

Human-Centered Digital Healthcare: Balancing Technological Innovation With Trust, Accessibility, Emotional Connection, and Patient Agency

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Abstract

Digital healthcare is often evaluated through technical performance, adoption, efficiency, and scalability, yet these measures incompletely represent whether digitally mediated care remains acceptable, usable, relationally meaningful, and responsive to patients' interests. This conceptual article develops a human-centered account of digital healthcare in which technological value is conditional on the conditions under which people encounter, interpret, and act through digital systems. The analysis distinguishes trust from trustworthiness; availability from accessibility, usability, and digital capability; digital participation from patient agency; data collection from legitimate data use; and automation from appropriately allocated human judgment. It further argues that emotional presence and relational continuity should be treated as substantive properties of care rather than optional additions to otherwise successful technological delivery. Evidence concerning digital literacy, therapeutic relationships, health-data sharing, artificial intelligence, empowerment, and digital inequity is integrated into a proposed multilevel architecture linking individual capability, patient-professional relationships, institutional conduct, technological characteristics, and structural conditions. The model does not assume that greater digitization necessarily produces either empowerment or exclusion. Instead, digital technologies may expand, constrain, or redistribute opportunities for participation depending on usability, resources, control, institutional trustworthiness, care context, and available alternatives. Human-centered digital healthcare is therefore framed as a problem of alignment: technological innovation becomes clinically and socially meaningful when technical capability is matched by warranted trust, usable access, relational adequacy, meaningful choice, proportionate data governance, and mechanisms for human judgment where uncertainty or consequence requires it.

Keywords: Digital health, Patient agency, Digital trust, Health equity, Therapeutic relationship, Artificial intelligence

Introduction

Digital health systems increasingly mediate how patients obtain information, communicate with clinicians, monitor illness, manage treatment, contribute data, and encounter automated recommendations. Their evaluation, however, often privileges technical metrics and adoption outcomes over the conditions under which patients can use technology meaningfully. Trust in digital healthcare is itself heterogeneous: it can concern a

clinician, an institution, a technology, a data practice, or the wider system responsible for deployment, and studies operationalize these objects inconsistently [1]. Similarly, patients' digital experiences are shaped not only by whether a service exists but by internet access, cost, confidence, self-efficacy, health status, competing pressures, and continuing preferences for human care [2]. Existing digital-health-equity frameworks reinforce the need for multilevel analysis but do not yet supply a single comprehensive account spanning individual, relational, organizational, technological, and structural conditions [3].

This article therefore treats human-centered digital healthcare as an analytical problem rather than a design slogan. Its central proposition is that technological capability has no fixed human value outside the circumstances of its use. A technically effective platform

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may remain inaccessible, a highly usable interface may still generate mistrust, an efficient automated process may weaken meaningful choice, and convenient remote contact may fail to preserve relational continuity. Conversely, digital systems can reduce geographic barriers, expand informational access, support self-management, and create new forms of continuity when the surrounding conditions enable rather than constrain participation.

The article develops a proposed framework across five linked questions: whether patients can realistically access and use a technology; whether the technology and its governing institutions merit trust; whether digitally mediated care preserves sufficient emotional and relational connection; whether patients retain meaningful agency over decisions and data; and whether automation is allocated in ways consistent with uncertainty, consequence, and accountability. These questions operate at different levels and should not be collapsed into a single construct such as “acceptance,” “engagement,” or “satisfaction.”

Beyond technology-centered digital health

Technology-centered interpretations tend to locate success or failure within the properties of an intervention: interface quality, interoperability, predictive accuracy, response time, or adoption rate. Those properties matter, but they do not determine who benefits, under what conditions, or at what social cost. Digital-health inequity can emerge through structural mechanisms that are outside an interface itself, including infrastructure, financing, commercial incentives, reimbursement design, unequal investment in digital literacy, and justified mistrust of institutions [4]. A well-designed application may therefore perform differently across settings because the social and organizational environment changes the practical meaning of the same technical function.

Evidence synthesized from qualitative studies likewise shows that advancing digital health equity requires more than simplifying software. Commonly identified requirements include usable design, access to infrastructure, educational and navigational support, engagement with affected communities, and preservation of nondigital routes where digital participation is difficult or inappropriate [5]. These observations challenge a substitution logic in which digital care is assumed to be a more advanced version of conventional care merely because it is faster, scalable, or remotely accessible.

