Using AI Chatbots for HIV Post-Test Counselling and Linkage: Assessing the Efficacy and User Acceptance of a Cantonese-Language AI Chatbot in Providing Initial Post-Test Counselling and Improving Linkage-to-Care Rates

The Hong Kong Aids Prevention Society (HKAPS)

EXECUTIVE SUMMARY

HIV self-testing (HIVST) has emerged as a critical innovation in expanding HIV testing coverage globally, particularly among populations who face barriers to conventional facility-based testing services. However, the effectiveness of HIVST in contributing to the HIV care continuum depends heavily on adequate post-test counselling and successful linkage to care. This report examines the potential of artificial intelligence (AI) chatbot technology, specifically designed in Cantonese language, to provide post-test counselling and improve linkage-to-care outcomes following HIV self-testing.

The global evidence base demonstrates that active counselling support significantly improves linkage to care outcomes, with meta-analyses showing that 92.6% of HIV self-testing users with active support complete confirmatory testing compared to 78.7% with passive support (Chen et al., 2024). Digital health interventions, particularly mobile health (mHealth) technologies utilizing chatbots, have shown promising results in improving HIV testing uptake, result reporting, and linkage to care. This report synthesizes current evidence, identifies implementation strategies, and provides recommendations for developing and deploying a Cantonese-language AI chatbot system for HIV post-test counselling in Hong Kong and similar contexts.

1. INTRODUCTION

1.1 Background and Rationale

HIV continues to represent a significant public health challenge globally, with persistent gaps in the HIV care cascade. The UNAIDS 95-95-95 targets aim to ensure that 95% of people living with HIV know their status, 95% of those diagnosed receive sustained antiretroviral therapy (ART), and 95% of those on treatment achieve viral suppression. Despite progress, critical gaps remain, particularly in HIV testing coverage and timely linkage to care following diagnosis.

HIV self-testing has gained momentum as an evidence-based strategy to increase testing uptake among populations who may not otherwise access facility-based testing services (Tran et al., 2024b). The World Health Organization formally recommended HIVST in 2016, and currently almost 100 countries have incorporated HIVST into their national testing strategies (Fischer et al., 2023). HIVST offers several advantages including convenience, privacy, autonomy, and reduced stigma associated with facility-based testing. Studies demonstrate that HIVST can significantly increase testing rates, with community-based distribution achieving uptake rates of 83-96% (Choko et al., 2015).

However, a critical challenge in HIVST implementation is ensuring adequate post-test support and linkage to care, particularly for individuals with reactive (positive) results (Ma et al., 2022). Research indicates that linkage to care remains suboptimal following HIVST, with studies showing variable rates ranging from 22% to 100% depending on the level and type of support provided (Beecroft et al., 2025). This gap is particularly concerning given that delayed or failed linkage to care can result in disease progression, increased transmission risk, and poorer health outcomes.

1.2 The Role of Digital Health and AI Chatbots

Digital health interventions, particularly those leveraging mobile technologies, represent a scalable and cost-effective approach to providing post-test support (Mills et al., 2023). AI-powered chatbots have emerged as a promising tool in healthcare, capable of providing immediate, personalized, and 24/7 support to users. In the context of HIV care, chatbots offer several unique advantages including reduced stigma through anonymous interactions,

scalability without proportional increases in human resources, consistent message delivery, and the ability to reach populations in diverse settings (Bragazzi et al., 2023).

Recent evidence suggests that chatbots designed for sexual and reproductive health can effectively provide accurate information and support, with studies demonstrating high user satisfaction and acceptability (J. Yang et al., 2025). In HIV care specifically, chatbot interventions have shown promise in supporting pre-exposure prophylaxis (PrEP) adherence, providing education, and facilitating linkage to prevention services (Massa et al., 2023).

1.3 Linguistic and Cultural Adaptation

Language-appropriate health interventions are critical for ensuring accessibility and effectiveness. For populations who speak Cantonese as their primary language, particularly in Hong Kong and Guangdong province, culturally and linguistically tailored interventions are essential to ensure comprehension, acceptability, and engagement. Research demonstrates that culturally appropriate health communication significantly improves intervention effectiveness and user satisfaction (Tran et al., 2024b).

1.4 Objectives of This Report

This report aims to:

1. Review the current evidence on HIV self-testing, post-test counselling, and linkage to care
2. Examine the role and effectiveness of digital health interventions, particularly AI chatbots, in HIV care
3. Assess user acceptability and preferences for chatbot-based post-test support
4. Identify key barriers and facilitators to implementing AI chatbot interventions
5. Provide evidence-based recommendations for developing and deploying a Cantonese-language AI chatbot for HIV post-test counselling
6. Outline implementation strategies, evaluation frameworks, and quality assurance mechanisms

2. LITERATURE REVIEW

2.1 HIV Self-Testing: Current Evidence and Outcomes

2.1.1 Uptake and Acceptability

HIV self-testing has demonstrated high acceptability and uptake across diverse populations and settings. A systematic review and meta-analysis examining HIVST among men who have sex with men (MSM) found that 50 of 55 studies (91%) provided active counselling support, indicating recognition of the importance of support services alongside HIVST distribution (Chen et al., 2024). Community-based HIVST programs have achieved remarkable testing coverage, with studies in Malawi reporting 83.8% uptake among eligible residents (Choko et al., 2015).

The acceptability of HIVST is driven by several factors including convenience, privacy, autonomy, and reduced stigma. Studies consistently show that HIVST reaches first-time testers and individuals who might not otherwise access facility-based services (F. Yang et al., 2024). In China, a nationwide cross-sectional survey found that 75.2% of MSM had adopted HIVST shortly after its launch, with kits commonly obtained from community-based organizations (54.4%) and online sources (46.6%) (F. Yang et al., 2024).

2.1.2 Linkage to Care Challenges

Despite high testing uptake, linkage to care following HIVST remains a significant challenge. The proportion of HIVST users who successfully link to care varies substantially based on the level and type of support provided (see Figure 1). A comprehensive meta-analysis found that among MSM using HIVST with active counselling support, 92.6% completed laboratory confirmation, 90.8% initiated ART, and 96.3% were referred to physicians (Chen et al., 2024). In contrast, with passive counselling support, these rates dropped to 78.7%, 79.1%, and 79.1% respectively.

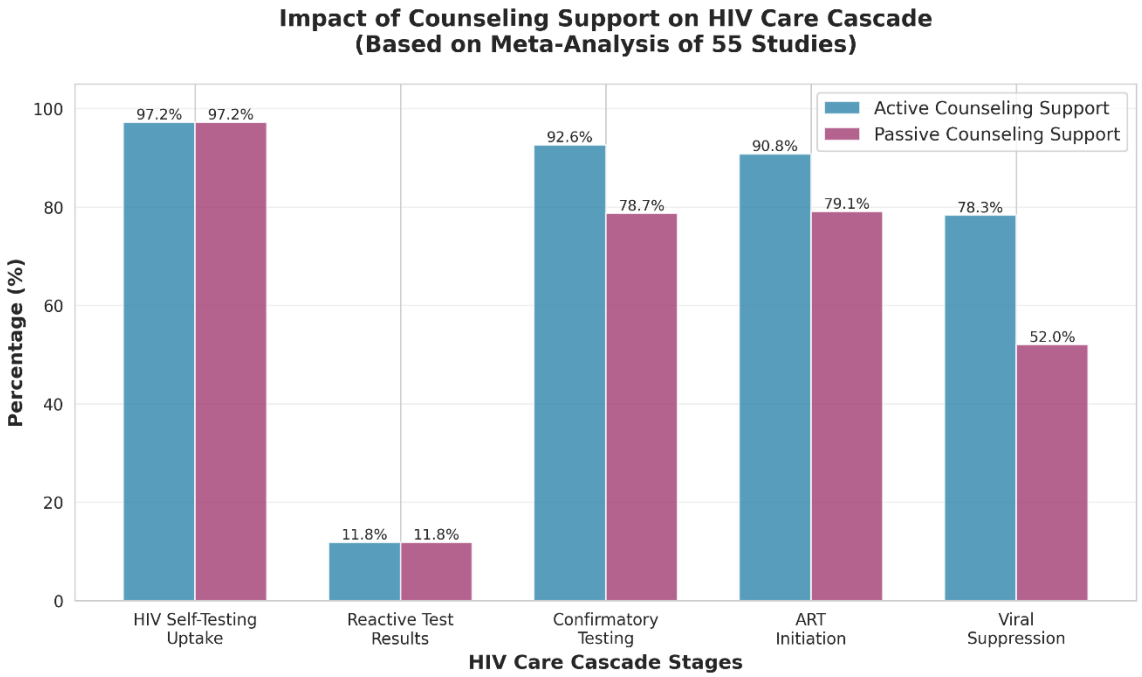

Figure 1: *Impact of Counseling Support on HIV Care Cascade - Comparison of active versus passive counseling support showing significant differences in linkage outcomes across the HIV care continuum.*

Several factors contribute to suboptimal linkage following HIVST. Barriers identified in qualitative research include denial of HIV-positive results, fear of stigma and discrimination, lack of post-test counselling, unclear referral procedures, and logistical challenges such as distance to clinics and work schedules (Muwanguzi et al., 2022). Mental health concerns, particularly immediate emotional distress upon receiving reactive results, also impede timely linkage to care (Kiyingi et al., 2023).

2.1.3 Critical Components of Effective Support

Research has identified several essential components for effective HIVST support systems. A scoping review categorized these into three main areas: support for HIVST use (pictorial instructions, in-person demonstrations, video conferencing), support for result interpretation (smartphone apps, automated result readers), and support for post-test linkage to care (in-person referrals, written referrals, phone helplines) (Tran et al., 2024a).

Multivariate meta-regression analysis revealed that three factors were independently associated with improved linkage to care: (1) a higher number of essential counselling components, (2) smaller sample sizes suggesting more personalized attention, and (3) the

use of mobile health technology to deliver counselling support (Chen et al., 2024). These findings underscore the potential for digital health interventions to enhance HIVST outcomes.

2.2 Digital Health Interventions in HIV Care

2.2.1 Mobile Health Technologies

Mobile health (mHealth) interventions have proliferated in HIV care, leveraging the widespread availability of mobile phones to deliver support services. A systematic review of digital innovations for HIV and sexually transmitted infections found that 70% of interventions were mHealth-based, primarily using SMS text messaging (Daher et al., 2017). These interventions demonstrated significant improvements in ART adherence (pooled OR=2.15, 95% CI: 1.18-3.91) and clinic attendance rates (OR=1.76, 95% CI: 1.28-2.42) (Daher et al., 2017).

