**Mobile Health Technology Use and the Acceptability of an mHealth Platform for HIV Prevention Among Men Who Have Sex With Men in Malaysia: Cross-sectional Respondent-Driven Sampling Survey**

Roman Shrestha¹, MPH, PhD; Francesca Maviglia², MPH; Frederick L Altice², MD; Elizabeth DiDomizio², MPH; Antoine Khati¹, MD; Colleen Mistler¹, MSc; Iskandar Azwa³, MD; Adeeba Kamarulzaman³, MD; Mohd Akbar Ab Halim³, BA; Jeffrey A Wickersham², PhD

¹Department of Allied Health Sciences, University of Connecticut, Storrs, CT, United States
²Section of Infectious Diseases, Yale University, New Haven, CT, United States
³Faculty of Medicine, University of Malaya, Kuala Lumpur, Malaysia

**Corresponding Author:**
Roman Shrestha, MPH, PhD
Department of Allied Health Sciences
University of Connecticut
358 Mansfield Rd
Storrs, CT, 06269
United States
Phone: 1 860 486 2446
Email: roman.shrestha@uconn.edu

**Abstract**

**Background:** The growth in mobile technology access, utilization, and services holds great promise in facilitating HIV prevention efforts through mobile health (mHealth) interventions in Malaysia. Despite these promising trends, there is a dearth of evidence on the use of mHealth platforms that addresses HIV prevention among Malaysian men who have sex with men.

**Objective:** The goal of this study was to gain insight into (1) access and utilization of communication technology (eg, landline phone, internet, mobile phone), (2) acceptability of mHealth-based interventions for HIV prevention services, and (3) preferences regarding the format and frequency of mHealth interventions among Malaysian men who have sex with men.

**Methods:** We conducted a cross-sectional survey with Malaysian men who have sex with men between July 2018 and March 2020. Participants were recruited using respondent-driven sampling in the Greater Kuala Lumpur region of Malaysia. We collected information on demographic characteristics, HIV risk-related behaviors, access to and the frequency of use of communication technology, and acceptability of using mHealth for HIV prevention using a self-administered questionnaire with a 5-point scale (1, never; 2, rarely; 3, sometimes; 4, often; 5, all the time).

**Results:** A total of 376 men participated in the survey. Almost all respondents owned or had access to a smartphone with internet access (368/376, 97.9%) and accessed the internet daily (373/376, 99.2%), mainly on a smartphone (334/376, 88.8%). Participants on average used smartphones primarily for social networking (mean 4.5, SD 0.8), followed by sending or receiving emails (mean 4.0, SD 1.0), and searching for health-related information (mean 3.5, SD 0.9). There was high acceptance of the use of mHealth for HIV prevention (mean 4.1, SD 1.5), including for receiving HIV prevention information (345/376, 91.8%), receiving medication reminders (336/376, 89.4%), screening and monitoring sexual activity (306/376, 81.4%) or illicit drug use (281/376, 74.7%), and monitoring drug cravings (280/376, 74.5%). Participants overwhelmingly preferred a smartphone app over other modalities (eg, text, phone call, email) for engaging in mHealth HIV prevention tools. Preference for app notifications ranged from 186/336 (53.9%), for receiving HIV prevention information, to 212/336 (69.3%), for screening and monitoring sexual activity. Acceptance of mHealth was higher for those who were university graduates (P=.003), living in a relationship with a partner (P=.04), engaged in sexualized drug use (P=.01), and engaged in receptive anal sex (P=.006).

**Conclusions:** Findings from this study provide support for developing and deploying mHealth strategies for HIV prevention using a smartphone app in men who have sex with men—a key population with suboptimal engagement in HIV prevention and treatment.
Introduction

In comparison with high-income countries, low- and middle-income countries have disproportionately high rates of HIV because funding and access to HIV prevention and treatment services are limited [1]. Men who have sex with men are at increased vulnerability to HIV due to a combination of biological factors (ie, sexual exposure risk, concurrent sexually transmitted infections) [2] and a higher sexual network or community HIV prevalence [3,4]. In addition, behavioral factors (eg, condomless sex, multiple sexual partners, sexualized drug use which is also known as Chemsex) have also been found to increase the risk of HIV in this group [4,5].

In Malaysia, HIV prevalence among men who have sex with men has grown exponentially in the past decade, peaking at 21.6% in 2017, compared with 0.4% among the general population [6,7]. The causes of Malaysia’s expanding HIV epidemic among men who have sex with men are multifactorial. In populations such as men who have sex with men, the uptake of HIV prevention and treatment services is often low due to reluctance to disclose their sexual orientation, lack of anonymity, and concerns about confidentiality [8]. In Malaysia, which is a middle-income country with a Muslim majority, same-sex sexual behavior is a crime according to both secular and Sharia criminal laws, which contributes to high levels of stigma and discrimination. The criminalization of same-sex relationships has been found to be associated with lower access to condoms, lubricants, HIV testing, and HIV treatment in a study [9] with a sample of men who have sex with men from 115 countries. Several studies [10-13] have documented negative attitudes and discrimination toward men who have sex with men in Malaysia, including in health care settings. Consequently, the scale-up of evidence-based HIV testing, prevention, and treatment programs that target those who are most vulnerable to HIV, including men who have sex with men, has been negatively impacted. Low HIV-testing uptake among men who have sex with men in Malaysia has resulted in many men who have sex with men being diagnosed with HIV at an advanced stage [8,14-16]. There is, therefore, a need for innovative strategies to reach with services and information and retain into care stigmatized populations such as men who have sex with men in Malaysia.

The use of mobile health (mHealth) technology to improve health outcomes has been expanding globally, and research is needed to guide its use in health care delivery [17-23]. mHealth has been found to be a promising and cost-effective strategy to reach and serve stigmatized and hidden populations such as men who have sex with men [24-27]. In Malaysia, leveraging an mHealth platform may allow users to feel safer and less vulnerable to potential legal or social harm (for example, by reducing face-to-face interactions with providers) and bypass barriers to care for marginalized populations [28-32]. Over the past decade, the use of mobile technology in Malaysia has grown markedly, with a mobile phone penetration rate of 97.5% and an internet penetration rate of 71.1% [33]. With increases in access to, utilization of, and services using communication technologies, an mHealth approach holds great promise to facilitate HIV prevention efforts in Malaysia.

Despite these promising trends, there is a dearth of evidence on the use of mHealth platforms to address HIV prevention in Malaysian men who have sex with men. Thus, the goal of this study was to gain insight into (1) access to and utilization of communication technology (eg, landline phone, internet, cell phone), (2) acceptability of mHealth-based interventions for HIV prevention services, and (3) preferences regarding the format and frequency of mHealth interventions among Malaysian men who have sex with men.

Methods

Study Design and Setting
We conducted a cross-sectional study with participants recruited from the Greater Kuala Lumpur region between July 2018 and March 2020. Data collection was conducted in a private room at the Centre of Excellence for Research in AIDS (University of Malaya), because of its central location in the Greater Kuala Lumpur region, accessibility by public transport, and ability to provide free parking to participants.

Study Participants and Procedures
Inclusion criteria were (1) being 18 years or older; (2) identifying as a cisgender male; (3) currently residing in the Greater Kuala Lumpur region; (4) reporting having been engaged in sexual activity with male sexual partners in the previous 6 months; and (5) being able to read and understand English, Chinese, or Bahasa Malaysia.

The questionnaires were created in English and then translated to Chinese and Bahasa Malaysia. We used forward-backward translation and pilot tested the translated questionnaires to ensure translation quality.