A human-centered interpretation instead asks whether technological functions can be converted into meaningful opportunities for care. This conversion can fail at several points. A patient may possess a device but lack confidence in using a portal; may understand the interface but not the clinical implications of the information presented; may obtain remote access but feel unable to communicate complex symptoms; or may accept a digital service because no realistic alternative exists. The article therefore proposes the concept of a human-use environment: the combined material, cognitive, relational, organizational, and governance conditions through which technical functions acquire practical value. This is not presented as an empirically validated construct. It is an organizing device for preventing technological capability from being mistaken for realized benefit.

Human needs in digitally mediated care

Digitally mediated healthcare does not remove the human relationship from care; it reorganizes the conditions under which that relationship is enacted. Evidence from respiratory secondary care, primary care, and telehealth suggests that digital communication can alter patient-provider interaction, the meaning attached to professional contact, and the experience of therapeutic connection [6-8]. These findings do not support a universal conclusion that digital care either improves or damages relationships. Rather, relational consequences depend on modality, prior relationship, clinical need, expectations, communication quality, and how technology is incorporated into continuing care.

This distinction is important because communication channel and relational quality are not equivalent. Video contact may reproduce visual and verbal interaction while still constraining subtle forms of presence. Asynchronous messaging may reduce immediacy yet improve continuity for a patient who needs repeated, low-burden contact. Remote monitoring may provide clinicians with more information while simultaneously making some patients feel observed rather than supported. A portal may increase access to records while leaving patients uncertain about how clinicians interpret those records.

Human needs in digital care therefore include more than information transfer. Patients may need recognition, interpretive help, reassurance, opportunities to disclose uncertainty, acknowledgment of personal circumstances, and confidence that a responsible person remains

available when automated or asynchronous processes reach their limits. The proposed framework treats these needs as performance conditions for human-centered care. Their importance will differ by illness severity, stage of care, prior therapeutic relationship, patient preference, cultural expectations, and the reversibility of decisions. Human-centeredness thus requires calibration rather than preservation of one preferred mode of interaction.

Trust and digital trustworthiness

Trust is frequently invoked as a prerequisite for digital-health adoption, but increasing trust is not always the appropriate objective. Patients may reasonably withhold trust from systems that are opaque, poorly governed, insecure, or unable to explain accountability. Survey evidence indicates that trust in the health system itself influences whether patients are comfortable with institutional use of artificial intelligence [9]. Public attitudes toward generative AI in healthcare are similarly heterogeneous and associated with privacy concerns, expectations, and broader trust rather than technical novelty alone [10].

The distinction between trust and trustworthiness is therefore foundational. Trust describes an orientation or willingness to accept vulnerability; trustworthiness concerns whether that vulnerability is warranted by the qualities and conduct of the person, institution, or technology involved. Framework work on medical AI emphasizes that governance should preserve the trust relationship between patients and health professionals rather than treating an algorithm as an autonomous object of trust [11]. International expert consensus likewise supports a multistakeholder account in which technical performance, ethics, institutional responsibility, transparency, regulation, and relational conditions jointly shape whether reliance is warranted [12].

This article consequently rejects indiscriminate trust maximization. A human-centered digital system should instead enable calibrated trust: sufficient confidence where evidence and governance justify reliance, but visible opportunities for questioning, contesting, escalating, or declining digital processes where uncertainty remains. Trustworthiness should therefore be designed at several levels. Technologies require appropriate validation and security; organizations require transparent data and accountability practices; clinicians require clarity concerning when they should rely on, override, or contextualize digital outputs; and patients

require understandable information about what a system does, what it does not establish, and where responsibility ultimately resides.

Trust may also be cumulative. A technically minor failure, an unexpected data-sharing practice, an inaccessible interface, or an unacknowledged automated error can affect later willingness to engage. Conversely, reliable communication and transparent correction may strengthen confidence without requiring claims of technological infallibility. The framework therefore treats trust as dynamic and relational, while treating trustworthiness as a set of observable and governable conditions against which that trust should be evaluated.

Accessibility, usability, and digital capability

Digital availability is the weakest form of access. A service may be technically reachable while remaining difficult to locate, understand, navigate, afford, or incorporate into everyday illness management. In a large English survey of NHS 111 Online, users and nonusers differed on dimensions of eHealth literacy, while long-term illness and other forms of disadvantage intersected with lower ability to engage with digital information and services [13]. Population-level research likewise demonstrates substantial heterogeneity in digital health literacy rather than a uniform capacity to benefit from increasingly digital care [14].

