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Digital Divide Barriers and Portal Enrollment in Community Clinic Patients: Implementation Study

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Abstract

Patient portals are vital tools for modern healthcare delivery, offering patients direct access to medical records, scheduling, and provider communication. However, the equitable adoption of these technologies is severely hindered by the digital divide, particularly among vulnerable populations served by community clinics. This study investigates the direct link between digital divide barriers and patient portal enrollment outcomes within an implementation science framework. Drawing on data from a comprehensive implementation study of community clinic patients, we examine how structural barriers, such as lack of broadband access, device limitations, and low digital health literacy, influence enrollment rates. Our quantitative analysis of five hundred and twenty-eight patients reveals that device access and digital literacy are the most significant predictors of successful portal utilization, even when technical support is provided. We also evaluate the effectiveness of a clinic-based implementation strategy designed to mitigate these barriers. The findings suggest that although hands-on technical assistance significantly improves enrollment among moderately literate patients, it is less effective for individuals facing multi-layered digital exclusion. These insights highlight the need for tailored, multi-level implementation strategies that move beyond simple technical onboarding to address systemic digital inequities in healthcare delivery.

Keywords: Digital Divide; Patient Portals; Community Health Clinics; Implementation Science; Portal Enrollment

1. Introduction

1.1 Background and Significance

The rapid digital transformation of the healthcare sector has fundamentally reshaped how medical services are delivered, managed, and experienced by patients. At the center of this transformation is the electronic health record system and its consumer-facing counterpart, the patient portal. Patient portals are secure online websites or mobile applications that give patients twenty-four-hour access to their personal health information from anywhere with an internet connection. By enabling patients to view laboratory results, request prescription refills, schedule appointments, and communicate directly with their healthcare providers, portals have been hailed as a revolutionary tool for promoting patient engagement, improving self-management of chronic conditions, and clinical outcomes [1]. Despite these promises, the benefits of digital health technologies have not been distributed equally across all segments of the population.

Community clinics, which include federally qualified health centers and other safety-net providers, serve as the primary source of medical care for millions of low-income, uninsured, racially and ethnically diverse, and medically underserved individuals. These populations often suffer from disproportionately high rates of chronic illnesses, making them the very groups who stand to benefit the most from the self-management tools provided by patient portals. However, these same populations are also the most likely to experience the negative consequences of the digital divide. The digital divide refers to the gap between individuals who have access to modern information and communication technology and those who do not. When healthcare systems transition to digital-first communication models, they risk exacerbating existing health disparities if vulnerable patients are systematically left behind due to technological barriers [2].

Understanding the specific mechanisms through which the digital divide impedes patient portal enrollment in community clinics is crucial for developing effective clinical workflows and policy interventions. While broad demographic correlations between low income and lower portal utilization are well-documented, there is a critical need for implementation study evidence that directly links specific, measurable digital barriers to portal enrollment outcomes within safety-net clinical settings. This study addresses this gap by examining the deployment of a targeted portal enrollment intervention across a network of community clinics, analyzing how individual-level digital access, connectivity issues, and technological literacy interact with clinic-based implementation strategies.

1.2 The Role of Patient Portals in Modern Healthcare

Modern healthcare systems increasingly rely on patient portals to streamline operations and enhance patient-centered care. From an operational perspective, portals reduce the administrative burden on clinical staff by automating routine tasks such as appointment booking and message routing. From a clinical perspective, portals serve as a critical infrastructure for managing chronic diseases like diabetes, hypertension, and asthma, which require continuous monitoring and frequent communication between patients and clinical teams [3]. When patients can easily track their lab values over time, receive automated preventive care reminders, and clarify medication instructions via secure messaging, they are more likely to adhere to their treatment plans and avoid unnecessary emergency department visits.

Furthermore, patient portals represent a shift in the provider-patient dynamic, moving from a paternalistic model of care to a collaborative partnership. Access to one's own clinical notes and diagnostic reports empowers patients, increases their health literacy, and fosters a sense of agency in their medical journeys. However, the operationalization of this model assumes that patients possess the necessary hardware, internet connectivity, and cognitive skills to navigate complex digital interfaces. For patients of community clinics, who may face unstable housing, financial strain, and limited educational opportunities, these assumptions often do not hold true.