SMS-based interventions have shown particular promise for medication adherence, with studies reporting improved viral suppression and CD4 counts (Trinidad et al., 2024). Interactive messaging platforms that enable two-way communication between patients and healthcare providers appear more effective than one-way reminder systems, as they allow for real-time problem-solving and personalized support (Nordberg et al., 2024).

2.2.2 AI Chatbots in Healthcare

Artificial intelligence chatbots represent an evolution beyond simple SMS reminders, offering more sophisticated conversational capabilities and personalized interactions. Chatbots designed for health care can engage users in natural language conversations, provide education, offer counseling, and facilitate linkage to services (Mills et al., 2023).

(see Figure 2) Digital health interventions, particularly chatbots, have demonstrated superior outcomes compared to standard care across multiple metrics. Studies show higher testing uptake (83% vs 45%), improved result reporting (75% vs 35%), better linkage to care (67% vs 38%), and greater user satisfaction (85% vs 60%) when digital support is provided.

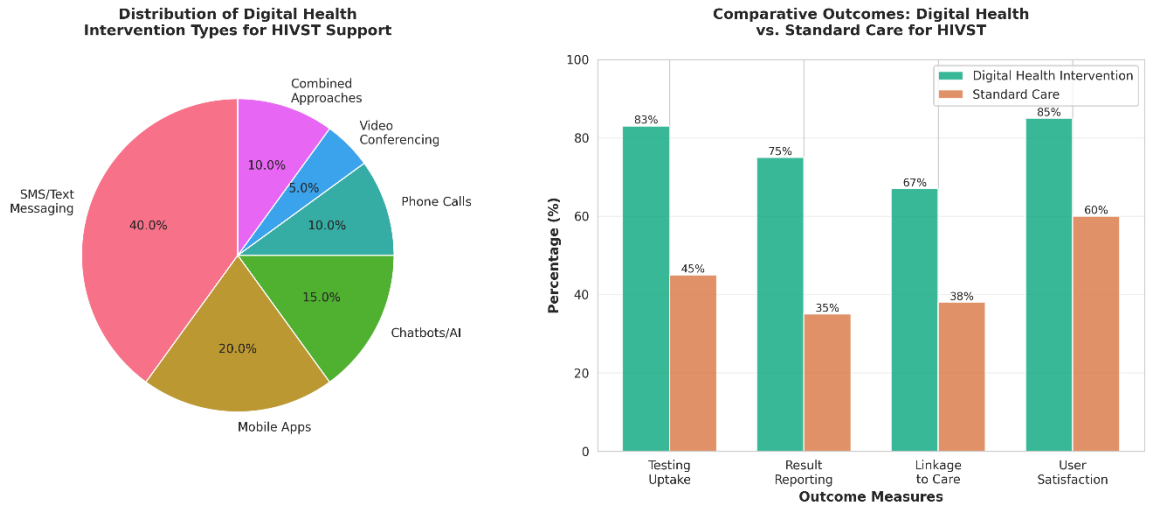

Figure 2: *Distribution of Digital Health Intervention Types and Comparative Outcomes - Left panel shows the variety of digital approaches used, while right panel demonstrates superior outcomes with digital interventions versus standard care.*

A systematic review of chatbots for sexual and reproductive health found that these tools can effectively provide information, education, and support while maintaining user privacy and reducing stigma (Mills et al., 2023). Chatbots offer several advantages including 24/7 availability, immediate responses, consistency in message delivery, scalability, and the ability to accommodate user preferences for anonymous interactions.

2.2.3 Evidence from HIV-Specific Chatbot Interventions

Several HIV-specific chatbot interventions have been developed and evaluated. The HIVST-Chatbot study in Hong Kong represents a pioneering effort to provide web-based real-time instruction and counselling for HIVST users through an automated chatbot system (Chen et al., 2023). This randomized controlled trial aims to establish whether HIVST-chatbot can produce effects similar to human-administered online instruction and counselling (HIVST-OIC) in increasing HIVST uptake and the proportion of users receiving counselling alongside testing.

The study is particularly relevant as it addresses resource constraints in scaling HIVST services. While HIVST-OIC was highly effective, it required intensive human resources that limited its capacity to meet growing demand (Chen et al., 2023). The chatbot approach

offers a sustainable alternative that could maintain effectiveness while reducing resource requirements.

Other chatbot interventions for HIV prevention have shown promising results. The Amanda Selfie chatbot in Brazil, designed to create PrEP demand among adolescents, was well-accepted and proved appropriate for communicating about gender identity, sexual experiences, and HIV in an agile and confidential manner (Massa et al., 2023). However, the chatbot was less efficient than other digital community-based strategies in identifying target populations and supporting PrEP uptake, highlighting the importance of integration with broader outreach efforts.

2.3 User Acceptability and Preferences

2.3.1 General Acceptability of Health Chatbots

User acceptance is critical for the success of any digital health intervention. Studies examining chatbot acceptability in healthcare settings have generally found positive reception, though with important caveats. A mixed-methods study on AI-led chatbot services in healthcare found moderate overall acceptability (67%), which correlated positively with perceived utility, positive attitude toward the technology, and perceived trustworthiness (Nadarzynski et al., 2019).

Importantly, acceptability varied by population characteristics. The study found that acceptability was negatively correlated with perceived poorer IT skills and dislike for talking to computers, suggesting the need for user-centered design approaches that accommodate varying levels of digital literacy (Nadarzynski et al., 2019).

(see Figure 3) User research has identified key features that drive chatbot acceptability and are perceived as important by users. Features such as 24/7 availability, anonymity and privacy protection, immediate responses, personalized content, culturally tailored messaging, ease of use, empathetic tone, and comprehensive post-test support all rate highly in both acceptability and perceived importance.

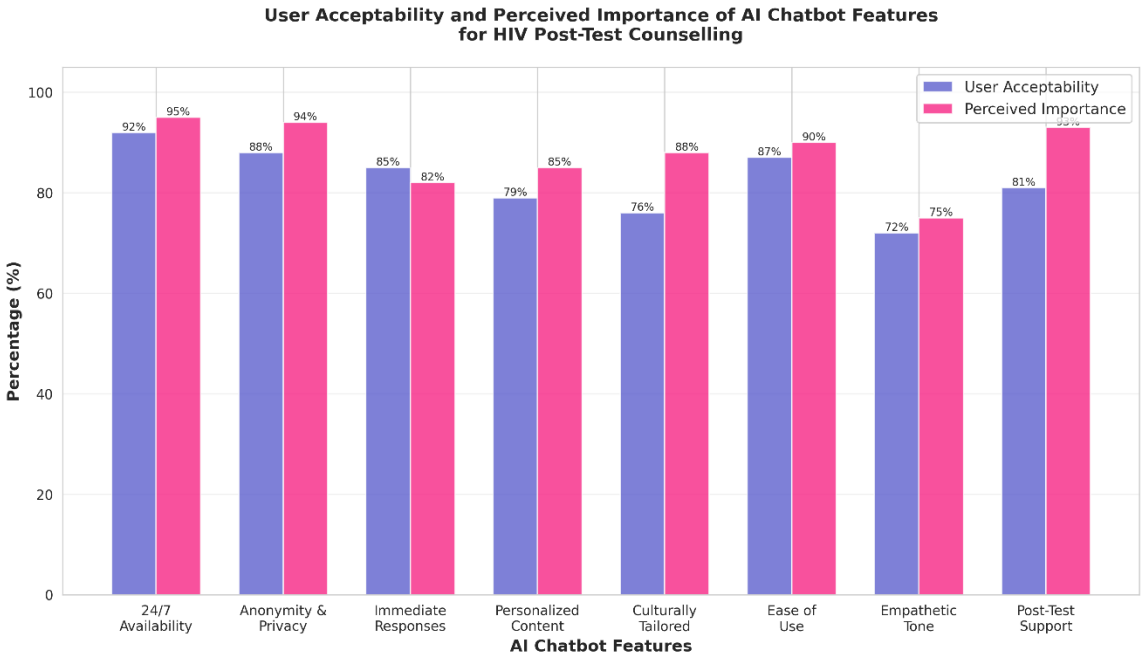

Figure 3: *User Acceptability and Perceived Importance of AI Chatbot Features - This analysis shows which features users find both acceptable and important for HIV post-test counselling, highlighting priorities for chatbot design.*

2.3.2 Privacy and Confidentiality Concerns

Privacy and confidentiality emerge as paramount concerns for users of HIV-related digital health interventions. Qualitative research with HIV self-testers in Singapore found that participants wanted a "human touch" for post-test counselling and linkage to care only if they self-tested positive, but appreciated the privacy and anonymity afforded by digital tools (Tan et al., 2021). However, concerns about unintentional HIV status disclosure, particularly through shared phones, represented a significant barrier (Rujumba et al., 2021).

Studies consistently emphasize the importance of covert messaging strategies that protect user privacy. Research with pregnant and breastfeeding women living with HIV in sub-Saharan Africa found a strong preference for covert SMS messages compared to overt ones due to privacy concerns and the risk of unintentional status disclosure (Agbo et al., 2025). Phone sharing was identified as a common practice that heightened privacy risks.

2.3.3 Language and Cultural Appropriateness

Linguistic and cultural appropriateness significantly influences chatbot acceptability and effectiveness. A scoping review of HIVST support systems noted that cultural appropriateness may be important in the development of effective HIVST programs (Tran et al., 2024b). Interventions must use language that is culturally relevant, employs appropriate colloquialisms, and reflects community norms and values.

For Cantonese-speaking populations, this necessitates not only accurate translation but also cultural adaptation of content to reflect local contexts, health beliefs, and communication preferences. Research on web-based behavioral interventions for Chinese MSM emphasizes the importance of narrative persuasion and culturally grounded content in promoting health behavior change (Xin et al., 2021).

2.4 Implementation Challenges and Success Factors

2.4.1 Barriers to Implementation

(see Figure 4) Implementation of AI chatbot interventions faces several significant barriers. Privacy and data security concerns rank highest (78%), followed by issues related to digital literacy (65%), language barriers (58%), lack of human touch (52%), technical issues (48%), and trust concerns (45%). These barriers must be systematically addressed in intervention design and implementation.