Measurement research reinforces this multidimensional view. The eHealth Literacy Questionnaire distinguishes several capacities involved in engaging with digital health systems rather than treating literacy as a single technical skill [15]. The Digital Health Literacy Instrument similarly separates operational, navigation, information-search, reliability-evaluation, relevance-evaluation, content-generation, and privacy-related skills [16]. These distinctions matter because failure at one stage does not imply generalized incapacity. A patient may operate a smartphone confidently yet struggle to assess the reliability of medical information, understand data-sharing settings, or translate a numerical result into a treatment decision.

The article therefore proposes that access be understood as a series of potentially reversible transitions: availability, entry, functional use, interpretive use, and sustained use within care. These stages are not assumed to occur in a fixed causal sequence for every patient. Rather, they identify different points at which contextual constraints may appear. Patients can also re-enter after

support, switch channels, or combine digital and nondigital care.

The analytical distinctions required to prevent these transitions from being collapsed into a binary “access/no access” variable are summarized in **Table 1**.

Table 1. Where Digital Access Can Be Lost, Recovered, or Misclassified Across a Care Interaction

What must become possible for the patient	Typical source of friction	Why apparent “use” can be misleading	Context that can alter the transition	Human-centered implication
Care-transition state — Service availability				
Know that a relevant digital option exists and can be reached	Connectivity, device access, cost, language, disability, registration requirements	A technically available service may remain practically unreachable	Infrastructure, geography, household resources, institutional enrollment rules	Evaluate effective availability rather than platform existence
Care-transition state — Entry into use				
Complete access, authentication, navigation, and initial task selection	Password burden, interface complexity, unfamiliar terminology, low confidence	Login or account creation does not establish successful care access	Prior digital experience, acute illness, cognitive burden, availability of assistance	Provide recoverable entry routes and assisted alternatives
Care-transition state — Functional use				
Complete the intended digital action correctly	Operational, navigation, or interaction difficulty	Completion may conceal errors, workarounds, or dependence on another person	Device type, accessibility needs, interface consistency, caregiver support	Test real task completion under heterogeneous user conditions
Care-transition state — Interpretive use				
Understand what information or recommendation means for one's care	Low health literacy, uncertain source credibility, numerical complexity, absent explanation	Information exposure may be counted as engagement despite misunderstanding	Illness complexity, prior knowledge, clinician availability, risk level	Pair information access with interpretive support
Care-transition state — Sustained integration				
Fit the technology into continuing illness management and clinical relationships	Fatigue, changing symptoms, loss of perceived usefulness, competing responsibilities	Repeated use can reflect necessity rather than preference or benefit	Disease trajectory, relationship continuity, burden of monitoring, alternatives	Permit switching, pause, escalation, and nondigital continuity
Care-transition state — Recovery or channel change				
Re-enter care after difficulty or move to a more suitable mode	Rigid digital-first workflows, lack of human escalation, fear of “failing” the system	Nonuse may represent adaptation rather than disengagement	Urgency, vulnerability, family support, service design	Treat channel switching as legitimate care adaptation, not noncompliance

Note: The transition structure is proposed by this article as an analytical synthesis. It should not be interpreted as a validated universal sequence or patient scoring system.

Emotional presence and relational continuity

Relational quality in digital care cannot be inferred from communication frequency alone. A patient may receive frequent automated messages while experiencing little interpersonal continuity, whereas a brief asynchronous exchange with a clinician who understands the patient's history may sustain a strong sense of being recognized.

Evidence concerning digitally mediated therapeutic relationships therefore supports attention to how technologies shape communication, expectations, continuity, and the meaning of professional contact rather than simply whether contact occurs.

Emotional presence refers here to the extent to which a patient experiences responsive attention,

acknowledgment, interpretive support, and an available human relationship when those functions matter clinically or psychologically. It does not require that every interaction be synchronous or face to face. Relational continuity similarly does not mean permanent contact with one professional. It concerns whether information, recognition, responsibility, and the ability to escalate concerns remain connected across encounters and modalities.

