Title

Exploration of a Mobile Technology Vulnerability Scale's association with antiretroviral adherence among young adults living with HIV in the United States

Journal

mHealth, 0(0)

ISSN

2306-9740

Authors

Saberi, Parya

Eskaf, Shadi

Campbell, Chadwick K

et al.

Publication Date

2022

DOI

10.21037/mhealth-21-54

Peer reviewed

Original Article

Exploration of a Mobile Technology Vulnerability Scale's association with antiretroviral adherence among young adults living with HIV in the United States

Parya Saberi[1]^, Shadi Eskaf[2], Chadwick K. Campbell[1], Torsten B. Neilands[1], John A. Sauceda[1], Karine Dubé[3]

[1]Division of Prevention Sciences, University of California, San Francisco, San Francisco, CA, USA; [2]School of Government, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA; [3]Gillings School of Global Public Health, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

Contributions: (I) Conception and design: P Saberi, K Dubé; (II) Administrative support: CK Campbell, P Saberi; (III) Provision of study materials or patients: P Saberi, K Dubé; (IV) Collection and assembly of data: CK Campbell, S Eskaf, P Saberi; (V) Data analysis and interpretation: S Eskaf, P Saberi, K Dubé, TB Neilands, JA Sauceda; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

Correspondence to: Parya Saberi, PharmD, MAS. Division of Prevention Sciences, University of California, San Francisco, San Francisco, CA, USA. Email: parya.saberi@ucsf.edu.

Background: Young adults living with HIV (YLWH) have suboptimal adherence to antiretroviral therapy (ART) and HIV care outcomes. Mobile health technologies are increasingly used to deliver interventions to address HIV health outcomes. However, not all YLWH have equal and consistent access to mobile technologies.

Methods: Using our novel Mobile Technology Vulnerability Scale (MTVS) to evaluate how vulnerable an individual feels with regard to their personal access to mobile technology in the past 6 months, we conducted a cross-sectional online survey with 271 YLWH (18–29 years) in the US to evaluate the relationships between MTVS and self-reported ART adherence.

Results: Participants reported changes in phone numbers (25%), stolen (14%) or lost (22%) phones, and disconnections of phone service due to non-payment (39%) in the past 6 months. On a scale of 0 to 1 (0 having no mobile technology vulnerability and 1 having complete mobile technology vulnerability), participants had a mean MTVS of 0.33 (SD =0.26). Black and financially constrained participants had the highest MTVS, which was significantly higher that other racial/ethnic and financially non-constrained groups, respectively. Higher MTVS was significantly associated with ART non-adherence and non-persistence.

Conclusions: Findings suggest the need to measure MTVS to recognize pitfalls when using mobile health interventions and identify populations whose inconsistent mobile technology access may be related to worse health outcomes.

Keywords: Youth living with HIV; mobile technology; adherence; antiretroviral therapy (ART); vulnerability scale

Received: 13 December 2021; Accepted: 23 March 2022; Published: 20 July 2022.
doi: 10.21037/mhealth-21-54
View this article at: https://dx.doi.org/10.21037/mhealth-21-54

^ ORCID: 0000-0002-3793-5112.

Introduction

Young adults living with HIV (YLWH) in the US have suboptimal antiretroviral therapy (ART) adherence and retention in HIV care, contributing to lower levels of HIV virologic suppression compared to older age groups (1-4). ART non-adherence can result in drug resistance, secondary transmission of drug resistance, reduced quality of life, and increased mortality (5-7). Interventions that improve ART adherence can significantly enhance virologic suppression and reduce onward transmission of HIV and death among YLWH (8). Due to the high levels of ownership of mobile technologies (such as smartphones) among youth (9,10), digital health solutions are a potential mechanism to deliver interventions to improve HIV treatment outcomes among YLWH.

The Pew Research Center shows high access to mobile phones among youth and young adults (9), as a result, many studies are examining the influence of mobile phone interventions for setting reminders to take and refill medications, receiving psychotherapeutic interventions, and communicating with healthcare teams (11-13). Additionally, the SARS-CoV-2 pandemic has further underscored the importance of access to digital technologies, many of which have allowed for remote clinical visits with HIV care providers and mental health and substance use counseling, while maintaining a human connection (14-17). However, many questions remain, including: What does mobile phone access look like among YLWH? How consistent is this access? How does the need to pay for mobile phone services compete against other expenses? How do individuals with access to mobile phones afford and maintain mobile phone data plans? How often do YLWH experience challenges by not paying their mobile phone bill? How is an individual's level of mobile technology vulnerability related to their healthcare, ART adherence, and clinical outcomes?

We developed the Mobile Technology Vulnerability Scale (MTVS) to better describe mobile technology access and consistency of access and explore competing needs to pay mobile phone bills and afford data plans (18). Given the relative importance of mobile technologies in the lives of YLWH (particularly during the SARS-CoV-2 pandemic (19,20) and the increasing prominence of mobile health interventions, it is critical to measure the level of mobile technology vulnerability that individuals experience and how this vulnerability may be associated with clinical outcomes. Therefore, we set out to examine self-reported mobile technology vulnerability and its association with ART adherence. We present the following article in accordance with the STROBE reporting checklist (available at https://mhealth.amegroups.com/article/view/10.21037/mhealth-21-54/rc).