Participants were recruited using respondent-driven sampling, which is a network-based sampling method that is often used for hard-to-reach populations and combines peer-driven recruitment and statistical adjustments to reduce bias and approximate random sampling [34]. During our formative work, initial respondent-driven sampling participants, called seed participants, were carefully selected with assistance from community-based organizations for men who have sex with men. We aimed to recruit a seed participant sample (n=27) that reflected the diversity (eg, ethnicity, age) of the community of men who have sex with men in the region.

Each participant who completed the study was given 3 coupons to recruit men from their peer networks, who were, in turn, also given 3 coupons. Each coupon card contained a unique...
respondent-driven sampling number that allowed us to trace the peer recruitment chain and important study-related information (study site address, contact information for the study team, and inclusion criteria). Coupon management software was used to track distributed and redeemed coupons during the study, and a standard numbering system was used to track the recruiter-recruit relationship. Participants received 30 Malaysian Ringgit (at the time of publication, 1 MYR was approximately equivalent to US $0.23) for study participation and an additional 10 MYR for each peer who was successfully recruited to the study (up to 3 peers).

Individuals could choose whether to come during walk-in hours or set an appointment by phone. The research site was open 7 days a week to offer maximum flexibility and accommodate different work schedules. Individuals who presented with a valid coupon underwent initial eligibility screening. If eligible, they were asked to provide informed consent. Each participant completed the web-based questionnaire (Qualtrics, Qualtrics XM) in a private room, which took approximately 20 minutes, while study staff waited outside the room, to ensure privacy.

Ethics Approval
The study was approved by the institutional review boards of the University of Malaya (201854) and Yale University (2000023152).

Measures
Participant Characteristics
We collected participant characteristics (age, ethnicity, educational status, relationship status, income, history of childhood physical abuse, history of childhood sexual assault, and depressive symptoms experienced in the past week).

Access to and Frequency of Use of Communication Technology
We adapted a scale that we used in previous studies [35-37] to measure participants’ access to and frequency of use of various types of communication devices, including landline telephone, mobile phone with internet access (smartphone) and without internet access (basic phone), tablet, laptop, and personal computer. Participants were asked how often they use each technology on a 5-point Likert scale (ranging from 1, never, to 5, all the time).

Additionally, participants were asked if they had daily access to the internet, which device was their primary device for accessing the internet, and the number of hours spent on the internet each week. Participants’ utilization of smartphones for various internet-based activities (including social networking, sending or receiving emails, using geosocial networking apps or websites, searching for health-related information, or using health-related apps) was assessed using a 5-point Likert scale (ranging from 1, never, to 5, all the time). Participants were also asked which men who have sex with men–related geosocial networking apps or websites (eg, Grindr, Hornet, Planet Romeo) they currently used.

Acceptability of mHealth
The mHealth acceptance scale was adapted from previous studies [35-37]. Participants were asked about their willingness to use 5 mHealth-related features—receiving medication reminders, monitoring drug cravings, screening and monitoring illicit drug use, screening and monitoring sexual activity, and receiving information about HIV prevention. Each feature was rated on a 5-point Likert scale (ranging from 1, not willing, to 5, extremely willing); the scale was later dichotomized for analysis, with “not willing” coded as no and “somewhat willing,” “willing,” “very willing,” “extremely willing” coded as yes. An mHealth acceptance score was created by taking an average cumulative score of the 5 mHealth-related dichotomized variables, with a higher score indicating greater acceptance (α=.88). Respondents’ preferred frequency (ie, daily, weekly, and monthly) and modality of mHealth (ie, phone call, text message, email, or app) were also assessed [35-37].

Childhood Trauma and Mental Health
Two items from the US Centers for Diseases Control and Prevention’s Behavioral Risk Factor Surveillance System questionnaire [38] were used to measure history of childhood and physical and sexual trauma. Childhood physical trauma was measured with a single-item question, “Before the age of 18, were you ever hit, slapped, kicked, or physically hurt by an adult?” Childhood sexual trauma was measured with 2 items: “Before the age of 18, were you ever forced to have sex by an adult or older child?” and “Before the age of 18, were you ever touched in a sexual way by an adult or older child when you did not want to be touched that way or were you ever forced to touch an adult or older child in a sexual way?” A “yes” response to either question resulted in a yes coding for the presence of childhood sexual trauma. Depressive symptoms were assessed using the 10-item Center for Epidemiological Studies Depression scale [39,40]. The total sum score ranges from 0 to 30, with a standard cut-off (score >10) for moderate to severe depression (α=.89) [40].

Sexual and Drug-Related Behaviors
Participants were asked information about their sexual behavior, including recent (past 6 months) engagement in anal sex and in which role (ie, insertive or receptive; participants were able to select both roles if applicable); recent engagement in an HIV-serodiscordant sexual relationship; consistent condom use; and lifetime engagement in sexualized drug use, which we defined as any use of crystal methamphetamine, gamma-hydroxybutyrate, gamma-butyrolactone, or 5-methoxy-N, N-diisopropyl tryptamine (commonly known as foxy or foxy methoxy [41]) before or during sexual activity. Additionally, participants were asked about any lifetime injection drug use. The 6-month cut-off point for sexual activity and engagement in a serodiscordant relationship was chosen based on the Centers for Disease Control and Prevention guidelines [42].

Participants were asked if they had ever been tested for or diagnosed with HIV or other sexually transmitted infections, including chlamydia (Chlamydia trachomatis), gonorrhea (Neisseria gonorrhoeae), syphilis (Treponema pallidum),
hepatitis B (Orthohepadnavirus hepatitis B virus), and hepatitis C (Hepacivirus hepacivirus C), and if they had ever used pre-exposure prophylaxis or postexposure prophylaxis for HIV prevention.

**Data Analysis**

Analyses were performed using SPSS software (version 26; IBM Corp). We calculated descriptive statistics, such as frequencies and percentages for categorical variables and means and standard deviations for continuous variables, and used multivariate linear regression to assess factors associated with the primary outcome—willingness to use mHealth (measured by the mHealth acceptability scale (continuous variable)). Candidate covariates were selected based on previous literature on mHealth acceptability and were included in the multivariable model if $P<.05$ in a bivariate model. Estimates were evaluated for statistical significance based on probability criteria of $P<.05$.

**Results**

**Participant Characteristics**

A total of 376 men (age: mean 27.5 years, SD 6.5 years) participated in the survey. Most participants identified ethnically as Malay (220/376, 58.5%). Over half of the participants were university graduates (216/376, 57.4%) and single (216/376, 56.4%). The mean monthly income was 3602.9 MYR. The majority of participants (222/376, 59.0%) reported symptoms consistent with moderate to severe depression (Table 1).

Although almost all participants had engaged in anal sex in the past 6 months (363/376, 96.5%; receptive role: 285/376, 75.8%), only one-fifth (72/376, 19.1%) reported consistent condom use. Moreover, one-fifth of participants (82/376, 21.8%) reported having ever engaged in sexualized drug use. Overall, 71.0% (267/376) of the participants had been tested for HIV at least once in their lifetime, and 27.4% (103/376) had been previously diagnosed with a sexually transmitted infection other than HIV. Only a small proportion of participants had ever used pre-exposure prophylaxis (26/376, 6.9%) or postexposure prophylaxis (27/376, 7.2%).
Table 1. Characteristics of participants.