These qualities become especially important where uncertainty, vulnerability, sensitive disclosure, or changing illness makes standardized interaction

insufficient. At the same time, more human contact is not necessarily better in every context. Some patients may prefer asynchronous communication, automated reminders, or remote monitoring because these reduce burden and preserve autonomy. The relevant question is therefore whether the digital arrangement allows relational intensity to increase when needed without requiring continuous high-intensity interaction.

Figure 1 represents this distinction as separate but permeable lanes rather than a single digital-to-human continuum.

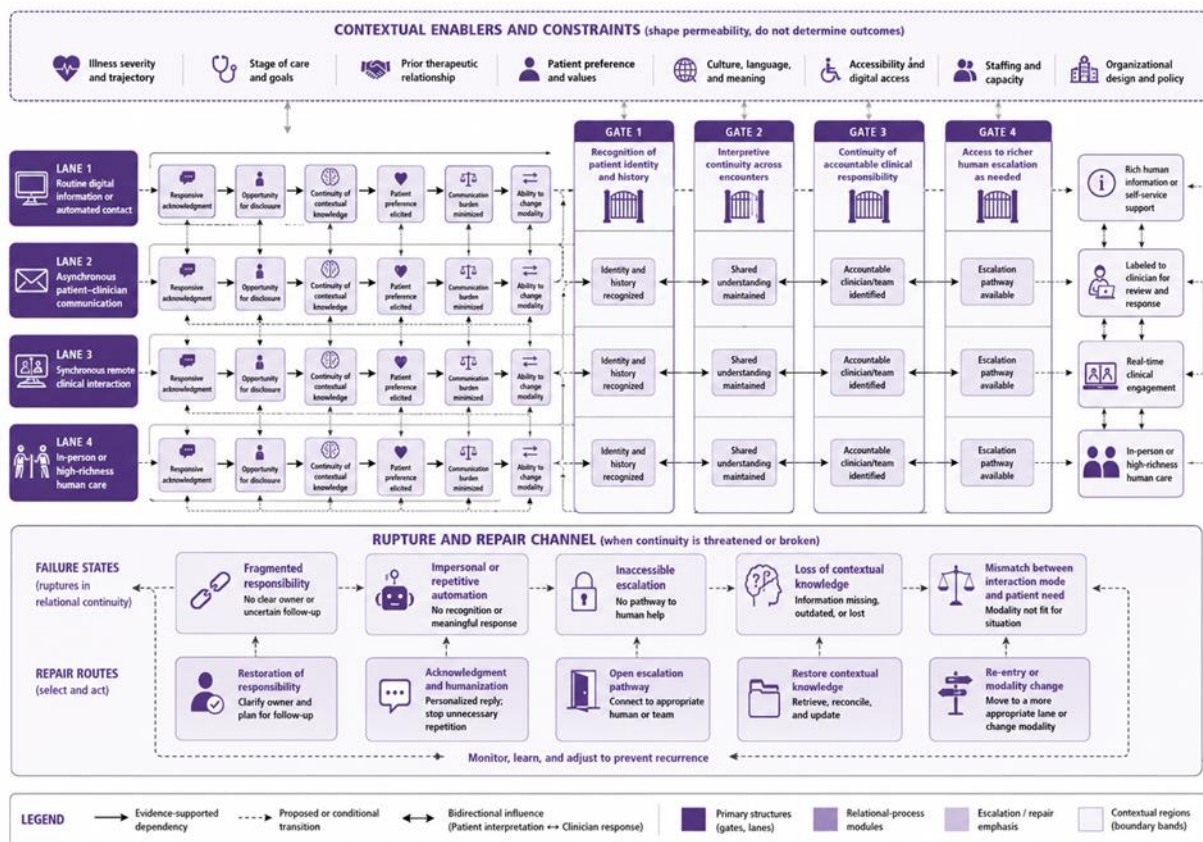


Figure 1. Relational Continuity Depends on Whether Digital Encounters Remain Permeable to Recognition, Interpretation, and Human Escalation

Patient agency, choice, and control

Digital health can expand the range of actions available to patients, but more available actions do not automatically create greater agency. A scoping review of people living with chronic conditions identified several empowering capabilities potentially supported by digital health technologies, including information and knowledge management, self-management, and

emotional or social support, while also emphasizing the conversion conditions required for those opportunities to become usable in practice [17]. Contemporary accounts of patient empowerment similarly describe shifts in informational access, participation, and roles rather than equating empowerment with device use or digital enthusiasm [18].