The enrollment process itself is a multi-step journey that presents numerous friction points. A patient must first be made aware of the portal's existence, receive an activation link or code, possess a compatible device, establish a secure internet connection, navigate to the portal login page, create a username and password, complete multi-factor authentication, and successfully log in for the first time. A failure at any single point in this sequence prevents successful enrollment. In community clinics, where patients may have limited experience with digital security protocols or lack a stable email address, these friction points are magnified, leading to high drop-off rates during the initial onboarding process.

1.3 Research Objectives and Contributions

The primary objective of this study is to identify, classify, and quantify the specific digital divide barriers that influence patient portal enrollment among patients receiving care at community health clinics. By employing an implementation science approach, we aim to move beyond simple demographic descriptions of the digital divide and instead analyze the operational reality of how these barriers affect the success of a structured clinic-based enrollment intervention. Specifically, this study seeks to answer two key research questions. First, how do distinct dimensions of the digital divide, including device ownership, internet stability, and self-reported digital literacy, predict successful patient portal enrollment? Second, to what extent can hands-on technical assistance provided by clinical staff mitigate these barriers?

This paper makes several key contributions to the existing literature on digital health equity and implementation science. First, we provide empirical evidence from a diverse, real-world sample of community clinic patients, capturing the actual barriers faced by underserved populations rather than relying on self-selected online survey respondents. Second, we utilize a validated, multi-dimensional assessment of digital barriers, allowing us to disentangle the relative impacts of hardware limitations versus cognitive literacy constraints. Third, we evaluate a live clinical implementation strategy, offering valuable practical insights for healthcare administrators, clinic managers, and policy-makers who are designing digital outreach programs. Ultimately, this research aims to inform the development of more equitable digital health policies that support, rather than marginalize, vulnerable patient populations [4].

2. Literature Review and Theoretical Framework

2.1 The Digital Divide in Healthcare Access

The conceptualization of the digital divide has evolved significantly since the term was first coined in the late twentieth century. Early research focused primarily on the first-level digital divide, which refers to the physical access to hardware and basic internet connectivity. In the context of healthcare, this meant studying whether patients owned a computer and had dial-up or broadband internet access at home. While physical access remains a critical barrier, particularly in rural and low-income areas, the rapid proliferation of smartphones has altered this landscape. Many individuals who lack a home computer now access the internet exclusively through mobile devices. However, mobile-only access is often accompanied by data caps, slower speeds, and small screen sizes that make navigating complex health portals challenging [5].

As physical access expanded, researchers identified the second-level digital divide, which encompasses cognitive and skill-based differences in technology use. This dimension focuses on digital literacy, defined as the ability to find, evaluate, use, and communicate information using digital platforms. In health contexts, this is closely linked to digital health literacy, which is the degree to which individuals can obtain, process, and understand health information from electronic sources to make appropriate health decisions. A patient may have a high-speed smartphone connection but still lack the cognitive skills to set up secure accounts, manage passwords, or interpret complex medical terminology displayed on a portal screen.

More recently, scholars have defined the third-level digital divide, which refers to the unequal benefits that individuals derive from technology use even when they have equal physical access and digital skills. In the healthcare domain, this is reflected in how empowered patients use portals to actively co-manage their health, compared to patients who merely use portals for passive tasks like viewing appointment times. This multi-layered understanding of the digital divide underscores that bridging the gap requires more than simply handing a patient a device or providing a free Wi-Fi connection. It requires a comprehensive understanding of how physical, cognitive, and social factors interact to shape the overall digital health experience.

2.2 Socioeconomic Barriers to Portal Enrollment

Socioeconomic status remains one of the most robust predictors of digital health disparities. Extensive literature has documented that individuals with lower incomes, lower educational attainment, and those who are unemployed are significantly less likely to enroll in and use patient portals compared to their wealthier, more educated peers. Financial constraints directly impact a patient's ability to maintain continuous internet access. For instance, low-income households frequently experience disruptions in cellular and broadband services due to non-payment, leading to a phenomenon known as net-unconnectedness, where patients cycle in and out of digital connectivity.

Age is another critical demographic factor that intersects with the digital divide. Older adults, particularly those over the age of sixty-five, face unique physical and cognitive barriers to portal adoption, such as age-related visual impairments, fine motor control challenges, and cognitive decline. Furthermore, many older patients did not grow up using digital technology and may feel anxious or incompetent when confronted with digital health platforms, preferring traditional, face-to-face, or telephone-based communication with their providers [6].