| Characteristic                                      | Respondents (n=376) |
|-----------------------------------------------------|---------------------|
| Age (years), mean (SD)                              | 27.5 (6.5)          |
| Ethnicity (Malaya), n (%)                           |                     |
| No                                                  | 156 (41.5)          |
| Yes                                                 | 220 (58.5)          |
| University graduate a, n (%)                        |                     |
| No                                                  | 160 (42.6)          |
| Yes                                                 | 216 (57.4)          |
| Relationship status, n (%)                          |                     |
| Single                                              | 212 (56.4)          |
| Partner                                             | 164 (43.6)          |
| Monthly income (MYR)b, mean (SD)                    | 3602.9 (5082.6)     |
| Ever had HIV test, n (%)                            |                     |
| No                                                  | 109 (29.0)          |
| Yes                                                 | 267 (71.0)          |
| Previously diagnosed with STI c, n (%)              |                     |
| No                                                  | 273 (72.6)          |
| Yes                                                 | 103 (27.4)          |
| Ever used pre-exposure prophylaxis, n (%)           |                     |
| No                                                  | 350 (93.1)          |
| Yes                                                 | 26 (6.9)            |
| Ever used postexposure prophylaxis, n (%)           |                     |
| No                                                  | 349 (92.8)          |
| Yes                                                 | 27 (7.2)            |
| Experienced childhood physical abuse, n (%)         |                     |
| No                                                  | 199 (52.9)          |
| Yes                                                 | 177 (47.1)          |
| Experienced childhood sexual assault, n (%)         |                     |
| No                                                  | 235 (62.5)          |
| Yes                                                 | 141 (37.5)          |
| Depressive symptoms, n (%)                          |                     |
| No                                                  | 154 (41.0)          |
| Yes                                                 | 222 (59.0)          |
| Ever injected drugs, n (%)                          |                     |
| No                                                  | 359 (95.5)          |
| Yes                                                 | 17 (4.5)            |
| Engaged in anal sex (past 6 months), n (%)          |                     |
| No                                                  | 13 (3.5)            |
| Yes                                                 | 363 (96.5)          |
| Type of anal sex (past 6 months)d, n (%)            |                     |
| Insertive                                           | 271 (72.1)          |
| Receptive                                           | 285 (75.8)          |
Respondents (n=376)

| Characteristic                                                                 | Respondents (n=376) |
|--------------------------------------------------------------------------------|---------------------|
| **HIV-serodiscordant relationship (past 6 months), n (%)**                     |                     |
| No                                                                              | 340 (90.4)          |
| Yes                                                                             | 36 (9.6)            |
| **Consistent condom use (past 6 months), n (%)**                               |                     |
| No                                                                              | 304 (80.9)          |
| Yes                                                                             | 72 (19.1)           |
| **Ever engaged in sexualized drug use, n (%)**                                 |                     |
| No                                                                              | 294 (78.2)          |
| Yes                                                                             | 82 (21.8)           |

aThis category included college, university, or professional degrees.
bMYR: Malaysian Ringgit (1 MYR is approximately US $0.23).
cSTI: sexually transmitted infections.
dThe total exceeds 100% because the options were not mutually exclusive.

**Access to and Frequency of Use of Communication Technology**

Almost all participants (368/376, 97.9%) owned or had access to a smartphone with internet access, and 13.3% (50/376) of participants had access to a basic cell phone without internet access (Table 2). More than two-thirds of participants (270/376, 71.8%) reported having access to a laptop; between one-quarter and one-fifth of participants had access to a personal computer (100/376, 26.6%), a tablet (85/376, 22.6%), and a landline telephone (81/376, 21.6%). The frequency of use of each device was largely consistent with the frequency of ownership and access, with smartphones representing the most frequently used technology (mean 4.9, SD 0.4), followed by laptops (mean 3.8, SD 1.2), personal computers (mean 2.5, SD 1.4), tablets (mean 2.3, SD 1.3), basic cell phones (mean 2.1, SD 1.3), and landline telephones (mean 1.8, SD 0.9).

Almost all participants (373/376, 99.2%) accessed the internet daily, largely through a smartphone (334/376, 88.8%), and spent on average 9.4 hours per week (SD 4.9) on the internet (Table 3). The most common activities that participants used the internet on their smartphones for were social networking (mean 4.5, SD 0.8) and sending or receiving emails (mean 4.0, SD 1.0). Participants also used their smartphones to access geosocial networking apps or websites (mean 3.6, SD 1.1), search for health-related information (mean 3.5, SD 0.9), and use health-related apps (mean 2.9, SD 1.1). The majority (345/376, 91.8%) of participants used geosocial networking apps, with Grindr, Blued, and Hornet being the most popular.

**Table 2.** Ownership or access to and frequency of use of communication technology.

| Variable                        | Ownership or access (n=376), n (%) | Frequency of usea, mean (SD) |
|---------------------------------|-----------------------------------|-------------------------------|
| **Mobile phone**                |                                    |                               |
| With internet access (smartphone)| 368 (97.9)                         | 4.9 (0.4)                     |
| Without internet access (basic phone) | 50 (13.3)                   | 2.1 (1.3)                     |
| Laptop                          | 270 (71.8)                         | 3.8 (1.2)                     |
| Personal computer               | 100 (26.6)                         | 2.5 (1.4)                     |
| Tablet                          | 85 (22.6)                          | 2.3 (1.3)                     |
| Landline telephone              | 81 (21.5)                          | 1.8 (0.9)                     |

aThis was assessed using a 5-point Likert scale (1, never; 2, rarely; 3, sometimes; 4, often; 5, all the time).
Table 3. Access to internet.

| Variables                              | Respondents (n=376) |
|----------------------------------------|---------------------|
| **Daily access to the internet, n (%)**|                     |
| No                                     | 3 (0.8)             |
| Yes                                    | 373 (99.2)          |
| **Primary device for accessing the internet, n (%)** |               |
| Smartphone                             | 334 (88.8)          |
| Laptop                                 | 21 (5.6)            |
| Personal computer                      | 6 (1.6)             |
| Others                                 | 15 (4.0)            |
| **Time spent on the internet (hours per week), mean (SD)** | 9.4 (4.9) |
| **Use of the internet on a smartphone for various activities**, mean (SD) | |
| Online social networking               | 4.5 (0.8)           |
| Send or receive emails                 | 4.0 (1.0)           |
| Geosocial networking apps or websites  | 3.6 (1.1)           |
| Search for health-related information  | 3.5 (0.9)           |
| Use health-related apps                | 2.9 (1.1)           |

This item was assessed using a 5-point Likert scale (1, never; 2, rarely; 3, sometimes; 4, often; 5, all the time).

**Acceptability of mHealth**

The majority of participants were interested in receiving HIV prevention information (345/376, 91.8%) on a monthly (147/376, 42.6% of those who expressed willingness) or weekly (131/376, 38.0%) basis, and in receiving medication reminders (336/376, 89.4%) mostly on a daily basis (191/376, 56.8%). Additionally, there was interest in using mHealth to screen and monitor sexual activity (306/376, 81.4%) on a weekly (135/376, 44.1%) or monthly (99/376, 32.4%) basis; screen and monitor illicit drug use (281/376, 74.7%) on a weekly (104/376, 37.0%) or monthly (100/376, 35.6%) basis; and monitor drug cravings (280/376, 74.5%) on a weekly (115/376, 41.1%) or monthly (79/376, 28.2%) basis. The preferred modality of mHealth strategies was via apps, regardless of the type of intervention (Table 4).
Table 4. Interest in and acceptance of mobile health (mHealth) among participants (N=376).