Agency is therefore defined here as the effective capacity to make consequential choices within care, including the ability to understand options, express preferences, accept or refuse digital processes where alternatives are reasonable, question recommendations, and seek human review. Earlier and newer empowerment literatures both indicate why technology exposure and realized empowerment should remain analytically separate [17, 19]. A patient who repeatedly submits remote-monitoring data may have little control over what happens next; another patient who rarely uses a portal may nevertheless exercise substantial agency by choosing when digital contact is useful and when direct clinical interaction is preferable.

Choice is also meaningful only when alternatives are feasible. A nominal option to telephone a clinic has limited value if waiting times make it practically unavailable. Likewise, a consent screen offers limited control if access to essential care depends on accepting broadly framed data practices. The proposed model therefore treats agency as relational and institutional as well as individual. Interface design can support agency, but so can transparent explanation, contestability, continuity with a responsible clinician, and organizational willingness to accommodate legitimate channel preferences.

Human-centered digital healthcare should consequently avoid confusing activation with compliance. The goal is not simply to induce patients to engage more often with technology. It is to preserve sufficient informational, relational, and procedural control for patients to participate in ways aligned with their circumstances and values.

Privacy, data use, and perceived vulnerability

Privacy concerns in digital healthcare are often treated as resistance to innovation or as a technical security problem. Both interpretations are incomplete. Patients may support data use in one context and reject it in another because willingness depends on the type of data involved, who receives them, the purpose of use, expected benefits, perceived sensitivity, transparency, and degree of control [20-22]. These conditions make privacy a relational and governance issue rather than a fixed personality characteristic.

Security and privacy should also be distinguished. Strong cybersecurity may reduce unauthorized access while leaving unresolved questions about authorized secondary use, commercial access, algorithmic inference, or whether patients can meaningfully understand and contest data flows. Perceived vulnerability emerges when people must accept exposure under conditions of informational or institutional asymmetry: another party understands more about the data system, determines future uses, or possesses greater power to define what counts as legitimate processing.

The proposed framework therefore analyzes vulnerability across four interacting dimensions: exposure, referring to the sensitivity and scope of collected data; opacity, referring to uncertainty about processing, sharing, or inference; asymmetry, referring to unequal control or knowledge between patients and institutions; and reversibility, referring to whether consent, access, or downstream use can realistically be changed. These dimensions are proposed as analytical categories, not as a validated privacy scale.

Table 2 maps how superficially similar data practices can generate different perceptions of vulnerability depending on governance and relational context.

Table 2. How Identical Data Collection Can Produce Different Levels and Forms of Perceived Vulnerability

Data-use condition	Source of vulnerability	What may make use more acceptable	What remains unresolved even with technical security	Power or equity concern	Human-centered governance response
Data required for direct clinical care	Dependence on care may reduce practical freedom to refuse	Clear purpose, clinical relevance, limited access, professional accountability	Whether patients understand secondary processing or retention	Refusal may be least feasible for people with few alternative providers	Separate essential clinical use from optional downstream uses
Data reused for service improvement or research	Purpose may extend beyond the original encounter	Transparent explanation, public benefit, proportionality,	Future analyses may not be foreseeable at the point of collection	Communities contributing data may not share equally in benefits	Make purpose boundaries and oversight structures visible

governance oversight					
Data shared with commercial or external partners	Uncertainty about incentives, onward sharing, profiling, or monetization	Specific purpose, partner disclosure, strict contractual limits, meaningful choice	Commercial incentives can remain opaque even when transfer is secure	Patients have little bargaining power over institutional partnerships	Require explicit accountability for recipient, purpose, retention, and onward use
Passive or continuous device-derived data	High-volume collection can reveal patterns beyond the patient's immediate intent	Granular settings, pause functions, clear feedback on what is being collected	Inferences may exceed the sensitivity of any single data point	Device ownership and digital literacy are unevenly distributed	Treat inference risk and continuous collection as distinct consent issues
Data used in predictive or automated decision systems	Patients may be affected by conclusions they cannot readily inspect or contest	Explanation of purpose, validation boundaries, human review, appeal pathways	Explanation does not guarantee model correctness or fair use	Institutional decisions may be harder to challenge for marginalized patients	Link data governance to contestability and accountable clinical responsibility
Data retained across long periods or linked across systems	Future combinations can create information that was not apparent at collection	Retention limits, auditability, access logs, deletion or correction routes where feasible	Some downstream consequences may be irreversible	Long-term data footprints can amplify earlier inequities or errors	Evaluate reversibility before collection rather than after harm occurs

Note: The four vulnerability dimensions and the comparative architecture of this table are proposed by this article. They should not be interpreted as validated measures of individual privacy concern.