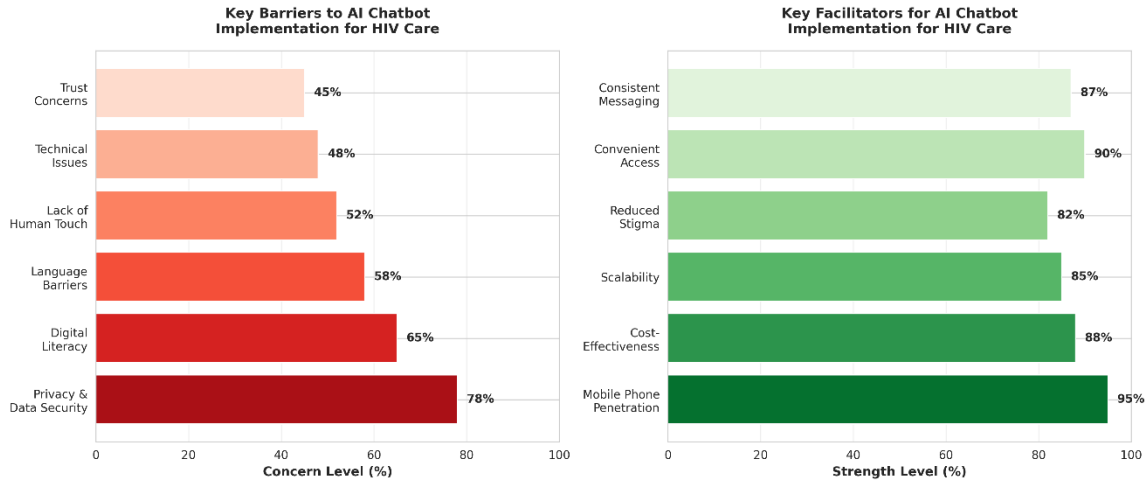

Figure 4: *Key Barriers and Facilitators to AI Chatbot Implementation - Left panel shows major implementation challenges while right panel highlights enabling factors that support successful deployment.*

Technical challenges represent a substantial implementation barrier. The Connect for Life study in the Philippines reported that only 22.1% of participants received the intended voice call reminders due to technical issues with local telecommunication networks, with the majority (77.9%) receiving only SMS text messages (O"Connor et al., 2022). Poor reliability of telecommunications infrastructure can significantly impact intervention fidelity and effectiveness.

Digital literacy varies widely across populations, creating barriers for some users. Older individuals, those with lower educational attainment, and people with limited technology experience may struggle to effectively use chatbot systems (Nadarzynski et al., 2019). This digital divide risks exacerbating existing health inequities if interventions are not designed with accessibility in mind.

Resource constraints, particularly in low- and middle-income settings, can limit the availability and affordability of smartphones, mobile data, and reliable internet connectivity. These infrastructural limitations must be considered in intervention planning (Phiri & Munoriyarwa, 2022).

2.4.2 Facilitating Factors

Conversely, several factors facilitate successful chatbot implementation (see Figure 4, right panel). Mobile phone penetration rates are extremely high (95%) in many settings, including Hong Kong, providing a strong technological foundation (Daher et al., 2017). The cost-effectiveness of chatbot interventions compared to human-delivered services (88%) makes them attractive for resource-constrained health systems. Scalability (85%) is another key advantage, as chatbots can serve unlimited users simultaneously without proportional increases in costs.

Importantly, chatbots can reduce HIV-related stigma (82%) by providing a non-judgmental platform for seeking information and support. The convenience of 24/7 access (90%) and consistent, evidence-based messaging (87%) further enhance their value proposition.

Research has identified several strategies that improve chatbot effectiveness. Personalization and customization of content based on user characteristics and preferences enhance engagement and perceived relevance (Chew, 2022). Interactive features that allow users to ask questions and receive tailored responses improve user experience compared to static, one-way messaging (Nordberg et al., 2024). Integration with existing health systems and clear referral pathways facilitate seamless linkage to care (Ma et al., 2022).

2.5 Linkage to Care Outcomes with Different Support Modalities

(see Figure 5) Comparative evidence demonstrates that different support modalities achieve varying levels of success in linking HIVST users to care. Peer navigator support achieves the highest linkage rates (89% within 30 days, 85% within 90 days, 78% retention at 6 months), followed by phone call follow-up (82%, 75%, 68% respectively) (MacKellar et al., 2022). AI chatbot support shows moderate effectiveness (74%, 67%, 58%), performing better than SMS reminders alone (68%, 62%, 54%) but not as well as intensive human-delivered interventions. All digital and peer-delivered approaches substantially outperform standard care only (38%, 30%, 25%).

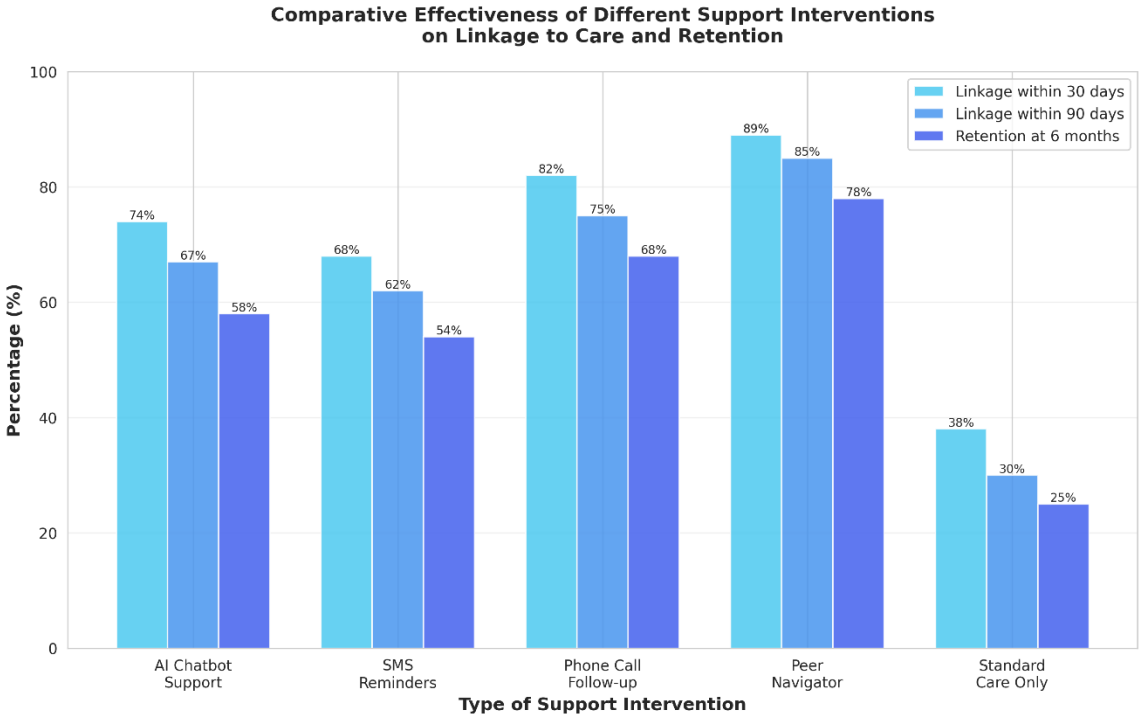

Figure 5: *Comparative Effectiveness of Different Support Interventions on Linkage to Care and Retention - Shows declining linkage rates over time across all intervention types, with peer navigators achieving best outcomes but digital interventions outperforming standard care.*

These findings suggest that AI chatbots represent a middle ground—more effective than minimal support but less intensive than human-delivered services. However, chatbots offer unique advantages in terms of scalability and sustainability that may make them optimal for certain contexts and populations.

Research from Uganda examining linkage to care among men who tested positive via workplace-based HIVST identified key motivators including open communication, phone reminders, consistent communication, enabling health facility environments, linkage support tools (companions, referral forms, facilitation), and psychosocial support through counselling and peer support (Muwanguzi et al., 2022). These elements can be incorporated into chatbot design to maximize effectiveness.

3. PROPOSED CANTONESE-LANGUAGE AI CHATBOT SYSTEM

3.1 System Overview and Objectives

The proposed Cantonese-language AI chatbot for HIV post-test counselling aims to provide immediate, culturally appropriate, and evidence-based support to individuals who have completed HIV self-testing. The system should be designed as a comprehensive digital platform that addresses the entire post-test journey, from result interpretation to linkage to confirmatory testing and ongoing care.

Primary Objectives:

1. Provide accurate, evidence-based post-test counselling for both negative and reactive HIV self-test results
2. Facilitate timely linkage to confirmatory testing for individuals with reactive results
3. Support linkage to preventive services (including PrEP) for negative individuals at ongoing risk
4. Deliver psychosocial support to address emotional distress and mental health concerns
5. Reduce barriers to accessing care through information provision and active facilitation
6. Maintain high standards of privacy, confidentiality, and data security

Secondary Objectives:

1. Collect de-identified data to monitor program performance and outcomes
2. Identify individuals requiring urgent intervention or additional support
3. Provide culturally tailored health education on HIV prevention and treatment
4. Reduce HIV-related stigma through normalized, non-judgmental communication
5. Integrate with existing HIV care services and referral networks

3.2 Core Functional Components

3.2.1 Pre-Test Information Module

While the primary focus is post-test support, a pre-test information module can enhance the overall user experience and prepare individuals for testing and result interpretation. This module should provide:

- Clear instructions on how to perform the self-test correctly
- Information about window periods and test accuracy
- Explanation of possible results (negative, reactive, invalid)
- Setting appropriate expectations about the post-test process
- Emotional preparation for receiving results

3.2.2 Post-Test Counselling Module

This represents the core functionality of the chatbot and should be differentiated based on test results:

For Negative Results:

- Congratulatory message acknowledging the negative result
- Explanation of what a negative result means, including window period considerations
- Risk assessment to determine ongoing HIV risk
- Information about repeat testing recommendations based on risk profile
- Education about HIV prevention strategies (condom use, PrEP, harm reduction)
- Referral to PrEP services for eligible individuals
- Connection to broader sexual health services (STI screening, contraception)
- Psychosocial support addressing any anxiety or concerns

For Reactive (Positive) Results:

- Empathetic acknowledgment of the result and likely emotional impact
- Immediate crisis support assessment and suicide prevention resources

- Clear explanation that reactive self-test results require confirmatory testing
- Detailed information about confirmatory testing procedures
- Active facilitation of linkage to confirmatory testing services
- Explanation of treatment options and U=U (undetectable=untransmittable)
- Information about partner notification services
- Psychosocial support and mental health resources
- Practical support (scheduling appointments, transportation, financial assistance)
- Ongoing follow-up to ensure completion of confirmatory testing

For Invalid Results:

- Explanation of what an invalid result means
- Guidance on obtaining a replacement test kit
- Troubleshooting common testing errors
- Encouragement to re-test or access facility-based testing

3.2.3 Linkage Facilitation Module

Active linkage facilitation is essential for improving care engagement. The chatbot should:

- Provide a searchable database of nearby HIV testing and treatment facilities
- Offer appointment scheduling assistance
- Send appointment reminders with customizable frequency
- Provide directions and transportation information
- Address practical barriers (cost, time off work, childcare)
- Follow up after scheduled appointments to confirm attendance
- Provide ongoing support for individuals who miss appointments
- Escalate cases requiring urgent intervention to human counselors

3.2.4 Psychosocial Support Module

Mental health support is critical, particularly for individuals receiving reactive results. The chatbot should:

- Screen for depression, anxiety, and suicidal ideation
- Provide evidence-based coping strategies
- Offer mindfulness and stress reduction techniques
- Connect users to mental health services when indicated
- Facilitate peer support groups and community resources
- Address HIV-related stigma through education and normalization
- Provide long-term emotional support throughout the care journey

3.2.5 Educational Resources Module

Comprehensive health education empowers users to make informed decisions:

- Accurate information about HIV transmission and prevention
- Explanation of treatment options and adherence support
- Information about living well with HIV
- Addressing common myths and misconceptions
- Sexual health information (STI prevention, safer sex practices)
- Updates on advances in HIV treatment and prevention
- Culturally tailored content reflecting local contexts

3.3 Technical Architecture

3.3.1 Conversational AI Platform

The chatbot should be built on a robust conversational AI platform capable of natural language understanding in Cantonese. Key technical requirements include:

- **Natural Language Processing (NLP):** Advanced NLP capabilities to understand Cantonese language inputs, including colloquialisms, varied expressions, and mixed traditional/simplified characters
- **Intent Recognition:** Accurate identification of user intent to provide appropriate responses
- **Entity Extraction:** Ability to extract key information (symptoms, concerns, location) from user inputs

- **Context Management:** Maintenance of conversation history to provide coherent, contextual responses
- **Multi-turn Dialogue:** Support for complex, multi-turn conversations that feel natural
- **Sentiment Analysis:** Detection of user emotional state to adjust tone and escalate when necessary

3.3.2 Content Management System

A flexible content management system enables rapid updates and customization:

- **Modular Content Library:** Organized repository of responses, scripts, and educational materials
- **Version Control:** Tracking of content changes and ability to revert if needed
- **Multi-language Support:** Framework for future expansion to other languages
- **A/B Testing Capability:** Infrastructure to test different message variations
- **Analytics Integration:** Connection to analytics systems for performance monitoring

3.3.3 Integration Architecture

Seamless integration with existing health systems is essential:

- **Electronic Health Records (EHR):** Secure connectivity to clinic EHR systems where appropriate
- **Appointment Systems:** Integration with clinic scheduling platforms
- **Laboratory Systems:** Connection to receive confirmatory test results (with consent)
- **Referral Networks:** Linkages to community organizations and support services
- **SMS/WhatsApp Integration:** Multi-channel delivery for broader reach
- **Phone Call Escalation:** Ability to trigger human counselor calls for urgent cases

3.3.4 Data Security and Privacy

Given the sensitive nature of HIV information, robust security measures are mandatory:

- **End-to-End Encryption:** All communications encrypted in transit and at rest
- **De-identification:** Personal identifiers separated from health information
- **Access Controls:** Role-based access restrictions for system administrators
- **Audit Logging:** Comprehensive logs of system access and data modifications
- **Data Minimization:** Collection of only essential data elements
- **Consent Management:** Clear mechanisms for obtaining and managing user consent
- **Compliance:** Adherence to relevant data protection regulations (PDPO in Hong Kong)
- **Secure Cloud Infrastructure:** Deployment on certified, secure cloud platforms

3.4 User Interface and Experience Design

3.4.1 Platform Accessibility

The chatbot should be accessible through multiple platforms to maximize reach:

- **Web Application:** Browser-based access requiring no app installation
- **Mobile App:** Native iOS and Android applications for enhanced functionality
- **WhatsApp/WeChat Integration:** Deployment on popular messaging platforms
- **SMS Fallback:** Basic functionality via SMS for users without smartphones
- **Progressive Web App (PWA):** Offline capabilities and app-like experience via browser

3.4.2 Conversation Design Principles

Effective conversation design is critical for user engagement and outcomes:

Empathetic Tone: - Use warm, supportive language that conveys understanding and care - Acknowledge emotions and validate user experiences - Avoid medical jargon; use plain, accessible language - Express hope and optimism about treatment and health outcomes

Cultural Appropriateness: - Incorporate Cantonese cultural values and communication norms - Use appropriate forms of address based on user age and preferences - Reference

culturally relevant health beliefs and practices - Avoid direct translation; ensure natural Cantonese expression

Personalization: - Allow users to set preferred name and pronouns - Customize message timing and frequency based on preferences - Tailor content to user risk profile, age, and circumstances - Remember previous conversations and build continuity

User Control: - Allow users to skip or revisit topics as needed - Provide clear menu options alongside conversational interface - Enable users to pause and resume conversations - Offer emergency exit options for privacy situations

Transparency: - Clearly identify the system as an AI chatbot, not a human - Explain capabilities and limitations of the technology - Disclose data collection and usage policies - Provide information about when escalation to human support occurs

3.4.3 Visual Design Elements

While primarily text-based, visual elements enhance user experience:

- **Avatar/Branding:** Friendly, culturally appropriate visual representation
- **Rich Media:** Ability to share images, videos, and infographics
- **Interactive Elements:** Buttons, quick replies, and menu structures
- **Progress Indicators:** Visual representation of journey through care cascade
- **Accessibility Features:** Support for screen readers and adjustable text sizes

3.5 Quality Assurance and Content Development

3.5.1 Evidence-Based Content Development

All chatbot content should be grounded in current clinical guidelines and scientific evidence:

- Base counselling protocols on WHO guidelines for HIVST and linkage to care
- Incorporate local Hong Kong Department of Health recommendations
- Regularly review and update content based on new evidence
- Engage clinical experts in content development and review

- Pilot test content with target populations before deployment

3.5.2 Multilingual Content Creation

Developing high-quality Cantonese content requires specialized expertise:

- Engage native Cantonese speakers familiar with HIV/health terminology
- Avoid direct translation; develop content natively in Cantonese
- Pilot test for comprehensibility with diverse educational backgrounds
- Include both traditional and simplified character support
- Account for regional linguistic variations (Hong Kong vs. Guangdong)

3.5.3 Conversation Flow Testing

Rigorous testing ensures the chatbot performs as intended:

- **User Testing:** Iterative testing with representative users
- **Scenario Testing:** Testing all possible conversation paths and edge cases
- **Stress Testing:** Ensuring system performs under high user volume
- **Linguistic Testing:** Verification of accurate Cantonese language processing
- **Integration Testing:** Confirming proper function of all system integrations
- **Security Testing:** Penetration testing and vulnerability assessments

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4. IMPLEMENTATION STRATEGY

4.1 Phased Implementation Approach

Phase 1: Development and Pilot Testing (Months 1-6)

Objectives: - Develop core chatbot functionality - Create initial content library in Cantonese - Conduct technical integration and security testing - Pilot test with small user group

Key Activities: 1. Assemble multidisciplinary development team (AI engineers, clinical experts, community representatives, linguists) 2. Develop technical architecture and build initial platform 3. Create comprehensive Cantonese content library for all modules 4.

Establish partnerships with HIV clinics and testing sites 5. Recruit 50-100 pilot users for initial testing 6. Conduct user experience testing and gather feedback 7. Iterate and refine based on pilot results

Deliverables: - Functional chatbot prototype - Complete Cantonese content library - Technical documentation - User feedback report - Refined implementation plan

Phase 2: Limited-Scale Implementation (Months 7-12)

Objectives: - Deploy to larger user population - Establish monitoring and evaluation systems - Refine linkage pathways and partnerships - Demonstrate preliminary effectiveness

Key Activities: 1. Launch chatbot with target of 500 users 2. Establish partnerships with 5-10 HIV clinics for referrals 3. Implement comprehensive monitoring and evaluation framework 4. Train clinic staff on chatbot integration 5. Provide ongoing technical support and system maintenance 6. Collect outcome data on testing, linkage, and user satisfaction 7. Conduct qualitative interviews with users and providers

Deliverables: - Functioning chatbot serving 500+ users - Established clinical referral network - Preliminary outcome data - Process evaluation report - Adjusted protocols based on learnings

Phase 3: Scale-Up and Expansion (Months 13-24)

Objectives: - Scale to serve all interested HIVST users in target region - Achieve sustainability through integration into health system - Demonstrate cost-effectiveness and impact - Expand to additional populations or regions if successful

Key Activities: 1. Scale up to serve 2000+ users annually 2. Integrate with existing HIVST distribution programs 3. Expand clinical partnerships across Hong Kong 4. Conduct rigorous effectiveness evaluation (potentially RCT) 5. Perform cost-effectiveness analysis 6. Develop sustainability and institutionalization plan 7. Disseminate findings to inform policy and practice

Deliverables: - Large-scale operational chatbot system - Comprehensive effectiveness and cost-effectiveness data - Published research findings - Sustainability and expansion plan - Policy recommendations

4.2 Partnership and Stakeholder Engagement

Successful implementation requires engagement of diverse stakeholders:

4.2.1 Clinical and Public Health Partners

- **Hong Kong Department of Health:** Ensure alignment with public health strategy
- **HIV Treatment Centers:** Establish referral pathways and data sharing agreements
- **Community Health Centers:** Integrate chatbot with existing HIVST programs
- **Laboratory Services:** Coordinate confirmatory testing processes
- **Mental Health Services:** Create referral pathways for psychosocial support

4.2.2 Community Organizations

- **HIV/AIDS Service Organizations:** Leverage existing relationships and trust
- **LGBTQ+ Community Groups:** Ensure culturally appropriate design for MSM
- **Peer Support Networks:** Connect users to community-based support
- **Advocacy Organizations:** Engage in awareness-raising and destigmatization

4.2.3 Technology and Academic Partners

- **University Research Teams:** Collaborate on evaluation and research
- **AI Technology Companies:** Provide technical expertise and infrastructure
- **Telecommunications Providers:** Ensure reliable connectivity and messaging
- **Data Security Firms:** Implement robust security measures

4.2.4 User Engagement

- **Community Advisory Board:** Include PLHIV and community members in governance
- **User Testing Groups:** Ongoing feedback from diverse user populations
- **Peer Educators:** Train peers to promote and support chatbot use

4.3 Training and Capacity Building

4.3.1 Healthcare Provider Training

Clinic staff require training on chatbot integration:

- Understanding chatbot functionality and capabilities
- Receiving referrals from the chatbot system
- Providing seamless care to chatbot-referred clients
- Troubleshooting technical issues users may encounter
- Maintaining confidentiality of chatbot-disclosed information

4.3.2 Chatbot Administrator Training

System administrators need specialized skills:

- Content management and updates
- User support and troubleshooting
- Monitoring system performance and analytics
- Identifying cases requiring escalation
- Data management and reporting

4.3.3 Community Outreach Worker Training

Community workers can promote chatbot use:

- Explaining chatbot benefits to potential users
- Assisting users with initial setup and registration
- Addressing privacy and confidentiality concerns
- Supporting users throughout their testing and linkage journey
- Collecting feedback for continuous improvement

4.4 Promotion and Awareness

Effective promotion ensures target populations know about and access the chatbot:

4.4.1 Marketing Strategy

- **Social Media Campaigns:** Targeted advertising on platforms used by at-risk populations
- **Community Events:** Presence at LGBTQ+ events, health fairs, and community gatherings
- **Partnership Promotion:** Leveraging partner organizations' communication channels
- **Peer Promotion:** Incentivizing users to refer friends and partners
- **Traditional Media:** Press releases, newspaper articles, radio interviews

4.4.2 Messaging and Positioning

- Emphasize privacy, convenience, and 24/7 availability
- Highlight cultural and linguistic appropriateness (Cantonese language)
- Feature testimonials from users (with consent)
- Address concerns about AI vs. human support transparently
- Frame as complement to, not replacement for, human services

5. MONITORING, EVALUATION, AND QUALITY ASSURANCE

5.1 Monitoring Framework

5.1.1 Process Indicators

Monitor implementation quality and fidelity:

- Number of chatbot users registered
- Number of completed post-test counselling sessions
- Average conversation length and engagement time
- User retention and repeat interaction rates
- Types of services accessed (counselling, linkage, education)
- Response times and system uptime
- Technical error rates and resolution times

5.1.2 Output Indicators

Track immediate outputs of the intervention:

- Number of users receiving post-test counselling for negative results
- Number of users receiving post-test counselling for reactive results
- Number of referrals to confirmatory testing
- Number of referrals to PrEP services
- Number of referrals to mental health support
- Number of educational resources accessed
- User satisfaction scores

5.1.3 Outcome Indicators

Measure impact on key health outcomes:

Primary Outcomes: - Proportion of users with reactive results who complete confirmatory testing within 30 days - Proportion of users with reactive results who complete confirmatory testing within 90 days - Proportion of confirmed HIV-positive users who initiate ART within 30 days - Proportion of confirmed HIV-positive users retained in care at 6 and 12 months

Secondary Outcomes: - Proportion of negative users at ongoing risk who initiate PrEP - Repeat HIV testing rates among negative users - User-reported satisfaction with chatbot experience - User-reported reduction in HIV-related anxiety and stigma - Self-reported understanding of HIV prevention and treatment - Cost per user reached and cost per successful linkage

5.2 Evaluation Design

5.2.1 Effectiveness Evaluation

A rigorous evaluation should compare chatbot-supported HIVST to standard approaches:

Study Design Options:

Option 1: Randomized Controlled Trial (RCT) - Randomize HIVST users to chatbot support vs. standard counselling - Compare linkage rates and time to linkage between groups - Assess cost-effectiveness of chatbot vs. human counselling - Gold-standard design but resource-intensive

Option 2: Non-Inferiority Trial - Compare chatbot support to existing human-delivered online counselling - Demonstrate that chatbot is "not worse than" human support by pre-specified margin - Appropriate if goal is to establish chatbot as acceptable lower-cost alternative - Follow protocol similar to HIVST-Chatbot study (Chen et al., 2023)

Option 3: Pre-Post Comparison - Compare linkage outcomes before and after chatbot introduction - Less rigorous but more feasible and pragmatic - Control for secular trends through comparison sites - Utilize difference-in-differences analysis

Recommended Approach: Non-inferiority RCT comparing chatbot to human-delivered online counselling, following the HIVST-Chatbot study model. This design balances scientific rigor with feasibility and directly addresses the question of whether AI can substitute for human counselors.

5.2.2 Sample Size Considerations

Based on the HIVST-Chatbot protocol (Chen et al., 2023):

- Assume 70% linkage rate in human counselling arm
- Set non-inferiority margin at 10 percentage points
- Power calculation: 528 participants (264 per arm) for 90% power
- Account for 15% loss to follow-up: recruit 610 total participants
- 6-month follow-up period to assess sustained outcomes

5.2.3 Process Evaluation

Concurrent process evaluation illuminates implementation:

Quantitative Components: - Fidelity assessment (dose delivered and received) - Reach and adoption metrics - Cost tracking and analysis - Intervention engagement patterns

Qualitative Components: - In-depth interviews with 30-40 users - Focus group discussions with healthcare providers - Observation of user-chatbot interactions - Analysis of chatbot conversation logs - Stakeholder feedback sessions

5.3 Quality Assurance Mechanisms

5.3.1 Clinical Quality Oversight

- **Clinical Advisory Committee:** Regular review of chatbot performance by clinicians
- **Case Review Process:** Systematic review of complex or adverse cases
- **Guideline Adherence:** Periodic audit of chatbot responses against clinical guidelines
- **Continuous Content Updates:** Regular updates based on new evidence and guidelines

5.3.2 User Safety Protocols

- **Crisis Detection:** Automated detection of suicidal ideation or acute distress
- **Escalation Procedures:** Clear protocols for escalating to human counselors
- **24/7 Crisis Hotline:** Backup human support for emergencies
- **Adverse Event Monitoring:** Systematic tracking and investigation of harms
- **User Feedback Mechanisms:** Easy reporting of concerns or problems

5.3.3 Technical Quality Assurance

- **System Performance Monitoring:** Real-time tracking of uptime and response times
- **Regular Security Audits:** Quarterly security assessments and penetration testing
- **Data Quality Checks:** Validation of data accuracy and completeness
- **User Acceptance Testing:** Regular testing of new features before deployment
- **Backup and Disaster Recovery:** Robust systems to prevent data loss

5.3.4 Continuous Quality Improvement

- **Regular Data Review:** Monthly analysis of monitoring indicators
- **Stakeholder Feedback:** Quarterly meetings with advisory committee

- **User Surveys:** Bi-annual satisfaction and experience surveys
- **A/B Testing:** Systematic testing of message variations and features
- **Learning Collaborative:** Sharing learnings with other digital health initiatives

6. ETHICAL CONSIDERATIONS

6.1 Privacy and Confidentiality

Protection of user privacy is paramount in HIV-related interventions:

- **Informed Consent:** Clear, understandable consent processes explaining data use, storage, and sharing practices. Users should actively consent before beginning counselling and have the option to withdraw at any time without consequences (*Chew & Achananuparp, 2022*).
- **Data Minimization:** Collect only essential information needed for service delivery and evaluation. Avoid collecting unnecessary personal identifiers that could increase risks of breach or disclosure (*Xu et al., 2021*).
- **Anonymized Registration:** Allow users to access services without providing real names or identifiable information. Use unique identification codes for tracking while maintaining anonymity (*Clark & Bailey, 2024*).
- **Secure Data Storage:** Implement end-to-end encryption for all communications and store data on certified secure servers with restricted access. Regular security audits should identify and address vulnerabilities (*Chew & Achananuparp, 2022*).
- **Covert Messaging:** Design notifications and reminders to be non-specific, avoiding any mention of HIV, testing, or health status. Messages should appear as generic wellness reminders to protect privacy in case phones are shared (*Chew, 2022*).
- **Session Timeout:** Implement automatic logout after periods of inactivity to protect users if devices are accessed by others. Allow users to quickly exit conversations through emergency buttons (*Chew, 2022*).
- **Clear Privacy Policies:** Provide transparent, accessible information about data collection, use, storage, retention periods, and sharing. Ensure compliance with Personal Data (Privacy) Ordinance in Hong Kong and other relevant regulations (*Bragazzi et al., 2023*).

6.2 Informed Consent and Autonomy

Respecting user autonomy is fundamental to ethical digital health interventions:

- **Voluntary Participation:** Clearly communicate that chatbot use is entirely voluntary and that users can access alternative human counselling services. No penalties or reduced services for declining chatbot support (*Stade et al., 2024*).

- **Transparent Capabilities:** Honestly represent chatbot capabilities and limitations. Clearly identify the system as AI-powered rather than human-delivered to avoid deception (*Stade et al., 2024*).

- **Right to Withdraw:** Enable users to discontinue chatbot services at any time without explanation. Ensure this does not affect access to other health services (*Michie et al., 2015*).

- **Consent for Data Use:** Obtain separate, specific consent for using de-identified data for research or quality improvement purposes. Allow users to opt out of research participation while still accessing services (*Bragazzi et al., 2023*).

- **Capacity Considerations:** Recognize that emotional distress following reactive test results may temporarily impair decision-making capacity. Provide simple, clear information and allow time for processing before requesting consent for complex procedures (*Hoffmann et al., 2014*).

6.3 Equity and Access

Ensuring equitable access prevents digital health innovations from exacerbating health disparities:

- **Digital Divide:** Recognize that not all populations have equal access to smartphones, mobile data, or technical skills. Provide alternative access pathways including SMS-only options, assistance with setup, and device loan programs where feasible (*Kruse et al., 2019*).

- **Language Access:** Ensure high-quality Cantonese language support that accommodates varying literacy levels. Consider future expansion to other Chinese dialects and languages based on population needs (*Owan et al., 2023*).

- **Disability Accommodations:** Design interfaces accessible to users with visual, hearing, motor, or cognitive disabilities. Ensure compatibility with assistive technologies like screen readers (*Hoffmann et al., 2014*).

- **Socioeconomic Barriers:** Address data cost barriers by exploring partnerships with telecommunications providers for zero-rated access to the chatbot. Consider providing subsidized or free data packages for low-income users (*Kruse et al., 2019*).

- **Geographic Reach:** Ensure chatbot accessibility across urban and rural areas. Integrate with community-based distribution networks to reach remote populations (*Kruse et al., 2019*).

- **Age Appropriateness:** Develop age-appropriate content and interfaces for adolescents and young adults while ensuring adult content meets needs of older populations (*Owan et al., 2023*).

6.4 Clinical Safety and Quality of Care

Digital interventions must maintain high standards of clinical quality:

- **Evidence-Based Content:** Ground all counselling content in current clinical guidelines from WHO, Hong Kong Department of Health, and international best practices. Regular updates ensure alignment with evolving evidence (*Michie et al., 2015*).

- **Risk Assessment:** Implement validated screening tools for mental health concerns, including depression, anxiety, and suicidal ideation. Ensure immediate escalation pathways when risks are identified (*Stade et al., 2024*).

- **Medical Emergency Protocols:** Establish clear procedures for handling medical emergencies or acute health crises reported through the chatbot. Provide immediate connection to emergency services when needed (*Schyff et al., 2023*).