| Interest in using mHealth to... | No, n (%) | Yes, n (%) |
|---------------------------------|-----------|------------|
| **Receive medication reminders** |           |            |
| Preferred frequency (n=374)     |           |            |
| Daily                           | 13 (32.5) | 191 (56.8) |
| Weekly                          | 10 (25.0) | 91 (27.1)  |
| Monthly                         | 8 (20.0)  | 44 (13.1)  |
| Never                           | 8 (20.0)  | 9 (2.7)    |
| Preferred mechanism (n=375)     |           |            |
| Phone calls                     | 10 (25.0) | 15 (4.5)   |
| Text messages                   | 13 (32.5) | 93 (27.7)  |
| App notification                | 12 (30.0) | 206 (61.3) |
| Email                           | 4 (10.0)  | 22 (6.5)   |
| **Monitor drug cravings**       |           |            |
| Preferred frequency (n=375)     |           |            |
| Daily                           | 10 (10.4) | 48 (17.1)  |
| Weekly                          | 17 (17.7) | 115 (41.1) |
| Monthly                         | 15 (15.6) | 79 (28.2)  |
| Never                           | 53 (55.2) | 38 (13.6)  |
| Preferred mechanism (n=375)     |           |            |
| Phone calls                     | 11 (11.5) | 2 (0.7)    |
| Text messages                   | 23 (24.0) | 65 (23.2)  |
| App                             | 45 (46.9) | 183 (65.4) |
| Email                           | 16 (16.7) | 30 (10.7)  |
| **Screen and monitor illicit drug use** | | |
| Preferred frequency (n=375)     |           |            |
| Daily                           | 10 (10.5) | 50 (17.8)  |
| Weekly                          | 17 (17.9) | 104 (37.0) |
| Monthly                         | 17 (17.9) | 100 (35.6) |
| Never                           | 50 (52.6) | 27 (9.6)   |
| Preferred mechanism (n=375)     |           |            |
| Phone calls                     | 9 (9.5)   | 5 (1.8)    |
| Text messages                   | 22 (23.2) | 55 (19.6)  |
| App                             | 45 (47.4) | 189 (67.3) |
| Email                           | 18 (18.9) | 32 (11.4)  |
| **Screen and monitor sexual activity** | | |
| Preferred frequency (n=373)     |           |            |
| Daily                           | 10 (14.3) | 58 (19)    |
| Weekly                          | 15 (21.4) | 135 (44.1) |
| Monthly                         | 17 (24.3) | 99 (32.4)  |
| Never                           | 26 (37.1) | 13 (4.2)   |
| Preferred mechanism (n=375)     |           |            |
| Phone calls                     | 8 (11.4)  | 5 (1.6)    |
| Text messages                   | 15 (21.4) | 59 (19.3)  |
Interest in using mHealth to...

|                          | No, n (%) | Yes, n (%) |
|--------------------------|-----------|------------|
| App                      | 32 (45.7) | 212 (69.3) |
| Email                    | 14 (20.0) | 30 (9.8)   |

Receive HIV prevention information

**Preferred frequency (n=374)**
- Daily: 6 (19.4) | 53 (15.4)
- Weekly: 6 (19.4) | 131 (38.0)
- Monthly: 10 (32.3) | 147 (42.6)
- Never: 8 (25.8) | 13 (3.8)

**Preferred mechanism (n=375)**
- Phone calls: 4 (12.9) | 13 (3.8)
- Text messages: 5 (16.2) | 70 (20.3)
- App: 12 (38.7) | 186 (53.9)
- Email: 9 (29) | 76 (22)

Correlates of mHealth acceptance

The mean score for mHealth acceptance was 4.1 (SD 1.5), with $\alpha=0.875$. In the multivariable model, being a university graduate ($\beta=0.456, P=.003$), being in a relationship with a partner ($\beta=0.322, P=.04$), lifetime engagement in sexualized drug use ($\beta=0.489, P=.01$), and recent engagement in receptive anal sex ($\beta=0.498, P=.006$) were associated with higher willingness to use mHealth strategies (Table 5).
| Variables                              | Univariate | Multivariable |
|----------------------------------------|------------|--------------|
|                                        | Beta       | SE           | P value | Beta       | SE           | P value |
| Age (years)                            | -0.008     | 0.012        | .52     | _a         | —            | —       |
| Ethnicity (Malaya)                     | 0.145      | 0.160        | .37     | —          | —            | —       |
| University graduate<sup>b</sup>        | 0.465      | 0.158        | .003    | 0.456      | 0.154        | .003    |
| Relationship status (partner)          | 0.333      | 0.158        | .04     | 0.322      | 0.154        | .04     |
| Monthly income                         | -0.001     | 0.001        | .70     | —          | —            | —       |
| Ever had HIV test                      | -0.003     | 0.174        | .99     | —          | —            | —       |
| Previously diagnosed with STI<sup>c</sup> | 0.039     | 0.117        | .82     | —          | —            | —       |
| Ever used pre-exposure prophylaxis     | 0.164      | 0.311        | .60     | —          | —            | —       |
| Ever used postexposure prophylaxis     | 0.034      | 0.306        | .91     | —          | —            | —       |
| Experienced childhood physical abuse   | 0.163      | 0.158        | .30     | —          | —            | —       |
| Experienced childhood sexual assault   | -0.017     | 0.163        | .92     | —          | —            | —       |
| Depressive symptoms                    | 0.253      | 0.160        | .12     | —          | —            | —       |
| Ever injected drugs                    | 0.678      | 0.379        | .07     | 0.408      | 0.389        | .29     |
| Engaged in anal sex (past 6 months)    | 0.599      | 0.432        | .17     | —          | —            | —       |
| **Type of anal sex (past 6 months)**   |            |              |         |            |              |         |
| Insertive                              | -0.036     | 0.176        | .84     | —          | —            | —       |
| Receptive                              | 0.502      | 0.183        | .006    | 0.498      | 0.179        | .006    |
| HIV-serodiscordant relationship (past 6 months) | -0.314   | 0.268        | .24     | —          | —            | —       |
| Consistent condom use (past 6 months)  | 0.130      | 0.201        | .52     | —          | —            | —       |
| Ever engaged in sexualized drug use    | 0.537      | 0.189        | .005    | 0.489      | 0.195        | .01     |

<sup>a</sup>No data because the variable was not included in the model.
<sup>b</sup>This category included college, university, or professional degrees.
<sup>c</sup>STI: sexually transmitted infection.

**Discussion**

**Principal Findings**

The rapid growth and use of web-based communication technologies have led to innovations in public health programming and patient care [28], particularly as COVID-19–related restrictions affect health care delivery, with decreased access to in-person health care and prevention interventions, which has had negative consequences on health [43-47]. The utilization of innovative tools in virtual spaces (eHealth or mHealth) can help bridge gaps in service delivery that are needed to improve access to needed health and prevention services, particularly among underserved populations [26]. Until now, there has been a lack of empirical evidence on how communication technologies can improve access to and engagement in care or support for the use of mHealth strategies for HIV prevention needs among men who have sex with men in Malaysia. The findings from this study allow us to assess opportunities to implement mHealth strategies for HIV prevention efforts and inform the specific format and features of a mHealth platform tailored to the needs of men who have sex with men in Malaysia. We found near-universal access to communication technology and internet use and high levels of acceptability of mHealth, particularly smartphone apps, for HIV prevention efforts. Our findings provide preliminary evidence that supports the feasibility of mHealth deployment to deliver HIV prevention and related interventions among men who have sex with men in Malaysia.

We identified a number of interventions that can be incorporated into HIV-prevention mHealth, including tracking and monitoring the sexual and drug use behaviors and assessing symptoms associated with depression. Consistent with information in existing literature [48-50], a considerable proportion of men who have sex with men in our sample had high rates of condomless sex, sexualized drug use, and mental health comorbidities and sexually transmitted infections, highlighting the vulnerabilities in men who have sex with men in an evolving and dynamic HIV epidemic. In addition, it was concerning that a proportion of participants had never been tested for HIV (109/376, 29.0%). HIV testing is the first step in engaging individuals in HIV prevention and treatment cascades; frequent screenings are thus of the utmost importance for individuals most at risk. mHealth can play a uniquely important role in assessing risk and reminding and motivating men who have sex with men to be tested regularly [51-55]. As such, innovations in mHealth can accelerate engagement in HIV testing and
facilitate the uptake of HIV prevention services, such as pre-exposure prophylaxis and HIV self-testing, particularly in areas where such services are underutilized or have limited availability [53]. Our findings underscore the urgent need for innovative strategies to reach and deliver HIV prevention services to this key population, particularly in a context where same-sex sexual behavior is deeply stigmatized.