Race, ethnicity, and language proficiency also play powerful roles in shaping digital health equity. Racial and ethnic minorities are disproportionately represented among patients served by community safety-net clinics and face systemic barriers to digital access. Language barriers are especially pronounced; many patient portals are designed primarily in English, with limited or poor-quality translations for non-English speakers. When translations are available, they are often buried within complex menu structures, making them inaccessible to patients with limited English proficiency. Consequently, non-English speaking patients face a double burden of low health literacy and low English digital literacy, which severely limits their ability to independently activate and navigate portals [7].

2.3 Implementation Science Frameworks for Digital Health

To successfully integrate digital health interventions into clinical practice, researchers and practitioners rely on implementation science frameworks. These frameworks provide structured approaches to identifying, understanding, and addressing the barriers that prevent evidence-based practices from being adopted and sustained in real-world settings. One of the most widely used frameworks is the Consolidated Framework for Implementation Research, which categorizes implementation barriers into five domains: outer setting (e.g., patient needs, local policies), inner setting (e.g., clinic culture, resources), characteristics of individuals (e.g., staff knowledge and beliefs), characteristics of the intervention (e.g., portal design, usability), and the implementation process (e.g., planning, engaging, executing).

In the context of patient portal enrollment in community clinics, the Consolidated Framework for Implementation Research highlights the need to align patient-level capabilities with clinic-level workflows. For example, while the inner setting of a clinic may have the technical infrastructure to send automated portal invitations, the outer setting (the patients' physical and economic environment) may lack the reliable cellular networks needed to receive them. This misalignment often results in low adoption rates despite significant institutional investment.

Another relevant framework is the Technology Acceptance Model, which posits that an individual's intention to use a new technology is primarily determined by two factors: perceived usefulness and perceived ease of use. In a community clinic setting, if a patient perceives that the portal is too difficult to navigate (low ease of use) or does not see how it will improve their health or clinic experience (low usefulness), they will not enroll. Implementation strategies must therefore target both elements, providing hands-on training to increase perceived ease of use while clearly

communicating the concrete benefits of portal enrollment, such as faster prescription refills and direct messaging with doctors.

3. Methodology and Research Design

3.1 Study Design and Setting

This study was conducted as a prospective, observational implementation study within a large network of community health clinics located in a metropolitan area. The clinic network serves as a critical safety-net provider, offering comprehensive primary care, dental, behavioral health, and social support services to over fifty thousand patients annually. The population served by these clinics is highly diverse, with a large proportion of low-income, uninsured, and publicly insured patients. The study was designed to evaluate the real-world effectiveness of a standardized clinic-based portal enrollment strategy and to identify the patient-level barriers that predicted enrollment failure.

During the six-month study period, the clinic network implemented an active portal onboarding intervention. When patients arrived for scheduled primary care appointments, they were greeted by clinical staff who assessed their portal status. If a patient was not currently enrolled, the clinic staff initiated a standardized onboarding protocol. This protocol involved explaining the benefits of the portal, generating an activation link, and offering immediate, hands-on assistance to guide the patient through the initial registration and login process on either the patient's personal mobile device or a clinic-provided tablet.

This active implementation approach provided a unique opportunity to study the digital divide in real-time. Because every non-enrolled patient was systematically offered assistance, we were able to minimize the self-selection bias that often characterizes digital health studies. We could observe which patients accepted help, which patients successfully completed enrollment with assistance, and which patients remained un-enrolled despite the clinical support provided. Ethical approval for the study was obtained from the institutional review board, and all participating patients provided informed consent prior to data collection.

3.2 Participant Recruitment and Data Collection

A total of five hundred and twenty-eight adult patients were recruited for the study. To be eligible for participation, individuals had to be active patients of the community clinic network, be eighteen years of age or older, speak English or Spanish, have an active clinical visit during the study period, and not be previously enrolled in the clinic's patient portal. Patients who had cognitive impairments that prevented them from providing informed consent or completing surveys were excluded from the study.

Data collection occurred in two distinct phases: a baseline survey administered immediately before the patient's medical appointment, and an electronic health record review conducted thirty days post-visit. The baseline survey was administered by trained research assistants in either English or Spanish, depending on the patient's preference. The survey was designed to capture detailed demographic information as well as specific, multi-dimensional digital divide barriers. The survey instrument included questions adapted from validated digital health scales and national health communication surveys [8].