Digital exclusion and equity

Digital exclusion is not adequately described as absence of internet access. Digital inclusion also depends on devices, connectivity, skills, support, accessible interfaces, confidence, and the ability to translate digital participation into usable healthcare opportunities [23]. When these conditions are unevenly distributed, digitization can reproduce existing social gradients even while expanding aggregate service reach [24]. Equity therefore cannot be inferred from the fact that a service is remote, scalable, or technically available.

This problem is visible in remote-monitoring research, where equity-related characteristics and multilevel determinants are often incompletely incorporated into design and reporting [25]. Exclusion can occur during enrollment, authentication, interpretation, sustained use, data contribution, escalation, or transition back to nondigital care. The same intervention may consequently increase opportunity for one patient while increasing burden for another.

The proposed model treats digital equity as differential capacity to convert technological availability into meaningful care opportunity. This capacity is shaped by

individual resources but also by language, disability, geography, organizational flexibility, social support, infrastructure, and institutional power. Human-centered design should therefore evaluate who can enter, who can remain, who can recover after difficulty, and who retains a viable alternative when digital participation becomes unsuitable.

Balancing automation with human judgment

Automation can reduce repetitive work, extend analytic capacity, and support clinical decision making, but human-centered healthcare requires more than placing a nominal “human in the loop.” The broader medical-AI literature suggests that useful systems are most plausibly understood as combinations of machine and human capabilities rather than straightforward replacements for professional judgment [26].

Human involvement, however, does not automatically guarantee appropriate decisions. Clinicians vary in how they interpret and rely on algorithmic output. In one reader study, additional explanation altered interaction with an AI system without reliably producing better calibrated trust or reliance [27]. Human oversight therefore requires competence, role clarity, adequate

information, and sufficient authority to challenge an output.

Early clinical evaluation of AI systems likewise needs to examine workflow, safety, human factors, and live clinical performance rather than treating technical discrimination metrics as sufficient evidence for deployment [28]. Explainability should also remain distinct from validation: an explanation can appear plausible without establishing that an individual prediction is correct, clinically appropriate, or safe [29].

The proposed decision principle is consequently conditional allocation of judgment. Greater automation may be reasonable where tasks are well validated, consequences are limited, outputs are reversible, and uncertainty is visible. Greater human review becomes more important as consequences, contextual dependence, ambiguity, vulnerability, or difficulty of reversal increase.

The distinctions required to avoid treating automation and human oversight as opposing absolutes are summarized in **Table 3**.

Table 3. Distinguishing Appropriate Automation from Situations Requiring Greater Human Interpretive Responsibility

Automation context	Human interpretive need	Risk of inappropriate substitution	Decision boundary
Decision condition — Repetitive, standardized task			
What automation may contribute	Speed, consistency, prioritization	Why automated output may remain insufficient	Local exceptions may fall outside model assumptions
Human responsibility that remains material	Verify applicability and respond to anomalies	Boundary requiring escalation	Unexpected or discordant input
Decision condition — Pattern-recognition support			
What automation may contribute	Detection of complex associations	Why automated output may remain insufficient	Prediction does not itself provide clinical meaning
Human responsibility that remains material	Integrate history, examination, goals, and competing explanations	Boundary requiring escalation	High uncertainty or contextual mismatch
Decision condition — Explained algorithmic output			
What automation may contribute	Visible rationale or feature contribution	Why automated output may remain insufficient	Explanation may not establish correctness or reliability
Human responsibility that remains material	Judge whether reliance is warranted	Boundary requiring escalation	Explanation conflicts with clinical evidence
Decision condition — High-consequence recommendation			
What automation may contribute	Decision support and evidence organization	Why automated output may remain insufficient	Error may be difficult to reverse
Human responsibility that remains material	Retain accountable review and contestability	Boundary requiring escalation	Serious potential harm or irreversible consequence
Decision condition — Patient-facing automated advice			
What automation may contribute	Rapid access and standardized guidance	Why automated output may remain insufficient	Patient vulnerability and comprehension vary
Human responsibility that remains material	Ensure understandable escalation to responsible human care	Boundary requiring escalation	Ambiguity, deterioration, distress, or preference for review
Decision condition — Continuously learning or rapidly changing system			
What automation may contribute	Adaptation to new information	Why automated output may remain insufficient	Performance and behavior may shift after deployment

Human responsibility that remains material

Monitor, audit, document, and reassess

Boundary requiring escalation

Drift, unexpected subgroup performance, or new use context

Note: The allocation logic is proposed by this article and does not constitute a validated clinical decision rule.