Near-universal access to smartphones, combined with daily internet access among our sample, consistent with previous studies [56] with Malaysian men who have sex with men, support the feasibility of developing mHealth strategies for Malaysian men who have sex with men. Participants reported already using their smartphones to search for health-related information or apps, and most participants used mobile technologies (ie, smartphones) far more frequently than they used other technologies (eg, computers, landline telephone). This likely reflects the digital revolution that is especially explosive in Asia and the fast-paced growth and use of mobile technologies in the community [57-61]. The rapid advances in mobile technologies and the development of apps open new opportunities for integrating mobile health into existing HIV prevention service delivery in the region. Future research, however, is needed to gather additional information on Malaysian men who have sex with men’s interests in health-related content using smartphones, access points (eg, websites, chatbots, apps), which types of information, and where gaps in existing web-based resources exist.

Our findings indicate that there is considerable interest in specific mHealth strategies, such as receiving information related to HIV (345/376, 91.8%), receiving medication reminders (336/376, 89.4%), screening and monitoring sex activity (306/376, 81.4%) and illicit drug use (281/376, 74.7%), and monitoring drug cravings (280/376, 74.5%). In the absence of public dialogue about these issues in Malaysia, it is not surprising that Malaysian men who have sex with men, similar to men who have sex with men in other settings [62-67], and specifically, for HIV prevention, in China [68], Vietnam [69], and Indonesia [66], expressed interest. In our sample, men expressed interest in the use of mHealth apps to receive daily reminders to take medications; however, weekly and monthly reminders were preferred for other activities, with smartphone apps being the preferred platform. An mHealth-based app may serve as an additional tool that can help support men who have sex with men who have sex with men in Malaysia; our findings on participants’ educational status are consistent with previous studies conducted among men who have sex with men in the region [49,71]. The educational level of our sample may explain the high level of interest in mHealth and the acceptability of mHealth interventions, as a higher level of education likely facilitates greater technology literacy. This is supported by the multivariable analysis of associations between mHealth acceptance and participant characteristics, which showed that university graduates were more willing to use mHealth strategies. Finally, although men in this study showed a strong willingness to use mHealth for various needs, it should be noted that willingness or interest may not fully reflect actual use; therefore, studies of mHealth interventions in practice are needed to assess use.

To the best of our knowledge, this is the first study to assess the acceptability of mHealth to address HIV prevention needs among men who have sex with men in Malaysia. Our findings show that mHealth use, particularly app-based platforms, appears to be highly acceptable to this population. This finding is particularly meaningful in Malaysia, where there are limited physical venues that are culturally acceptable for men who have sex with men to seek health care since same-sex sexual behavior is illegal, and men who have sex with men are highly stigmatized and are frequent targets of discrimination [9].

Future Implications

Our findings support the development of mHealth-based strategies, especially smartphone apps, to jumpstart the HIV prevention cascade by promoting HIV testing and, depending on the results, linking individuals to the appropriate prevention or treatment services. mHealth strategies, such as culturally
tailored apps, are uniquely positioned to deliver multicomponent interventions, and thus, can bridge systematic gaps needed to address syndemic and complex interrelated health needs and more effective utilization of health services in this underserved population [53,55,73-76].

In recent years, several apps for HIV prevention and treatment efforts have been evaluated in pilot studies or randomized trials that incorporate components such as HIV testing, condom use, pre-exposure prophylaxis, treatment as prevention, and other support services (eg, mental health, drug use) [53,55,73-76]. Some of these apps offer the opportunity to assess, with ecological momentary assessment, or intervene, via ecological momentary interventions, individuals in their natural environment, thereby enabling a better understanding of the factors triggering problems and addressing the problems when and where they arise [77-79].

Most, if not all, of the available apps, however, are primarily developed for use in high-income countries [53,55,73-76]. Additional research to assess the design, functionality, and content preferences of Malaysian men who have sex with men is now needed to facilitate the design of a customized mHealth app in the Malaysian context (specifically, addressing the multiethnic population of Malaysia, as well as men who have sex with men in nonurban settings, will be important). Further research is also needed to understand the perspective of those tasked with providing care and support services via the mHealth platforms (eg, physicians, pharmacists, counselors, outreach workers). Such research will inform and facilitate the integration of mHealth platforms within existing health care services.

Acknowledgments
RS was supported in part by a career development award from the National Institute on Drug Abuse (K01 DA051346, principal investigator: RS) and a research grant from the Fogarty International Center (R21 TW011665; principal investigator: RS). The funders had no role in the study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Conflicts of Interest
None declared.

References
1. Shao Y, Williamson C. The HIV-1 epidemic: low- to middle-income countries. Cold Spring Harb Perspect Med 2012 Mar 22;2(3):a007187 [FREE Full text] [doi: 10.1080/09540121.2014.894616] [Medline: 2393534] [Medline: 22390629]
2. Patel P, Borkowf C, Brooks J, Lasry A, Lansky A, Mermin J. Estimating per-act HIV transmission risk: a systematic review. AIDS 2014 Jun 19;28(10):1509-1519 [FREE Full text] [doi: 10.1097/QAD.0000000000000298] [Medline: 24809629]
3. Sexually transmitted infections treatment guidelines. Center for Disease Control and Prevention. 2021 Jul. URL: https://www.cdc.gov/std/treatment-guidelines/toc.htm [accessed 2022-06-13]
4. Koblin B, Husnik M, Colfax G, Huang Y, Madison M, Mayer K, et al. Risk factors for HIV infection among men who have sex with men. AIDS 2006 Mar 21;20(5):731-739. [doi: 10.1097/01.aids.0000216374.61442.55] [Medline: 16514304]
5. HIV infection risk, prevention, and testing behaviors among men who have sex with men national HIV behavioral surveillance, 23 U.S. cities. Centers for Disease Control and Prevention. 2017. URL: https://www.cdc.gov/hiv/pdf/library/reports/surveillance/cdc-hiv-surveillance-special-report-number-22.pdf [accessed 2022-06-13]
6. Global AIDS monitoring 2020: Malaysia HIV/AIDS progress report. Ministry of Health Malaysia. 2019. URL: https://www.moh.gov.my/moh/resources/Penerbitan/Laporan/Umum/Laporan_Global_AIDS_Monitoring_2020_new.pdf [accessed 2022-06-13]
7. Malaysia. Joint United Nations Programme on HIV/AIDS. URL: https://www.unaids.org/en/regionscountries/countries/malaysia [accessed 2022-06-13]
8. Lim SH, Alias H, Kien JK, Akbar M, Kamarulzaman A, Wong LP. A qualitative study of HIV “test-and-treat” experience among men who have sex with men in Malaysia. AIDS Educ Prev 2019 Jun;31(3):193-205 [FREE Full text] [doi: 10.1521/aeap.2019.31.3.192] [Medline: 31145000]
9. Arreola S, Santos G, Beck J, Sundararaj M, Wilson PA, Hebert P, et al. Sexual stigma, criminalization, investment, and access to HIV services among men who have sex with men worldwide. AIDS Behav 2015 Feb 3;19(2):227-234. [doi: 10.1007/s10461-014-0869-x] [Medline: 25086670]
10. Earnshaw VA, Jin H, Wickersham J, Kamarulzaman A, John J, Altice FL. Exploring intentions to discriminate against patients living with HIV in Malaysia. AIDS Behav 2014 Jun 26;18(6):672-679 [FREE Full text] [doi: 10.1007/s10461-014-1069-x] [Medline: 24665456]
11. Jin H, Earnshaw VA, Wickersham JA, Kamarulzaman A, Desai MM, John J, et al. An assessment of health-care students’ attitudes toward patients with or at high risk for HIV: implications for education and cultural competency. AIDS Care 2014;26(10):1223-1228 [FREE Full text] [doi: 10.1080/09540121.2014.894616] [Medline: 24625279]
12. Tee YC, Earnshaw VA, Altice FL, Jin H, Kamarulzaman A, Wickersham JA. Evaluating physicians’ intention to discriminate against patients living with HIV in Malaysia. AIDS Behav 2019 Apr 17;23(4):1039-1047 [FREE Full text] [doi: 10.1007/s10461-018-2362-4] [Medline: 30560483]
13. Earnshaw VA, Jin H, Wickersham JA, Kamarulzaman A, John J, Lim SH, et al. Stigma toward men who have sex with men among future healthcare providers in Malaysia: would more interpersonal contact reduce prejudice? AIDS Behav 2016 Jan 1;20(1):98-106 [FREE Full text] [doi: 10.1007/s10461-015-1168-x] [Medline: 26324078]