The electronic health record review conducted thirty days after the index visit was used to determine the primary outcome variable: successful portal enrollment. By linking the baseline survey data with objective system-generated login logs from the electronic health record, we were able to match self-reported digital barriers with actual enrollment behavior, avoiding the biases associated with self-

reported technology use. Figure 1 outlines the comprehensive workflow of the patient outreach, screening, support, and enrollment verification process.

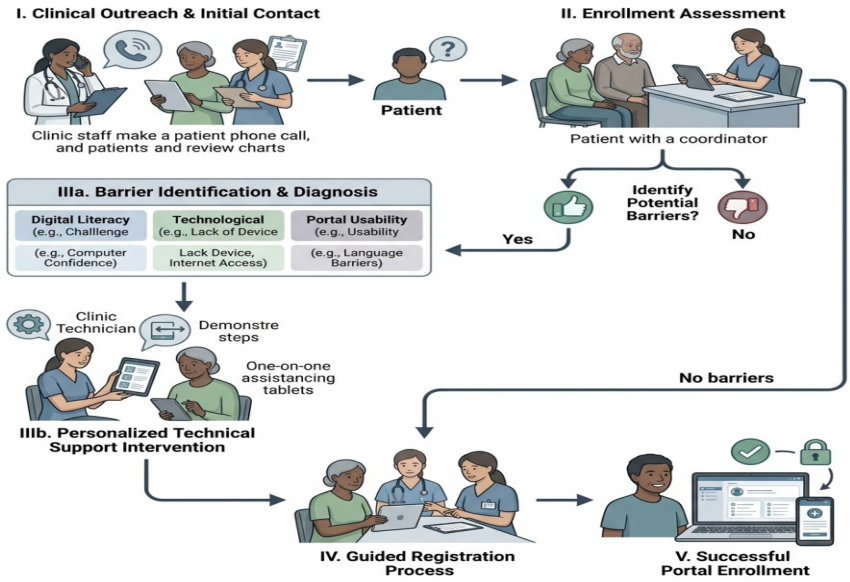

Figure 1: Comprehensive Workflow of Patient Portal Enrollment and Barrier Identification

3.3 Variable Measurement and Coding

The primary dependent variable was successful portal enrollment, coded as a binary outcome (one for enrolled, zero for not enrolled). Successful enrollment was defined as a patient completing the registration process and logging into the portal at least once within thirty days of their baseline clinic visit.

The primary independent variables represented three key dimensions of the digital divide: physical device access, internet connectivity, and digital literacy. Physical device access was categorized into three levels: computer or tablet access (high access), smartphone-only access (moderate access), and no personal digital device access (low access). Internet connectivity was measured by asking patients about the stability of their internet connection, categorized as stable (e.g., reliable home Wi-Fi or unlimited data plan) versus unstable (e.g., public Wi-Fi dependent, prepaid cellular data caps, or no internet access).

Digital literacy was assessed using a validated three-item screener that measured a patient's self-reported confidence in performing digital tasks: navigating websites, completing online forms, and searching for information online. Responses were scored on a Likert scale and aggregated to classify patients into three levels: high, moderate, and low digital literacy. Control variables included key demographic characteristics such as age, gender, race/ethnicity, primary language spoken, and educational attainment, as well as clinical variables such as the number of chronic conditions diagnosed.

Table 1 displays the demographic and digital divide characteristics of the study cohort, stratified by their portal enrollment status at thirty days post-visit.

Table 1: Demographic and Digital Divide Characteristics of the Study Cohort

Variable	Enrolled (N=284)	Not Enrolled (N=244)	p-value
Age 18 to 34	92	41	less than 0.001
Age 35 to 54	118	98	less than 0.001
Age 55 and older	74	105	less than 0.001
Female Gender	162	134	0.520

