions, rather than empirical evidence from patients themselves. Future research would benefit from incorporating patient-reported outcomes to triangulate these findings and enhance the comprehensiveness of the evidence base.

Strengths and limitations

A key strength of this study is its focus on a diverse sample of nurses working in educational hospitals, ensuring that findings reflect real-world clinical experiences. Additionally, the study utilised both quantitative and qualitative approaches, allowing for a comprehensive understanding of nurses' perceptions. The inclusion of open-ended responses provided deeper insights into specific concerns and facilitators, complementing the structured survey findings.

However, the study has several limitations. Firstly, the use of a cross-sectional design limits the ability to assess changes in nurses' perceptions over time. Future longitudinal studies would provide a clearer understanding of how attitudes toward AI-enabled wearables evolve with increased exposure and technological advancements. Secondly, the study relied on self-reported data, which may be subject to social desirability bias. Participants may have provided responses that reflect positive perceptions of AI technologies rather than their actual experiences. Additionally, while the sample included nurses from various departments and specialisations, the findings may not be generalisable to nurses working in non-educational hospital settings or those with minimal exposure to digital health technologies.

A notable limitation of this study is the absence of direct input from patients. The data concerning patient engagement, adherence, and the perceived usability of AI-enabled wearable devices were drawn exclusively from nurses' accounts. This reliance on second-hand reporting introduces the potential for recall bias and subjective interpretation, and may limit the generalisability of the findings to the wider patient population. Future studies should aim to include patient perspectives to provide a more balanced and empirically grounded understanding of wearable technology use in clinical practice.

Implications for practice and future research

The findings of this study have important implications for clinical practice, policy development, and future research. Given the increasing integration of AI-driven wearable technologies in healthcare, it is essential to provide structured training programmes for nurses to enhance AI literacy and confidence in wearable device usage. Healthcare institutions should implement clear guidelines on the integration of wearable data into patient care, ensuring that AI-generated insights are used effectively while maintaining human oversight in clinical decision-making.

Future research should explore strategies to address nurses' concerns regarding data privacy, AI reliability, and patient-provider communication. Investigating how wearable technology adoption varies across different healthcare settings and specialisations would provide further insights into the barriers and facilitators of AI integration. Additionally, research on the long-term impact of AI-enabled wearables on patient health outcomes and healthcare efficiency would offer valuable evidence to inform policy and implementation strategies.

Conclusion

This study contributes to the growing body of research on AI-integrated wearable health technologies by examining nurses' perceptions, awareness, and trust in these innovations. While nurses generally recognised the potential benefits of AI-enabled wearables, concerns regarding data privacy, reliability, and human interaction remain prominent barriers to widespread adoption. The findings underscore the importance of targeted education, institutional support, and robust implementation strategies to facilitate the effective integration of wearable technologies into clinical practice. Addressing these concerns will be crucial for ensuring that AI-driven wearables fulfil their potential to enhance patient care, improve clinical decision-making, and support sustainable healthcare delivery.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12912-025-03343-y.

Supplementary Material 1

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Author contributions

H.A. Wrote the entire manuscript.

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Data availability

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical approval

All methods in this study were performed in accordance with the declaration of Helsinki and was approved by the Institutional Review Board (IRB) of Qassim University No. 23-19-02. All the participants provided informed consent to participate. In the case of the questionnaire-based study, all participants were informed of the voluntary nature, confidentiality, and aim of the study and the nature of their participation before they participated in the study.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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