14. Guadamuz TE, Cheung DH, Wei C, Koe S, Lim SH. Young, online and in the dark: scaling up HIV testing among MSM in ASEAN. PLoS One 2015 May 14;10(5):e0126658 [FREE Full text] [doi: 10.1371/journal.pone.0126658] [Medline: 25973907]

15. Lim SH, Bazazi AR, Sim C, Choo M, Altice FL, Kamarulzaman A. High rates of unprotected anal intercourse with regular and casual partners and associated factors in a sample of ethnic Malay men who have sex with men (MSM) in Penang, Malaysia. Sex Transm Infect 2013 Dec;20;89(8):642-649. [doi: 10.1136/sextrans-2012-050995] [Medline: 23787168]

16. Chong SCS, Kamarulzaman A, Azwa I, Ng R, Chong M, Raman N, et al. Delayed HIV testing and treatment seeking, and associated support needs among people living with HIV in Malaysia: a qualitative study. Sex Health 2021 May;18(2):147-155. [doi: 10.1071/SH20180] [Medline: 33715762]

17. Chawarski MC, Vicknasingam B, Mazlan M, Schottenfeld RS. Lifetime ATS use and increased HIV risk among not-in-treatment opiate injectors in Malaysia. Drug Alcohol Depend 2012 Jul 01;124(1-2):177-180 [FREE Full text] [doi: 10.1016/j.drugalcdep.2011.12.024] [Medline: 22266088]

18. Fendrich M, Avci O, Johnson TP, Mackesy-Amiti ME. Depression, substance use and HIV risk in a probability sample of men who have sex with men. Addict Behav 2013 Mar;38(3):1715-1718 [FREE Full text] [doi: 10.1016/j.addbeh.2012.09.005] [Medline: 23254224]

19. Daskalopoulos M, Rodger A, Phillips AN, Sherr L, Speakman A, Collins S, et al. Recreational drug use, polydrug use, and sexual behaviour in HIV-diagnosed men who have sex with men in the UK: results from the cross-sectional ASTRA study. Lancet HIV 2014 Oct;1(1):e22-e31 [FREE Full text] [doi: 10.1016/S2352-3018(14)70001-3] [Medline: 26423813]

20. Hirsfield S, Remien RH, Humberstone M, Walvallak I, Chissao MA. Substance use and high-risk sex among men who have sex with men: a national online study in the USA. AIDS Care 2004 Nov 27;16(8):1036-1047. [doi: 10.1080/0954012041233129255] [Medline: 15511735]

21. Van Tieu H, Koblin BA. HIV, alcohol, and noninjection drug use. Curr Opin HIV AIDS 2009 Jul;4(4):314-318. [FREE Full text] [doi: 10.1097/COH.0b013e32832aa902] [Medline: 19532070]

22. Halkitis PN, Parsons JT. Recreational drug use and HIV-risk sexual behavior among men frequenting gay social venues. J Gay Lesbian Soc Serv 2008 Sep 22;14(4):19-38. [doi: 10.1300/J041v14n04_02]

23. Sandfort T, Knox J, Alcala C, El-Bassel N, Kuo I, Smith LR. Substance use and HIV risk among men who have sex with men in africa: a systematic review. J Acquir Immune Defic Syndr 2017;76(2):e34-e46. [doi: 10.1097/qai.0000000000001462]

24. Cooper V, Clatworthy J, Whetham J, Consortium E. mHealth interventions to support self-management in HIV: a systematic review. Open AIDS J 2017 Nov 21;11(1):119-132 [FREE Full text] [doi: 10.2174/1874613601711010119]

25. Converse DF, Jennings L, Aguiliar C, Shin G, Handler L, Maman S. Systematic review of mobile health behavioural interventions to improve uptake of HIV testing for vulnerable and key populations. J Telemed Telecare 2017 Feb;23(2):347-359 [FREE Full text] [doi: 10.1177/1357633X16639186] [Medline: 27056905]

26. Marcolino MS, Oliveira IAQ, D’Agostino M, Ribeiro AL, Alkmim MBM, Novillo-Ortiz D. The impact of mhealth interventions: systematic review of systematic reviews. JMIR Mhealth Uhealth 2018 Jan 17;6(1):e23 [FREE Full text] [doi: 10.2196/mhealth.8873] [Medline: 2933463]

27. mHealth: new horizons for health through mobile technologies: second global survey on eHealth. World Health Organization. 2011. URL: https://apps.who.int/iris/handle/10665/44607 [accessed 2022-06-13]

28. Free C, Phillips G, Watson L, Galli L, Felix L, Edwards P, et al. The effectiveness of mobile-health technologies to improve health care service delivery processes: a systematic review and meta-analysis. PLoS Med 2013 Jan 15;10(1):e1001363 [FREE Full text] [doi: 10.1371/journal.pmed.1001363] [Medline: 23458994]

29. Lyster RT, Ritzo P, Mills EJ, Kairiri A, Karanja S, Chung MH, et al. Effects of a mobile phone short message service on antiretroviral treatment adherence in Kenya (WelTel Kenya1): a randomised trial. Lancet 2010 Nov 27;376(9755):1838-1845. [doi: 10.1016/S0140-6736(10)60997-6] [Medline: 21071074]

30. Mbilicy J, Lunskey M, Strang J. Solving the problem of non-attendance in substance abuse services. Drug Alcohol Rev 2014 Nov 06;33(6):625-636. [doi: 10.1111/dar.12194] [Medline: 25196817]

31. Mbaagbaw L, Mursleen S, Lytvyn L, Smieja M, Dolovich L, Thabane L. Mobile phone text messaging interventions for HIV and other chronic diseases: an overview of systematic reviews and framework for evidence transfer. BMC Health Serv Res 2015 Jan 22;15(1):33-16 [FREE Full text] [doi: 10.1186/s12913-014-0654-6] [Medline: 25609559]

32. Hand phone users survey 2018. Malaysian Communications and Multimedia Commission. 2019. URL: https://www.mcmc.gov.my/skmmgovmy/media/General/pdf/HPUS2018.pdf [accessed 2022-06-13]