Variable	Enrolled (N=284)	Not Enrolled (N=244)	p-value
Preferred Language English	198	132	less than 0.001
Preferred Language Spanish	86	112	less than 0.001
High School Graduate or Less	110	168	less than 0.001
More than High School	174	76	less than 0.001
Stable Internet Connection	212	104	less than 0.001
Unstable Internet Connection	72	140	less than 0.001
Access via Computer or Tablet	124	42	less than 0.001
Access via Smartphone Only	142	136	less than 0.001
No Personal Device Access	18	66	less than 0.001
High Digital Literacy	154	48	less than 0.001
Moderate Digital Literacy	98	112	less than 0.001
Low Digital Literacy	32	84	less than 0.001

3.4 Data Analysis and Statistical Methods

All statistical analyses were performed using standard statistical software. First, we conducted descriptive analyses to summarize the demographic characteristics and digital divide barriers of the study sample. Bivariate analyses, including chi-square tests for categorical variables and independent samples t-tests for continuous variables, were used to examine the baseline differences between patients who successfully enrolled in the portal and those who did not.

Next, we constructed a series of multivariate logistic regression models to identify the independent predictors of portal enrollment [9]. Model one included only demographic variables (age, gender, language, education) to establish a baseline of sociodemographic disparities. Model two added the physical access variables (device type, internet stability). Model three added the digital literacy variable to assess whether cognitive barriers explained additional variance beyond demographic and physical access factors.

Multicollinearity among the independent variables was assessed using variance inflation factors, with all values falling well below the standard threshold of five, indicating that multicollinearity was not a concern in our final models. Model goodness-of-fit was evaluated using the Hosmer-Lemeshow test and Cox and Snell pseudo-R-squared values. Odds ratios and ninety-five percent confidence intervals were calculated for all predictors. Statistical significance was defined using a two-sided alpha level of 0.05.

4. Results and Empirical Analysis

4.1 Demographic Characteristics of the Study Population

The study population reflected the diverse and highly vulnerable demographic profile characteristic of safety-net community health centers. Of the five hundred and twenty-eight participants, slightly more than half were female, and a significant portion of the sample fell into older age brackets, with approximately one-third of the participants being fifty-five years of age or older. Reflecting the bilingual patient population served by the clinic network, a substantial minority of participants selected Spanish as their preferred language for health communication and survey completion [10].

Education levels were relatively low across the entire cohort, with more than half of the participants reporting high school graduation or less as their highest level of education. The prevalence of chronic illnesses was high, with the vast majority of patients managing at least one chronic condition, such as type two diabetes, hypertension, or asthma, and many managing multiple co-

morbidities. This high disease burden underlines the clinical importance of the patient portal as a tool for self-management in this specific population.

The baseline survey revealed substantial digital divide barriers. Unstable internet connectivity was reported by a significant portion of the sample, with many patients describing relying on prepaid cellular plans with restrictive data caps or public Wi-Fi hotspots located at libraries or fast-food restaurants. Device access was also highly constrained. While most patients owned a mobile phone, only a minority had access to a personal computer or tablet. Furthermore, a non-trivial segment of the study population owned no personal digital device whatsoever, relying entirely on shared devices or having no digital access at all. Digital literacy was similarly skewed, with a large group of patients reporting low confidence in their ability to perform basic online tasks.

4.2 Association Between Digital Divide Barriers and Portal Enrollment

The bivariate analyses presented in Table 1 demonstrate highly significant differences between the enrolled and non-enrolled groups across nearly all demographic and digital divide measures. Patients who successfully enrolled within thirty days of their clinical visit were significantly younger, more likely to speak English as their primary language, and had higher levels of formal education. More importantly, the enrolled group reported dramatically higher levels of digital access and readiness. Specifically, those who enrolled were much more likely to have a stable internet connection, have access to a computer or tablet, and possess high digital literacy.

To isolate the independent effects of these barriers, we conducted a multivariate logistic regression analysis. The results of the final fully adjusted model are presented in Table 2. After controlling for age, language, and education, the physical and cognitive dimensions of the digital divide remained strong and statistically significant predictors of portal enrollment.