A human-centered digital healthcare model

The preceding domains suggest that digital healthcare should be analyzed as a nested sociotechnical system rather than as an interaction between an isolated user and a technological product. The NASSS framework demonstrates why adoption and sustainability depend on interacting complexities involving technologies, users, organizations, wider systems, value, and change over time [30]. Building on that multilevel premise, this article proposes a specifically human-centered architecture organized around five interdependent conditions: usable capability, warranted trust, relational adequacy, meaningful agency, and accountable governance.

These conditions operate across nested levels. At the patient level, resources, literacy, preferences, health status, and accessibility shape possible engagement. At the relational level, recognition, interpretation,

communication, and responsibility shape whether digital contact remains clinically meaningful. At the organizational level, workflow, staffing, escalation routes, data practices, and accountability determine what technologies actually permit. Structural and policy environments influence infrastructure, incentives, regulation, exclusion, and available alternatives.

No level is assumed to determine outcomes independently. A strong interface cannot fully compensate for inaccessible infrastructure; high technical accuracy cannot create institutional trustworthiness; extensive data access cannot substitute for patient control; and relationally attentive clinicians cannot always overcome organizational systems that restrict escalation. **Figure 2** therefore represents the model as nested systems separated by explicit scale-transfer boundaries.

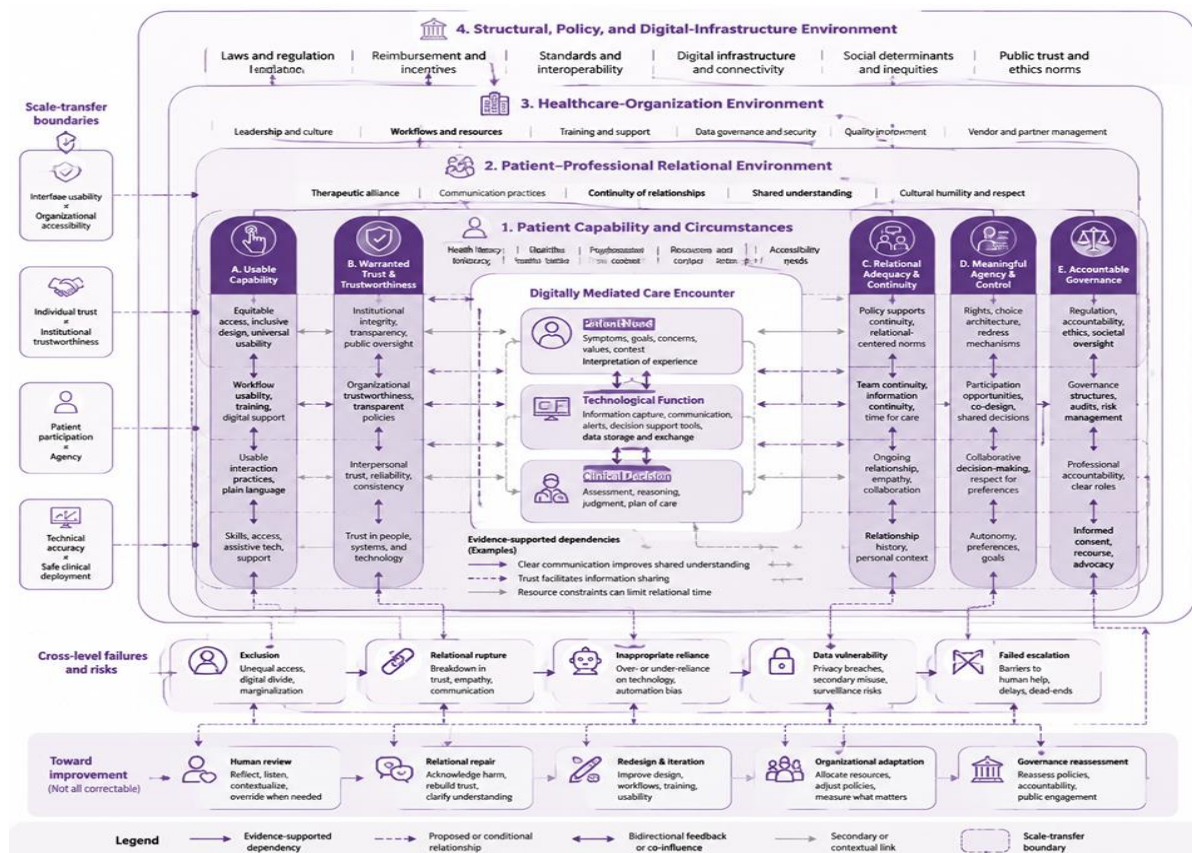


Figure 2. Human-Centered Digital Care Emerges Only When Technical Capability Survives Cross-Level Tests of Capability, Trustworthiness, Relationship, Agency, and Governance

Design and governance principles

Human-centered digital healthcare requires governance to develop alongside technological capability rather than after deployment. Responsible digital-health practice therefore extends beyond usability toward privacy, equity, bias, institutional accountability, and regulatory responsibility [31]. Rapid deployment without sufficient transparency or monitoring can otherwise transform routine care into poorly governed experimentation [32]. The proposed framework yields four design principles. First, systems should remain contestable: patients and clinicians need routes to question, correct, or escalate consequential digital outputs. Second, they should remain recoverable: failure to complete a digital process should not automatically become failure to receive care. Third, they should remain proportionate: data collection, automation, and monitoring should match the clinical purpose and consequences involved. Fourth, they should remain plural: human-centered systems should preserve alternative interaction modes where a single digital pathway would create avoidable exclusion.

These principles require empirical evaluation rather than assumption. Appropriate tests include longitudinal analyses of trust after system failures, comparative studies of channel switching, accessibility evaluation across heterogeneous populations, examination of patient understanding of data practices, and prospective assessment of how different forms of human oversight alter safety and reliance.