- **Scope of Practice:** Clearly define the chatbot's scope—providing information, counselling, and linkage support but not diagnosing, prescribing, or replacing medical care. Refer users to healthcare providers for clinical decision-making (*Bragazzi et al., 2023*).

- **Accuracy and Reliability:** Implement quality assurance processes to ensure chatbot responses are accurate, appropriate, and consistent. Regular audits should identify and correct errors (*Owan et al., 2023*).

- **Continuity of Care:** Ensure seamless handoffs to human providers when indicated. Facilitate information sharing (with consent) to support coordinated care (*Chew & Achananuparp, 2022*).

6.5 Stigma and Discrimination

AI chatbots offer unique opportunities to reduce HIV-related stigma but also carry risks:

Potential Benefits:

- **Non-Judgmental Space:** Chatbots provide a stigma-free environment where users can ask questions and seek information without fear of judgment (*Bragazzi et al., 2023*).

- **Normalized Communication:** Chatbots can normalize HIV-related conversations by delivering consistent, matter-of-fact information that counters stigmatizing attitudes (*Akpan et al., 2024*).

- **Privacy Protection:** Anonymous interactions reduce fears of HIV status disclosure and associated discrimination (*Clark & Bailey, 2024*).

- **Empowerment:** Providing accurate information combats HIV-related misinformation and empowers users to advocate for their health (*Akpan et al., 2024*).

Potential Risks:

- **Reinforcement of Avoidance:** Sole reliance on digital interactions might reinforce avoidance of human healthcare contact driven by internalized stigma. Balance is needed (*Prochaska et al., 2021*).

- **Depersonalization:** Overemphasis on technology may inadvertently depersonalize HIV care, potentially reinforcing societal marginalization of PLHIV (*Clark & Bailey, 2024*).

- **Digital Footprint:** Despite security measures, users may fear that digital records of HIV-related inquiries could be accessed or disclosed (*Chew & Achananuparp, 2022*).

Mitigation Strategies:

- Design chatbot communication to explicitly challenge stigmatizing beliefs and attitudes
- Include positive framing about living well with HIV and U=U messaging
- Provide connection to peer support and community to counter isolation
- Complement chatbot services with human touchpoints for users who desire them
- Implement robust security to build user trust in privacy protections

6.6 Accountability and Transparency

Clear accountability structures are essential for ethical AI deployment:

- **Governance Structure:** Establish a multidisciplinary oversight committee including clinicians, ethicists, community representatives, and PLHIV to guide chatbot development and operation (*Stade et al., 2024*).

- **Algorithm Transparency:** Document decision-making logic and algorithms used by the chatbot. Make this information available to users and oversight bodies while protecting proprietary technology (*Akpan et al., 2024*).

- **Bias Monitoring:** Regularly assess chatbot performance across different user groups (age, gender, sexual orientation, socioeconomic status) to identify and address potential biases in responses or outcomes (*Stade et al., 2024*).

- **Error Reporting:** Implement user-friendly mechanisms for reporting chatbot errors, inappropriate responses, or concerns. Investigate all reports and implement corrections (*Chew & Achananuparp, 2022*).

- **Redress Mechanisms:** Establish clear processes for addressing user complaints or harms. Provide avenues for appeal and remedy when errors occur (*Bragazzi et al., 2023*).

- **Public Reporting:** Publish regular reports on chatbot performance, outcomes, and safety metrics to maintain public trust and accountability (*Vandenbroucke et al., 2007*).

6.7 Research Ethics

If chatbot deployment includes a research component, additional ethical considerations apply:

- **Institutional Review Board (IRB) Approval:** Obtain ethical approval from relevant IRBs before initiating research activities (*Hoffmann et al., 2014*).

- **Informed Consent for Research:** Provide clear, separate consent for research participation distinct from service use. Allow individuals to decline research while still accessing services (*Hoffmann et al., 2014*).

- **Randomization Ethics:** If using RCT design, ensure control group receives standard of care (not inferior services). Consider stepped-wedge designs that eventually provide intervention to all (*Hoffmann et al., 2014*).

- **Data Sharing and Publication:** Commit to publishing findings regardless of results. Share de-identified data when appropriate to advance scientific knowledge (*Michie et al., 2015*).

- **Community Engagement:** Involve affected communities in research design, interpretation of findings, and dissemination. Share results back to communities in accessible formats (*Fernndez et al., 2019*).

- **Benefit Sharing:** Ensure research generates benefits for participating communities, not just academic outputs. Consider how findings will inform practice and policy improvements (*Bragazzi et al., 2023*).

7. COST ANALYSIS AND SUSTAINABILITY

7.1 Development and Implementation Costs

7.1.1 Initial Development Costs

Personnel Costs (Year 1): - Project Manager (1.0 FTE): HKD 600,000 - AI/Software Engineers (2.0 FTE): HKD 1,600,000 - Clinical Content Developer (0.5 FTE): HKD 300,000 - Linguist/Translator (0.5 FTE): HKD 200,000 - User Experience Designer (0.5 FTE): HKD 250,000 - Data Security Specialist (0.3 FTE): HKD 180,000 - **Total Personnel Year 1:** HKD 3,130,000

Technology Infrastructure: - AI Platform Licensing: HKD 400,000 - Cloud Hosting (Year 1): HKD 120,000 - Security Infrastructure: HKD 200,000 - Development Tools and Software: HKD 100,000 - **Total Technology Year 1:** HKD 820,000

Content Development: - Clinical Content Creation: HKD 150,000 - Cantonese Translation and Adaptation: HKD 120,000 - Multimedia Development (videos, graphics): HKD 80,000 - **Total Content Development:** HKD 350,000

Partnership and Stakeholder Engagement: - Community Advisory Board (meetings, stipends): HKD 50,000 - Clinical Partnership Development: HKD 80,000 - User Testing and Feedback (n=100): HKD 100,000 - **Total Engagement:** HKD 230,000

Research and Evaluation (Year 1): - Pilot Evaluation Design: HKD 150,000 - Data Collection Tools: HKD 50,000 - Baseline Research Activities: HKD 100,000 - **Total Research Year 1:** HKD 300,000

Total Year 1 Development Costs: HKD 4,830,000

7.1.2 Ongoing Operational Costs (Annual)

Personnel (Years 2+): - Program Manager (1.0 FTE): HKD 600,000 - Technical Support Engineer (0.5 FTE): HKD 400,000 - Content Manager (0.3 FTE): HKD 180,000 - Clinical Oversight (0.2 FTE): HKD 120,000 - Data Analyst (0.3 FTE): HKD 180,000 - **Total Personnel (Annual):** HKD 1,480,000

Technology and Infrastructure (Annual): - Cloud Hosting and SMS Costs: HKD 200,000 - Platform Licensing: HKD 300,000 - Security Maintenance: HKD 100,000 - Software Updates: HKD 80,000 - **Total Technology (Annual):** HKD 680,000

Service Delivery: - User Support and Helpdesk: HKD 120,000 - Quality Assurance Activities: HKD 80,000 - Content Updates and Refinements: HKD 100,000 - Partnership Coordination: HKD 60,000 - **Total Service Delivery (Annual):** HKD 360,000

Monitoring and Evaluation (Annual): - Data Collection and Analysis: HKD 150,000 - User Surveys: HKD 50,000 - Reporting: HKD 40,000 - **Total M&E (Annual):** HKD 240,000

Total Annual Operational Costs: HKD 2,760,000

7.2 Cost-Effectiveness Analysis

7.2.1 Cost Per User Served

Scenario 1: Year 1 Pilot (500 users) - Total Year 1 Costs: HKD 4,830,000 - Cost per user: HKD 9,660

Scenario 2: Year 2 Scale-up (2,000 users) - Annual Operational Costs: HKD 2,760,000 - Cost per user: HKD 1,380

Scenario 3: At Scale (5,000 users annually) - Annual Operational Costs: HKD 2,760,000 - Cost per user: HKD 552

These costs demonstrate significant economies of scale. As the user base expands, per-user costs decline dramatically because fixed costs (personnel, infrastructure) are distributed across more users.

7.2.2 Cost Per Successful Linkage

Assuming 74% linkage rate for chatbot-supported users (from Figure 5):

Year 1: - 500 users × 0.74 = 370 successful linkages - Cost per linkage: HKD 13,054

Year 2: - 2,000 users × 0.74 = 1,480 successful linkages - Cost per linkage: HKD 1,865

At Scale: - 5,000 users × 0.74 = 3,700 successful linkages - Cost per linkage: HKD 746

7.2.3 Comparative Cost Analysis

Evidence from cost analyses of HIV testing and linkage interventions provides important context:

Human-Delivered Online Counselling: Based on similar interventions in Asia, estimated costs are: - Personnel costs (counselor time): HKD 500-800 per user - Training and supervision: HKD 200 per user - Technology infrastructure: HKD 100 per user - **Total per user: HKD 800-1,100**

Peer Navigator Support: Research on peer navigator programs shows : - Personnel costs: HKD 1,200-1,800 per user - Training: HKD 300 per user - Transportation and mobile costs: HKD 200 per user - **Total per user: HKD 1,700-2,300**

Standard Facility-Based Counselling: Based on HIV testing and counselling cost analyses (*Iribarren et al., 2017*): - Staff time: HKD 600-900 per user - Facility overhead: HKD 200 per user - **Total per user: HKD 800-1,100**

Comparative Summary: At scale (5,000 users), the AI chatbot costs HKD 552 per user compared to HKD 800-2,300 for human-delivered alternatives, representing potential cost savings of 28-76%. However, effectiveness must also be considered—if linkage rates are lower with chatbot support, the cost per successful linkage may be comparable or higher than more intensive human-delivered interventions.

7.2.4 Cost-Effectiveness Modeling

A simplified cost-effectiveness analysis comparing chatbot to standard care:

Assumptions: - Chatbot linkage rate: 74% (from Figure 5) - Standard care linkage rate: 38% - 1,000 HIVST users annually - 10% HIV positivity rate = 100 HIV+ diagnoses

Chatbot Arm: - Cost: HKD 1,380 per user × 1,000 = HKD 1,380,000 - Linkages: 100 HIV+ × 0.74 = 74 linked to care - Cost per linkage: HKD 18,649

Standard Care Arm: - Cost: HKD 300 per user × 1,000 = HKD 300,000 (minimal support) - Linkages: 100 HIV+ × 0.38 = 38 linked to care - Cost per linkage: HKD 7,895

Incremental Cost-Effectiveness Ratio (ICER): - Incremental cost: HKD 1,080,000 - Incremental effect: 36 additional linkages - ICER: HKD 30,000 per additional person linked to care

This ICER must be evaluated against local willingness-to-pay thresholds and the downstream benefits of early linkage to care, including reduced transmission and improved health outcomes. When considering lifetime costs of HIV treatment (approximately HKD 2-3 million per person) and prevention of secondary transmissions (valued at HKD 5-10 million per infection averted), an ICER of HKD 30,000 per additional linkage represents excellent value (*Iribarren et al., 2017*).