Table 2: Multivariate Logistic Regression Predicting Successful Portal Enrollment

Predictor	Odds Ratio	95% Confidence Interval	p-value
Age 35 to 54 (vs 18 to 34)	0.68	0.42 to 1.10	0.112
Age 55 and older (vs 18 to 34)	0.42	0.24 to 0.73	0.002
Preferred Language Spanish (vs English)	0.54	0.33 to 0.88	0.014
More than High School (vs High School or Less)	1.82	1.18 to 2.80	0.007
Unstable Internet (vs Stable Internet)	0.48	0.31 to 0.74	0.001
Smartphone Only (vs Computer or Tablet)	0.52	0.32 to 0.84	0.008
No Personal Device (vs Computer or Tablet)	0.18	0.09 to 0.36	less than 0.001
Moderate Digital Literacy (vs High Literacy)	0.38	0.23 to 0.62	less than 0.001
Low Digital Literacy (vs High Literacy)	0.14	0.07 to 0.28	less than 0.001

The regression results indicate that physical access barriers represent a severe hurdle to portal enrollment [11]. Patients with unstable internet connectivity had less than half the odds of enrolling compared to those with stable connections, even when receiving help at the clinic. Device type was also a major factor: mobile-only users had significantly lower odds of enrollment than those with computer or tablet access, and those with no device access at all were highly unlikely to enroll.

Cognitive barriers were even more influential. Patients with moderate digital literacy had low odds of enrolling, and those with low digital literacy had extremely low odds of enrolling compared to patients with high digital literacy. These findings show that digital literacy is a powerful bottleneck; even if a patient has a device and internet access, a lack of digital skills can prevent successful

portal enrollment. Figure 2 displays the empirical framework, showing how these physical, structural, and cognitive barriers block portal enrollment.

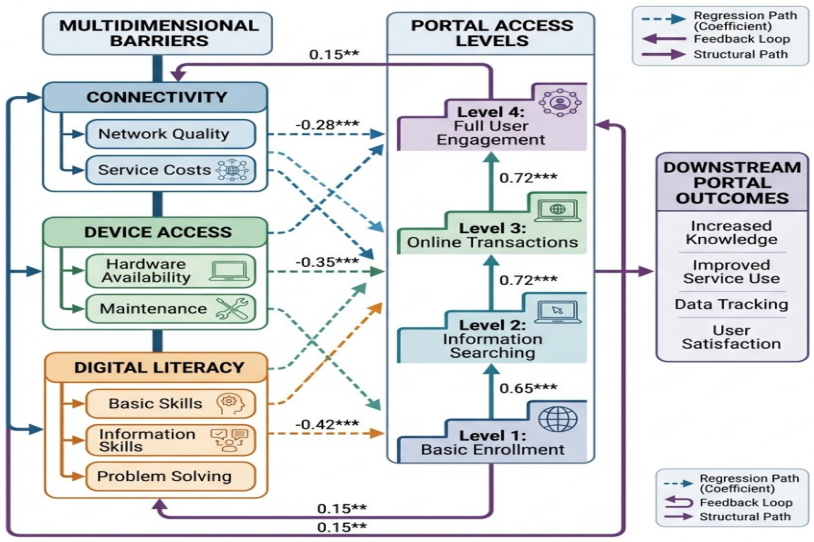

Figure 2: Empirical Framework Mapping Digital Divide Barriers to Portal Access Levels

4.3 Implementation Strategy Evaluation

The evaluation of the clinic-based implementation strategy revealed important nuances regarding the limits of clinical interventions. The hands-on onboarding support provided by clinical staff and digital health navigators was not equally effective across all patient segments. To understand these differences, we conducted a stratified analysis of enrollment success rates based on patients' baseline digital literacy and device access.

For patients who possessed moderate digital literacy and had stable internet connections, the hands-on assistance strategy was highly successful. In this group, the physical presence of a staff member who could walk the patient through the login screen and explain how to reset a forgotten password was often enough to overcome minor administrative friction. Many of these patients expressed that they had wanted to enroll in the past but had been intimidated by the setup process, and the clinic-based intervention successfully bridged this small gap.

In contrast, the intervention was remarkably ineffective for patients facing multi-layered digital exclusion, such as those with low digital literacy who also lacked personal devices or had unstable internet. For these individuals, the clinic-provided technical support was a temporary patch that did not translate into sustainable portal access. Even when staff successfully registered these patients using a clinic tablet during the visit, these patients were rarely able to log in again from home due to a lack of compatible hardware, continuous data plans, or the confidence to navigate the portal interface independently. This finding reveals a clear digital ceiling effect, where clinic-level implementation strategies fail to resolve broader societal and structural inequities.