Results and Discussion

The central implication of this analysis is not that digital healthcare should become less technological. It is that technical sophistication and human-centered performance describe different dimensions of quality. A system may perform strongly in one while failing in the other.

The evidence also cautions against several common equivalences. Access is not availability; digital use is not empowerment; trust is not proof of trustworthiness; explanation is not validation; device ownership is not data consent; frequent contact is not relational continuity; and human oversight is not automatically calibrated judgment. These distinctions matter because collapsing them can make implementation appear successful while concealing who bears additional burden or vulnerability. The proposed model therefore treats human-centeredness as an alignment problem across levels. Trustworthiness,

capability, relational adequacy, agency, and governance can reinforce one another, but compensation should not be assumed. Strong relational continuity may mitigate some technological friction, whereas serious exclusion or opaque data use may constrain participation despite otherwise excellent clinical functionality. The magnitude and direction of such interactions remain empirical questions.

The framework also has important boundaries. Evidence arises from heterogeneous technologies, populations, clinical settings, study designs, and national systems. Many relevant studies are cross-sectional, qualitative, conceptual, or focused on stated attitudes. Their findings should not be interpreted as universal causal mechanisms or direct evidence of improved clinical outcomes. Cultural expectations, disability, language, disease trajectory, resources, organizational capacity, and regulatory environment may substantially alter the relationships proposed here.

Human-centered digital healthcare should therefore be evaluated not through a single satisfaction or adoption measure but through multiple questions: who can use the system, whose trust is warranted, whether meaningful human connection remains available, whether patients retain consequential choice, how vulnerability is distributed, and whether automated decisions remain appropriately accountable.

Conclusion

Human-centered digital healthcare requires technological innovation to be evaluated within the human and institutional conditions that give technology practical meaning. The proposed model integrates usable capability, warranted trust, relational adequacy, meaningful agency, equity, and accountable governance without assuming that these domains are interchangeable or universally causal. Digital systems may expand healthcare opportunity, but they may also redistribute burden, vulnerability, and decision authority. The relevant design goal is therefore not maximal digitization or maximal human contact. It is a form of digitally mediated care in which technological capability remains accessible, contestable, relationally adequate, proportionate to risk, and connected to responsible human judgment when context or uncertainty demands it.

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