33. Beckthorn D. Respondent-driven sampling: a new approach to the study of hidden populations. Soc Probl 1997 May;44(2):174-199. [doi: 10.1525/sp.1997.44.2.03x0221nm]
35. Krishnan A, Ferro EG, Weikum D, Vagenas P, Lama JR, Sanchez J, et al. Communication technology use and mHealth acceptance among HIV-infected men who have sex with men in Peru: implications for HIV prevention and treatment. AIDS Care 2015 Oct 06;27(3):273-282 [FREE Full text] [doi: 10.1080/09540121.2014.963014] [Medline: 25285464]
36. Shrestha R, Karki P, Copenhaver M. Interest in use of mHealth technology in HIV prevention and associated factors among high-risk drug users enrolled in methadone maintenance program. AIDS Care 2017 Sep 08;29(9):1144-1148 [FREE Full text] [doi: 10.1080/09540121.2017.1325439] [Medline: 28478076]
37. Shrestha R, Huedo-Medina TB, Altice FL, Krishnan A, Copenhaver M. Examining the acceptability of mHealth technology in HIV prevention among high-risk drug users in treatment. AIDS Behav 2017 Nov 26;21(11):3100-3110 [FREE Full text] [doi: 10.1007/s10461-016-1637-x] [Medline: 28025735]
38. Behavioral risk factor surveillance system (BRFSS) questionnaire. Centers for Disease Control and Prevention. 2006. URL: https://www.cdc.gov/brfss/index.html [accessed 2022-06-13]
39. Radloff LS. The CES-D scale. Appl Psychol Meas 2016 Jul 26;1(3):385-401 [FREE Full text] [doi: 10.1177/01466216770100306]
40. Bjorgvinsson T, Kertz SJ, Bigda-Peyton JS, McCoy KL, Aderka IM. Psychometric properties of the CES-D-10 in a psychiatric sample. Assessment 2013 Aug 18;20(4):429-436. [doi: 10.1177/1073191113481998] [Medline: 23513010]
41. Sogawa C, Sogawa N, Tagawa J, Fujiwara O, Ohyama K, Asanuma M, et al. 5-Methoxy-N,N-diisopropyltryptamine (Foxy), a selective and high affinity inhibitor of serotonin transporter. Toxicol Lett 2007 Apr 05;170(1):75-82. [doi: 10.1016/j.toxlet.2007.02.007] [Medline: 17382495]
42. US Preventive Services Task Force, Owens DK, Davidson KW, Krist AH, Barry MJ, Cabana M, et al. Preexposure prophylaxis for the prevention of HIV infection: US Preventive Services Task Force recommendation statement. JAMA 2019 Jun 11;321(22):2203-2213. [doi: 10.1001/jama.2019.6390] [Medline: 31184747]
43. Cantor J, Sood N, Bravata DM, Pera M, Whaley C. The impact of the COVID-19 pandemic and policy response on health care utilization: evidence from county-level medical claims and call center data. J Health Econ 2022 Mar;82:102581-102516 [FREE Full text] [doi: 10.1016/j.jhealeco.2022.102581] [Medline: 35067386]
44. Malhotra C, Chaudhry I, Ozdemir S, Finkelstein EA. Reduced health-care utilization among people with chronic medical conditions during coronavirus disease 2019. Proceedings of Singapore Healthcare 2020 Oct 07;30(3):254-257. [doi: 10.1177/2010105820964533]
45. Sanchez TH, Zlotorzynska M, Rai M, Baral SD. Characterizing the impact of COVID-19 on men who have sex with men across the United States in April, 2020. AIDS Behav 2020 Jul 29;24(7):2024-2032 [FREE Full text] [doi: 10.1007/s10461-020-02984-2] [Medline: 32350773]
46. Santos G, Ackerman B, Rao A, Wallach S, Ayala G, Lamontage E, et al. Economic, mental health, HIV prevention and HIV treatment impacts of COVID-19 and the COVID-19 response on a global sample of cisgender gay men and other men who have sex with men. AIDS Behav 2021 Feb 11;25(2):311-321 [FREE Full text] [doi: 10.1007/s10461-020-02969-0] [Medline: 32654021]
47. Mistler CB, Curley CM, Rosen AO, El-Krab R, Wickersham JA, Copenhaver MM, et al. The impact of COVID-19 on access to HIV prevention services among opioid-dependent individuals. J Community Health 2021 Oct 26;46(5):960-966 [FREE Full text] [doi: 10.1007/s10461-020-02894-2] [Medline: 33770334]
48. Lim SH, Mburo G, Bourne A, Pang J, Wickersham JA, Wei CKT, et al. Willingness to use pre-exposure prophylaxis for HIV prevention among men who have sex with men in Hong Kong: Findings from an online survey. PLoS One 2017 Sep 13;12(9):e0182383 [FREE Full text] [doi: 10.1371/journal.pone.0182383] [Medline: 28902857]
49. Kanter J, Koh C, Razali K, Tai R, Izenberg J, Rajan L, et al. Risk behaviour and HIV prevalence among men who have sex with men in a multiethnic society: a venue-based study in Kuala Lumpur, Malaysia. Int J STD AIDS 2011 Jan 01;22(1):30-37. [doi: 10.1258/ijsta.2010.010277] [Medline: 21364064]
50. Shrestha R, Alias H, Wong LP, Altice FL, Lim SH. Using individual stated-preferences to optimize HIV self-testing service delivery among men who have sex with men (MSM) in Singapore: results from a conjoint-based analysis. BMC Public Health 2020 Nov 25;20(1):1777-1711 [FREE Full text] [doi: 10.1186/s12889-020-00832-w] [Medline: 33238941]
51. Zhu X, Zhang W, Operario D, Zhao Y, Shi A, Zhang Z, et al. Effects of a mobile health intervention to promote HIV self-testing with MSM in China: a randomized controlled trial. AIDS Behav 2019 Nov 9;23(11):3129-3139 [FREE Full text] [doi: 10.1007/s10461-019-02452-5] [Medline: 30852278]
52. Sanabria G, Scherr T, Garofalo R, Kuhns LM, Bushover B, Nash N, et al. Usability evaluation of the mLab app for improving home HIV testing behaviors in youth at risk of HIV infection. AIDS Educ Prev 2021 Aug;33(4):312-324 [FREE Full text] [doi: 10.1521/aap.2021.33.4.312] [Medline: 34370566]
53. Biello KB, Hill-Rorie J, Valente PK, Futterman D, Sullivan PS, Hightow-Weidman L, et al. Development and evaluation of a mobile app designed to increase HIV testing and pre-exposure prophylaxis use among young men who have sex with men in the United States: open pilot trial. J Med Internet Res 2021 Mar 24;23(3):e25107 [FREE Full text] [doi: 10.2196/25107] [Medline: 33759792]
54. Biello KB, Horvitz C, Mullin S, Mayer KH, Scott H, Coleman K, et al. HIV self-testing and STI self-collection via mobile apps: experiences from two pilot randomized controlled trials of young men who have sex with men. Mhealth 2021 Apr;7:26-26 [FREE Full text] [doi: 10.21037/mhealth-20-70] [Medline: 33898595]

55. Sullivan PS, Hightow-Weidman L. Mobile apps for HIV prevention: how do they contribute to our epidemic response for adolescents and young adults? Mhealth 2021 Apr;7:36-36 [FREE Full text] [doi: 10.21037/mhealth-20-71] [Medline: 33898605]

56. Shrestha R, Lim SH, Altice FL, Copenhaver M, Wickersham JA, Saifi R, et al. Use of smartphone to seek sexual health information online among Malaysian men who have sex with men (MSM): implications for mhealth intervention to increase HIV testing and reduce HIV risks. J Community Health 2020 Feb;2;45(1):10-19 [FREE Full text] [doi: 10.1007/s10900-019-00713-x] [Medline: 31375976]