5. Discussion and Implementation Implications

5.1 Synthesis of Key Findings

This study provides clear empirical evidence linking specific digital divide barriers directly to patient portal enrollment outcomes within a vulnerable community clinic population. Our findings demonstrate that despite the deployment of an active, resource-intensive clinical onboarding intervention, structural digital inequities continue to drive significant disparities in portal adoption.

Both physical access barriers, such as unstable internet and lack of computer hardware, and cognitive barriers, such as low digital literacy, act as robust, independent impediments to successful portal enrollment [12].

Our findings challenge the common assumption in healthcare administration that low portal enrollment is primarily a motivational issue that can be solved with patient education or marketing campaigns. Instead, our research shows that for many patients, the barrier is a structural impossibility. A patient who does not own a compatible device or cannot afford a stable data plan cannot realistically use a digital portal, regardless of how much they value their healthcare provider or understand the benefits of digital tracking. Furthermore, the strong predictive power of digital literacy underscores that technology design itself is a significant barrier. Current portal interfaces are often too complex, requiring a level of digital navigation skill that many safety-net patients do not possess.

Importantly, our evaluation of the clinical onboarding intervention highlights the limits of clinic-based support. While hands-on technical assistance is highly valuable for patients who are close to the digital adoption threshold (i.e., those with moderate literacy and stable access), it is not a cure-all for deep-seated digital exclusion. When clinical systems implement portal-support strategies without addressing underlying device and connectivity deficits, they risk creating a false sense of progress, registering patients who ultimately remain unable to access their health information once they leave the clinic doors.

5.2 Implementation Strategies for Community Clinics

For community clinics and safety-net health systems committed to digital health equity, these findings have important practical implications. To ensure that the digital transformation of healthcare does not widen equity gaps, clinics must move beyond basic, one-size-fits-all onboarding protocols and instead adopt multi-level, tailored implementation strategies. First, clinics should implement brief, validated screening tools at the point of care to assess patients' specific digital barriers, such as device access, connectivity, and digital literacy. By understanding each patient's digital profile, clinic staff can target resource-intensive interventions, like hands-on training, to those who will benefit most, while steering highly excluded patients toward alternative, non-digital care pathways.

Second, healthcare systems should actively partner with community organizations, public libraries, and local government programs to address the physical dimensions of the digital divide. For example, clinics can establish device-lending libraries or assist eligible patients in signing up for subsidized government broadband programs. Providing free, high-speed Wi-Fi in clinic parking lots and waiting rooms can also offer a reliable connection point for patients who lack internet access at home.

Third, portal developers and healthcare IT departments must prioritize universal design principles. Patient portal interfaces should be simplified, utilizing icon-based navigation, clear translations, and lower reading-level requirements to accommodate individuals with limited digital and health literacy. Portals must be optimized for mobile-only users, ensuring that all key features are fully functional on basic smartphones and do not require high-speed broadband connections. Until these systemic physical and cognitive barriers are addressed, clinical workflows must maintain robust, high-quality, non-digital communication options, such as telephone outreach and paper-based materials, to ensure that the most vulnerable patients are not excluded from care.

5.3 Study Limitations and Future Research

This study has several limitations that should be acknowledged when interpreting the findings. First, the data were collected from a single community health clinic network in a metropolitan area, which

may limit the generalizability of the findings to rural settings or different geographic regions where internet infrastructure and demographic profiles vary. Second, our assessment of physical access and digital literacy relied on self-reported survey measures, which are subject to social desirability and recall biases. While we used validated screening tools, direct clinical observations of patients attempting to navigate the portal would provide a more objective measure of digital skills.

Third, our study focused primarily on the initial thirty-day portal enrollment outcome. While securing the first login is a critical hurdle, it does not guarantee long-term, meaningful engagement with the digital platform. A patient may successfully register with staff assistance but never log in again to message their provider or view lab results. Future research should track patients over longer periods to examine the predictors of sustained portal utilization and to determine whether digital divide barriers continue to impact long-term engagement in the same manner.

Finally, future implementation studies should investigate the effectiveness of multi-level interventions that combine clinical technical support with community-based digital inclusion programs. For example, clinical trials comparing standard clinical onboarding to an integrated intervention that couples clinical enrollment with community-based digital literacy training and device provision would offer valuable insights into how to systematically dismantle the digital ceiling. Such research is essential for building an equitable digital health infrastructure that serves all patients, regardless of their socioeconomic or technological background.

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