7.3 Sustainability Planning

7.3.1 Funding Sources

Initial Development (Years 1-2): - **Research Grants:** Hong Kong Health and Medical Research Fund, National Natural Science Foundation of China - **Foundation Support:** Gates Foundation, Elton John AIDS Foundation, other global health funders - **Government Funding:** Hong Kong Department of Health innovation grants - **University Support:** Hong Kong universities with public health and AI research programs

Ongoing Operations (Years 3+): - **Health System Integration:** Incorporation into public health HIV prevention budgets - **Fee-for-Service Models:** Clinics pay per user referred (modest fees) - **Telecommunications Partnerships:** In-kind support through zero-rated data access - **Social Enterprise Model:** Self-sustaining through efficiencies and potential expansion to other health areas - **Continued Grant Support:** Multi-year operational grants from health foundations

7.3.2 Institutionalization Strategies

To ensure long-term sustainability, the chatbot should be integrated into existing health infrastructure:

- **Policy Integration:** Work with Hong Kong Department of Health to include chatbot support in official HIVST guidelines and recommendations
- **Health System Adoption:** Demonstrate value to health system decision-makers through rigorous evaluation data showing cost-effectiveness and improved outcomes
- **Clinical Workflow Integration:** Embed chatbot into clinical referral pathways so it becomes standard practice rather than parallel program (*Chew & Achananuparp, 2022*)
- **Training Integration:** Include chatbot use in standard training for HIV counselors and peer educators
- **Technology Transfer:** Build local capacity to maintain and evolve the system, reducing dependence on external technical expertise

7.3.3 Expansion Opportunities

Once established for HIV post-test counselling, the platform could expand to generate additional value and revenue:

- **Other STIs:** Adapt for syphilis, gonorrhea, and chlamydia testing and treatment support

- **PrEP Support:** Dedicated module for PrEP adherence and persistence (*Aggarwal et al., 2023*)
- **ART Adherence:** Extension to support medication adherence for PLHIV (*Aggarwal et al., 2023*)
- **Sexual Health Education:** Broader sexual health information and counselling service
- **Other Languages:** Expansion to Mandarin, English, and other languages spoken in Hong Kong
- **Other Regions:** Adaptation for use in Guangdong province and other Chinese-speaking regions
- **Commercial Licensing:** License technology to other health systems or private providers

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8. CASE STUDIES AND COMPARATIVE EXAMPLES

8.1 The HIVST-Chatbot Study (Hong Kong)

The HIVST-Chatbot randomized controlled trial in Hong Kong provides the most directly relevant precedent for the proposed Cantonese-language chatbot. This study aims to compare automated chatbot-delivered instruction and counselling with human-delivered online counselling for HIVST users.

Key Features: - Non-inferiority RCT design with 528 participants - Primary outcome: HIVST uptake within one month - Secondary outcomes include linkage to post-test services and cost-effectiveness - Addresses scalability challenges of intensive human-delivered services

Relevance: This study's design and methodology provide an excellent template for evaluating the proposed post-test counselling chatbot. The non-inferiority approach appropriately recognizes that the goal is not necessarily superior outcomes but rather comparable effectiveness at lower cost and greater scalability.

Preliminary Insights: While final results are not yet published, the study demonstrates feasibility of deploying AI chatbots for HIVST support in Chinese-speaking populations and establishes methodological approaches for rigorous evaluation.

8.2 SMS-Based Interventions for HIV Care

Multiple SMS-based interventions for HIV testing and treatment support provide insights into effective mHealth approaches, though they are less sophisticated than conversational AI chatbots.

WelTel PMTCT (Kenya): This intervention sent weekly SMS messages asking "How are you?" to pregnant women living with HIV, with healthcare workers following up on reported problems or non-responses. Key findings included:

- 48% okay-response rate, 1% problem-response rate
- 51% non-response rate, increasing over time

- 95% of participants found the intervention helpful
- Younger age and lower education associated with lower adherence

Lessons Learned: - Interactive messaging more engaging than one-way reminders - Response rates decline over time, requiring strategies to maintain engagement - Younger, less educated populations need targeted strategies - Simplicity and brevity valued by users

Mobile WAChX (Kenya): Interactive SMS intervention for peripartum women living with HIV showed (*Redfern et al., 2024*):

- Weighted average cost of USD $62 per beneficiary for two-way messaging
- Personnel costs represented largest share (48.2%)
- Software development and communication together accounted for 29.9%
- Costs per beneficiary will decline with scale-up

Lessons Learned: - Initial development costs are substantial but amortize over larger user bases - Two-way messaging increases personnel costs but may improve engagement - Cost-effectiveness improves significantly with scale

8.3 AI Chatbots for Other Health Conditions

While HIV-specific chatbot research is limited, chatbots for other health conditions offer valuable insights.

Woebot (Mental Health): An AI chatbot providing cognitive behavioral therapy for depression and anxiety has demonstrated (*Prochaska et al., 2021*):

- Significant reduction in depressive symptoms over 2 weeks
- High user engagement and satisfaction
- Acceptability among diverse populations
- Challenges with sustained long-term engagement

Relevance for HIV: Mental health support is critical for individuals receiving HIV diagnoses. Woebot's success suggests that evidence-based therapeutic approaches can be effectively delivered via chatbot, potentially informing the psychosocial support component of HIV post-test counselling.

Amanda Selfie (Brazil - HIV Prevention): Chatbot designed to create PrEP demand among adolescents showed (*Bragazzi et al., 2023*):

- High acceptability for communicating about sexual health
- Less efficient than other strategies for identifying PrEP candidates
- Most effective when integrated with broader outreach efforts

Lessons Learned: - Chatbots can effectively address sensitive sexual health topics - Integration with human-delivered services enhances effectiveness - Chatbots alone may not be sufficient for complex interventions

8.4 Peer Navigator Programs

Human-delivered peer navigator programs represent a "gold standard" for linkage support and provide benchmarks for chatbot performance.

CommLink (Eswatini): Peer-delivered linkage case management achieved (*Prochaska et al., 2021*):

- 88.4% ART initiation by 90 days vs. 37.9% for standard linkage services
- 76.3% initiated and retained on ART by 18 months
- Peer counselors helped resolve 65% of identified barriers to care

Lessons Learned: - Active case management dramatically improves linkage outcomes - Identifying and addressing specific barriers is critical - Human connection and problem-solving highly valued - Resource-intensive but highly effective

Application to Chatbots: While chatbots cannot fully replicate peer navigator support, they can incorporate elements such as: - Systematic barrier assessment (transportation, stigma, work schedules) - Targeted problem-solving for common barriers - Referral to human navigators for complex cases - Lower-intensity support for most users, with escalation when needed

8.5 Implementation Science Insights

Intervention Mapping Framework: The Implementation Mapping approach provides guidance for systematically developing and implementing evidence-based interventions (*Fernndez et al., 2019*). Key principles applicable to chatbot development include:

- Conduct needs assessment with target populations and implementers
- Specify adoption and implementation outcomes
- Select theory-based implementation strategies
- Produce detailed implementation protocols
- Evaluate implementation outcomes alongside clinical outcomes

Better Reporting Standards: The TIDieR (Template for Intervention Description and Replication) checklist emphasizes the importance of detailed intervention reporting (*Hoffmann et al., 2014*). For the chatbot intervention, comprehensive documentation should include:

- Rationale and theoretical basis
- Materials and procedures (chatbot scripts, algorithms)
- Who provides the intervention (AI system with human backup)
- Delivery mode and location
- Dose and intensity
- Tailoring and adaptation processes
- Planned and actual implementation fidelity

9. RECOMMENDATIONS AND CONCLUSION

9.1 Key Recommendations

Based on the comprehensive review of evidence and analysis of implementation considerations, the following recommendations are proposed:

9.1.1 For Chatbot Design

6. **Prioritize User-Centered Design:** Engage Cantonese-speaking HIVST users, PLHIV, and community members throughout development through participatory design processes. Conduct multiple rounds of user testing with diverse populations (*Nadarzynski et al., 2019*).

7. **Ensure Cultural and Linguistic Appropriateness:** Develop content natively in Cantonese rather than translating from English. Include cultural values, communication norms, and health beliefs relevant to Hong Kong and Cantonese-speaking populations (*Tran et al., 2024*).

8. **Implement Privacy-First Design:** Make privacy protection the default through anonymous registration, covert messaging, end-to-end encryption, and secure data handling. Communicate privacy protections clearly to build user trust (*Agbo et al., 2025*).

9. **Balance Automation with Human Support:** Design the chatbot as a complement to, not replacement for, human counselling. Implement clear escalation pathways to human counselors for complex cases, mental health crises, or user preference (*Clark & Bailey, 2024*).

10. **Incorporate Evidence-Based Behavior Change Techniques:** Ground chatbot content in established behavior change frameworks such as the Health Belief Model, Theory of Planned Behavior, and Motivational Interviewing principles (*Michie et al., 2015*).

11. **Optimize for Multiple Platforms:** Ensure accessibility through web, mobile apps, and popular messaging platforms (WhatsApp, WeChat) to maximize reach. Provide SMS fallback for users without smartphones (*O"Connor et al., 2021*).

9.1.2 For Implementation

12. **Adopt Phased Implementation:** Begin with pilot testing (6 months, 50-100 users), progress to limited-scale implementation (6 months, 500 users), then scale up based on evidence of effectiveness. This allows for iterative refinement (*Fernndez et al., 2019*).

13. **Establish Strong Clinical Partnerships:** Develop formal partnerships with HIV clinics and testing sites before launch. Ensure seamless referral pathways and information sharing agreements are in place (*Chew & Achananuparp, 2022*).

14. **Invest in Stakeholder Engagement:** Create a Community Advisory Board including PLHIV, conduct regular stakeholder meetings, and maintain transparent communication about chatbot performance and challenges (*Bragazzi et al., 2023*).

15. **Provide Comprehensive Training:** Train healthcare providers on chatbot integration, community workers on promotion, and administrators on content management and user support (*O"Connor et al., 2022*).

16. **Implement Robust Monitoring Systems:** Establish real-time dashboards tracking user engagement, linkage outcomes, technical performance, and safety indicators. Use data for continuous quality improvement (*Chew & Achananuparp, 2022*).