57. Sedik TS, Chen S, Feyzioglu T, Ghazanchyan M, Gupta S, Jahan S, et al. The digital revolution in Asia and its macroeconomic effects. ADBI Working Paper Series. 2019. URL: https://www.adbi.org/sites/default/files/publication/535846/adbi-wp1029.pdf [accessed 2022-06-26]

58. Li B, Piachaud D. Technological innovations and social development in Asia. J Asian Public Policy 2018 Nov 23;12(1):1-14. [doi: 10.1080/17516234.2018.1546419]

59. Hossain M, Weng W, Bhattacharya S, Majumder H, Faizah F. Digital health divide in South Asia: ethical concerns, challenges, and recommendations. SocArxiv Preprint posted online on April 1, 2020. [doi: 10.31235/osf.io/qhexc]

60. Baur A, Yew H, Xin M. The future of healthcare in Asia: digital health ecosystems. McKinsey & Company. 2021. URL: https://www.mckinsey.com/industries/healthcare-systems-and-services/our-insights/the-future-of-healthcare-in-asia-digital-health-ecosystems [accessed 2022-06-13]

61. Seman S. Are we ready to app?: a study on mHealth apps, its future, and trends in Malaysia context. In: Ramayah T. editor. Mobile Platforms, Designs, and Apps for Social Commerce. Hershey, Pennsylvania, USA: IG Global; 2017:1-15.

62. Lu X, Gao P, Wang X, Wang X, Zhao X, He Q, et al. User preferences for an mhealth approach to support HIV self-testing and linkage to HIV prevention or care services for MSM in China. AIDS Educ Prev 2021 Dec;33(6):534-550. [doi: 10.1521/aepc.2021.33.6.534] [Medline: 34874759]

63. Allahabi N, Carbello-Dieuguez A, Bakken S, Rojas M, Brown W, Carry M, et al. Using the information-motivation-behavioral skills model to guide the development of an HIV prevention smartphone application for high-risk MSM. AIDS Educ Prev 2015 Dec;27(6):522-537 [FREE Full text] [doi: 10.1521/aepc.2015.27.6.522] [Medline: 26595265]

64. Goldenberg T, McDougall SJ, Sullivan PS, Stekler JD, Stephenson R. Preferences for a mobile HIV prevention app for men who have sex with men. JMI R Mhealth Uhealth 2019 Oct 29;2(4):e47 [FREE Full text] [doi: 10.2196/mhealth.3745] [Medline: 25355249]

65. Zhao Y, Zhu X, Pérez AE, Zhang W, Shi A, Zhang Z, et al. MHealth approach to promote oral HIV self-testing among men who have sex with men in China: a qualitative description. BMC Public Health 2018 Sep 27;18(1):1146-1148 [FREE Full text] [ doi: 10.1186/s12889-018-6046-9] [Medline: 30261856]

66. Garg PR, Uppal L, Mehra S, Mehra D. Mobile health app for self-learning on HIV prevention knowledge and services among a young Indonesian key population: cohort study. JMI R Mhealth Uhealth 2020 Sep 08;8(9):e17646 [FREE Full text] [doi: 10.2196/17646] [Medline: 34806988]

67. Holloway IW, Winder TJ, Lea CH, Tan D, Boyd D, Novak D. Technology use and preferences for mobile phone–based HIV prevention and treatment among black young men who have sex with men: exploratory research. JMI R Mhealth Uhealth 2017 Apr;7:26-26 [FREE Full text] [ doi: 10.1186/s12889-018-6046-9] [Medline: 28408360]

68. Marley G, Fu G, Zhang Y, Li J, Tucker JD, Tang W, et al. Willingness of Chinese men who have sex with men to use smartphone-based electronic readers for HIV self-testing: web-based cross-sectional study. J Med Internet Res 2021 Nov 19;23(11):e26480 [FREE Full text] [ doi: 10.2196/26480] [Medline: 34806988]

69. Trang K, Le LX, Brown CA, To MQ, Sullivan PS, Jovanovic T, et al. Feasibility, acceptability, and design of a mobile ecological momentary assessment for high-risk men who have sex with men in Hanoi, Vietnam: qualitative study. JMI R Mhealth Uhealth Form Res 2022 Jan 27:6(1):e3060 [FREE Full text] [ doi: 10.1186/s12889-018-6046-9] [Medline: 25084340]

70. Muessig K, LeGrand S, Horvath K, Bauermeister J, Hightow-Weidman L. Recent mobile health interventions to support medication adherence among HIV-positive MSM. Curr Opin HIV AIDS 2017 Sep;12(5):432-441 [FREE Full text] [doi: 10.1097/COH.0000000000000401] [Medline: 28639990]

71. Krishnan A, Weikum D, Cravero C, Kamarulzaman A, Altice FL. Assessing mobile technology use and mHealth acceptance among HIV-positive men who have sex with men and transgender women in Malaysia. PLoS One 2021 Mar 23;16(3):e0248705 [FREE Full text] [ doi: 10.1371/journal.pone.0248705] [Medline: 33755693]

72. Graduates statistics 2020. Department of Statistics Malaysia. 2021. URL: https://www.dosm.gov.my/v1/index.php?r=column/themeByCat&cat=476&bel_id=U1tVWpwNXNRRUR2NhRSZmenRMUT09&menu_id=Thn8znRdVRNWWlWjRhwrlDk1UT09 [accessed 2022-06-13]

73. Sullivan PS, Driggers R, Stekler JD, Siegler A, Goldenberg T, McDougall SJ, et al. Usability and acceptability of a mobile comprehensive HIV prevention app for men who have sex with men: a pilot study. JMI R Mhealth Uhealth 2017 Mar 09;5(3):e26 [FREE Full text] [doi: 10.2196/mhealth.7199] [Medline: 28279949]
Canan CE, Waselewski ME, Waldman ALD, Reynolds G, Flickinger TE, Cohn WF, et al. Long term impact of PositiveLinks: Clinic-deployed mobile technology to improve engagement with HIV care. PLoS One 2020;15(1):e0226870 [FREE Full text] [doi: 10.1371/journal.pone.0226870] [Medline: 31905209]

Hung R, Bandy J, Wantuck J. PlushCare tele-PrEP, a nationwide app-based program’s California success. 2019 Presented at: National HIV Prevention Conference; March 18-21, 2019; Atlanta, Georgia.

Wong KYK, Stafylis C, Klausner JD. Telemedicine: a solution to disparities in human immunodeficiency virus prevention and pre-exposure prophylaxis uptake, and a framework to scalability and equity. Mhealth 2020;6:21 [FREE Full text] [doi: 10.21037/mhealth.2019.12.06] [Medline: 32270013]

Fatseas M, Serre F, Swendsen J, Auriacombe M. Effects of anxiety and mood disorders on craving and substance use among patients with substance use disorder: an ecological momentary assessment study. Drug Alcohol Depend 2018 Jun 01;187:242-248. [doi: 10.1016/j.drugalcdep.2018.03.008] [Medline: 29684892]

Jones A, Tiplady B, Houben K, Nederkoorn C, Field M. Do daily fluctuations in inhibitory control predict alcohol consumption? An ecological momentary assessment study. Psychopharmacology (Berl) 2018 May 1;235(5):1487-1496 [FREE Full text] [doi: 10.1007/s00213-018-4860-5] [Medline: 29497782]

Merikangas KR, Swendsen J, Hickie IB, Cui L, Shou H, Merikangas AK, et al. Real-time mobile monitoring of the dynamic associations among motor activity, energy, mood, and sleep in adults with bipolar disorder. JAMA Psychiatry 2019 Feb 01;76(2):190-198 [FREE Full text] [doi: 10.1001/jamapsychiatry.2018.3546] [Medline: 30540352]

Abbreviations

mHealth: mobile health
MYR: Malaysian Ringgit