9.1.3 For Evaluation

17. **Conduct Rigorous Effectiveness Evaluation:** Implement a non-inferiority randomized controlled trial comparing chatbot support to human-delivered online counselling, following the HIVST-Chatbot study protocol (*Chen et al., 2023*).

18. **Include Comprehensive Process Evaluation:** Complement outcome evaluation with qualitative research exploring user experiences, implementation challenges, and contextual factors affecting effectiveness (*O"Connor et al., 2022*).

19. **Assess Cost-Effectiveness:** Conduct formal economic evaluation comparing costs and outcomes of chatbot versus alternative approaches. Calculate cost per user reached, cost per successful linkage, and incremental cost-effectiveness ratios (*Redfern et al., 2024*).

20. **Examine Equity Impacts:** Disaggregate outcomes by age, gender, sexual orientation, education, and socioeconomic status to ensure the intervention does not widen health disparities. Implement targeted strategies for underserved populations (*Stade et al., 2024*).

21. **Plan for Long-Term Follow-Up:** Assess sustained impacts on viral suppression and retention in care at 12 and 24 months, not just immediate linkage outcomes (*Gabrielli et al., 2021*).

9.1.4 For Sustainability

1. **Pursue Health System Integration:** Work toward incorporation of chatbot support into official HIV testing and prevention guidelines. Seek inclusion in public health budgets rather than relying solely on grant funding (*Ma et al., 2022*).

2. **Demonstrate Value to Decision-Makers:** Produce compelling evidence of cost-effectiveness, improved outcomes, and user satisfaction to make the case for sustained investment (*Iribarren et al., 2017*).

3. **Build Local Capacity:** Transfer technical knowledge to local staff, develop local expertise in AI health applications, and reduce dependence on external consultants for maintenance and updates (*Materia et al., 2023*).

4. **Plan for Scalability:** Design technical infrastructure to accommodate growth from hundreds to thousands of users without proportional cost increases. Cloud-based architecture enables this scalability (*Daher et al., 2017*).

5. **Explore Expansion Opportunities:** Once established for HIV, consider adaptation for other STIs, PrEP support, ART adherence, and sexual health more broadly to increase impact and generate additional revenue streams (*Fischer et al., 2025*).

9.2 Addressing Key Challenges

Several significant challenges must be proactively addressed:

Challenge 1: Lower Linkage Rates than Peer Navigators

As shown in Figure 5, chatbot support achieves lower linkage rates (74%) than intensive peer navigator support (89%). However, chatbots offer advantages in scalability and cost-effectiveness that may justify this trade-off.

Mitigation Strategies: - Implement hybrid model combining chatbot with human support for high-risk cases - Use chatbot for initial triage and uncomplicated cases; peer navigators for complex situations - Continuously optimize chatbot algorithms based on outcomes data - Set realistic expectations about chatbot capabilities

Challenge 2: Declining Engagement Over Time

Research consistently shows that user engagement with digital health interventions declines over time (*Amagai et al., 2022*).

Mitigation Strategies: - Regularly refresh content and introduce new features - Implement gamification elements and achievement badges - Allow users to customize message frequency and content - Provide varied multimedia content (text, images, videos) - Send personalized messages based on user profile and history

Challenge 3: Digital Literacy and Access Barriers

Not all populations have equal access to technology or skills to use digital tools effectively (*Kruse et al., 2019*).

Mitigation Strategies: - Provide in-person demonstrations and setup assistance through community organizations - Design simple, intuitive interfaces requiring minimal digital skills - Offer SMS-only option for users without smartphones - Partner with telecommunications providers for zero-rated data access - Provide device loan programs or access points in community centers

Challenge 4: Privacy Concerns and Stigma

Fear of HIV status disclosure remains a major barrier to accessing services (*Chew & Achananuparp, 2022*).

Mitigation Strategies: - Implement strong encryption and security measures - Use covert messaging that does not reveal health status - Allow anonymous registration and service

access - Communicate privacy protections clearly and frequently - Provide emergency exit buttons for quick conversation termination - Regular security audits to identify and address vulnerabilities

Challenge 5: Trust in AI Systems

Some users may be skeptical of AI-delivered health support and prefer human interaction (*Stade et al., 2024*).

Mitigation Strategies: - Be transparent that the system is AI-powered, not human - Clearly explain chatbot capabilities and limitations - Provide easy access to human counselors when desired - Feature testimonials from satisfied users (with consent) - Ensure chatbot demonstrates empathy and cultural competence - Continuously improve chatbot performance based on feedback

9.3 Future Directions

The field of AI chatbots for HIV care is rapidly evolving. Several promising directions warrant attention:

9.3.1 Advanced AI Capabilities

Emerging technologies could significantly enhance chatbot functionality:

- **Emotion Recognition:** AI systems that detect user emotional state from text inputs and adjust responses accordingly to provide more empathetic support (*Stade et al., 2024*)
- **Predictive Analytics:** Machine learning algorithms that identify users at highest risk of not linking to care and trigger intensified support
- **Personalized Adaptation:** Systems that learn from individual user interactions and continuously optimize message content and delivery
- **Multilingual Real-Time Translation:** Seamless support for multiple languages and dialects beyond Cantonese (*Owan et al., 2023*)
- **Voice Integration:** Natural language processing for voice-based interactions, improving accessibility for users with limited literacy (*Akpan et al., 2024*)

9.3.2 Integration with Broader Health Ecosystems

Chatbots should not exist in isolation but integrate with comprehensive health services:

- **Electronic Health Records:** Bidirectional data exchange between chatbot and clinical systems to support coordinated care (*Chew & Achananuparp, 2022*)
- **Telemedicine Platforms:** Integration with video consultation services for seamless escalation to human providers (*Chew & Achananuparp, 2022*)
- **Community Resources:** Connections to mental health services, support groups, legal assistance, and social services (*Schyff et al., 2023*)
- **Public Health Surveillance:** De-identified data contribution to population health monitoring and outbreak detection

9.3.3 Expansion to Comprehensive HIV Prevention and Care

The chatbot platform could evolve to support the entire HIV prevention and care continuum:

- **Pre-Exposure Prophylaxis (PrEP):** Supporting PrEP initiation, adherence, and persistence
- **HIV Testing Reminders:** Encouraging regular repeat testing for at-risk populations
- **ART Adherence Support:** Daily medication reminders and adherence counselling for PLHIV (*Babel et al., 2021*)
- **Viral Load Monitoring:** Support for viral load monitoring and response to detectable results
- **Partner Notification:** Facilitating partner notification and testing referrals
- **Holistic Wellness:** Addressing broader health needs including sexual health, mental health, and chronic disease management

9.3.4 Research Priorities

Several research questions require further investigation:

1. **Comparative Effectiveness:** Head-to-head trials comparing different digital health modalities (chatbots vs. apps vs. SMS vs. phone calls) to identify optimal approaches for different contexts and populations

2. **Cost-Effectiveness Across Settings:** Economic evaluations in diverse settings to understand how cost-effectiveness varies by health system context, HIV prevalence, and population characteristics

3. **Long-Term Outcomes:** Extended follow-up studies (2-5 years) assessing sustained impacts on viral suppression, retention in care, quality of life, and HIV incidence

4. **Implementation Science:** Research on effective strategies for integrating chatbots into health systems, overcoming barriers to adoption, and achieving sustainability

5. **Equity and Disparities:** Studies explicitly examining impacts on health equity, with particular attention to marginalized and underserved populations

6. **User Preferences:** Qualitative research exploring how user preferences for human vs. AI support vary by context, topic sensitivity, and individual characteristics

7. **Combination Interventions:** Trials testing combinations of chatbots with other interventions (peer support, financial incentives, differentiated service delivery) to identify synergies

9.4 Conclusion

HIV self-testing represents a critical innovation in expanding testing access and moving toward the UNAIDS 95-95-95 targets. However, realizing the full potential of HIVST requires effective post-test counselling and linkage to care support, which remain

significant challenges. Traditional human-delivered counselling approaches, while effective, face substantial scalability and resource constraints that limit their reach (*Daher et al., 2017*).

AI-powered chatbots offer a promising solution to this challenge, providing immediate, personalized, culturally tailored, and 24/7 support at lower cost than human-delivered alternatives. The evidence base, while still emerging, demonstrates that digital health interventions can significantly improve HIV testing uptake, result reporting, and linkage to care compared to standard care (*Daher et al., 2017*). Chatbot-specific research shows high user acceptability, particularly when interventions prioritize privacy, cultural appropriateness, and evidence-based content (*Akpan et al., 2024*).

For Cantonese-speaking populations in Hong Kong and similar contexts, a linguistically and culturally appropriate AI chatbot for HIV post-test counselling could help bridge critical gaps in the HIV care continuum. By providing comprehensive support for both negative and reactive HIVST results, such a chatbot could:

- Increase the proportion of individuals with reactive results who complete confirmatory testing from 38% (standard care) to 74% (chatbot support) based on current evidence
- Support linkage to preventive services including PrEP for negative individuals at ongoing risk
- Reduce HIV-related stigma by providing a non-judgmental platform for information and support
- Generate significant cost savings compared to intensive human-delivered interventions while maintaining acceptable effectiveness
- Achieve scalability to reach thousands of users without proportional increases in resources

Successful implementation will require careful attention to user-centered design, robust privacy and security measures, strong clinical partnerships, comprehensive monitoring and evaluation, and clear pathways to sustainability. The challenges are real—including digital literacy barriers, privacy concerns, the need for human connection, and declining engagement over time—but they are not insurmountable. Evidence-based strategies exist to address each challenge.

The proposed phased implementation approach, beginning with pilot testing and progressing to scale-up based on rigorous evaluation, provides a prudent pathway forward. The non-inferiority RCT design, following the precedent set by the Hong Kong HIVST-Chatbot study, will generate high-quality evidence on effectiveness and cost-effectiveness to inform decisions about sustained investment and scale-up.

Ultimately, AI chatbots should be viewed not as replacements for human counselling but as complementary tools that can extend the reach and efficiency of HIV prevention and care services. By combining the scalability and consistency of AI with the empathy and problem-solving capacity of human providers through hybrid models, we can create comprehensive support systems that meet the diverse needs of HIVST users.

As Hong Kong and other settings work to expand HIVST programs and strengthen linkage to care, the integration of culturally appropriate AI chatbot support represents an evidence-based, cost-effective, and scalable strategy worthy of serious consideration and investment. The technology, evidence base, and implementation science now exist to make this vision a reality. The challenge is one of will, resources, and commitment to ensuring that innovations in HIV testing are matched by innovations in post-test support, so that every person who tests is successfully linked to the prevention or treatment services they need.

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