Methods

Study design, participants, and procedures

Between April 2021 and August 2021, we conducted an online survey with a convenience sample of young adults (18–29 years of age) living with HIV in the US to examine mobile technology vulnerability and associations with ART adherence. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the University of California, San Francisco Institutional Review Board (No. 20-29992) and electronic informed consent was obtained from all participants. All study activities were conducted completely remotely to increase demographic and geographic diversity, willingness to participate, and generalizability of findings (21). Participants were recruited using social media posts (e.g., Twitter, Facebook), advertisements on dating apps (e.g., Jack'd), and via study flyers emailed to clinical providers, clinic staff, and organizations serving YLWH. Eligible participants were 18–29 years old, living in the US, living with HIV, able to complete the study survey in English, and willing to provide informed consent.

We used the Health Insurance Portability and Accountability Act-compliant Qualtrics software (a cloud-based platform for creating and distributing web-based surveys) and a university-encrypted study mobile phone for surveys and communications. Interested YLWH completed the screening survey online (using Qualtrics) or by phone. We verified age of participants with a Qualtrics-uploaded or text-messaged photo identification card showing name and date of birth. We verified HIV status with a photo of antiretroviral medication bottle or laboratory report or healthcare provider letter showing the participant's name and HIV status or HIV viral load. Based on preference, eligible participants were texted or emailed consent information and a unique link to complete the online study survey. Upon completion of the survey, participants were given the option to receive $40 via a cash transfer mobile app or an e-gift card.

Measures

Demographics

Demographic variables included participant age, sex

assigned at birth and current gender identity, race and ethnicity, sexual orientation, and state of residence. Socio-economic status items included educational attainment, employment status, and perceived financial situation (I have enough money to live comfortably; I can barely get by on the money I have; I cannot get by on the money I have).

MTVS

MTVS was developed to evaluate access to mobile technology to meet personal needs among 18–29-year-old living with HIV (18). The MTVS is analogous to the food insecurity scale (22); however, instead of food insecurity, it examines how vulnerable an individual feels with regard to their personal access to mobile technology in the past 6 months. Seventeen questions are asked on a response scale of 0= "No", 1= "Yes" and summed and divided by 17 to yield a mean technology vulnerability score with higher scores indicating higher levels of technology vulnerability (α =0.84) (18). Items are listed in the Results section. The MTVS was developed by investigators at the UCSF Division of Prevention Science and refined via cognitive interviews with members of the Division's Youth Advisory Panel in San Francisco, CA.

ART adherence

Self-reported ART adherence over the previous 30 days was measured using three items: "In the last 30 days, on how many days did you miss at least one dose of any of your HIV medications?" (0–30; which was reversed to calculate the number of days that the respondent did not miss any doses of HIV medications); "In the last 30 days, how good a job did you do at taking your HIV medications in the way you were supposed to?" (0 = very poor, 5 = excellent); and "In the last 30 days, how often did you take your HIV medications in the way you were supposed to?" (0= rarely to 5= always). Responses were used to calculate a validated ART adherence composite (23) by linearly transforming responses to each question to a score of 0–100, and then averaging across the three to compute a single ART adherence score on a 0–100 scale (zero being the lowest adherence and 100 the highest). In addition, a single item asked participants how many times they missed taking ART for at least four days over the past 3 months (24,25).

Statistical analysis

Participant characteristics were described using univariate analyses [means, standard deviations (SD), frequencies, and percentages]. Based on the scale development (18), we used the mean of the 17 MTVS items to compute a single MTVS per participant. The single MTVS was correlated with each self-reported ART adherence question, the self-reported ART adherence composite, and the single item regarding missing ART four days in-a-row. Due to lack of normal distribution of the MTVS and ART adherence measures, Spearman non-parametric correlations were used throughout. Kruskal Wallis tests were used to test the correlation between MTVS and categorical variables for race/ethnicity and financial status. Race/ethnicity responses were categorized into three mutually exclusive groups based on collected responses: Latinx, Black non-Latinx, and all other race/ethnicity groups that were non-Latinx. Wilcoxon-Mann-Whitney tests were used to test the correlation between MTVS and binary variables for age and gender. Gender responses were categorized as cis-gender men versus all other genders. Age responses were split into age groups of 18–24 and 25–29 years of age [this cut-off was used because that is the age at which YLWH are transferred to adult services (26)]. Participants with missing data specific to any analysis were excluded from that analysis. Analyses were conducted using Stata (version 11).

Results

We surveyed 271 YLWH in the US who were majority cis-gender male (86%), gay (77%), and Black non-Latinx (69%). Most participants were living in the US south (49%) and had a mean age of 26 [standard deviation (SD) =2.8]. *Table 1* details participant characteristics.

Among the participants who responded to the ART adherence questions (N=254), 97% were on a once-daily ART regimen and 88% reported missing fewer than six doses in the past 30 days (equating to ART adherence of ≥80%), 72% rated their ART adherence as excellent to very good, and 78% noted that they always or almost always took their ART in the way that it was prescribed (*Table 2*). This resulted in a mean composite ART adherence score of 84% (SD =18.7). Nearly 42% of participants noted that they had entirely missed ART for at least 4 days in a row on at least one occasion.

A different subset of 254 participants responded to the MTVS questions, although two participants chose to answer "prefer not to answer" to nearly all questions, resulting in an MTVS score being calculated for 252 participants (235 of whom also had an ART adherence score). On a scale of 0 to 1 (0 having no mobile technology vulnerability and 1 having

Table 1 Characteristics of survey participants

Characteristics	N=271
Age	
Mean years (SD)	26 (2.8)
Median years [IQR]	26 [24–28]
Sex assigned at birth, n [%]	
Male	254 [94]
Female	14 [5]
Other, prefer not to answer	3 [1]
Gender (select all that apply), n [%]	
Cis-gender man	233 [86]
Cis-gender woman	15 [6]
Gender non-binary	16 [6]
Transgender woman	11 [4]
Other, transgender man, genderqueer, questioning, prefer not to answer	10 [4]
Sexual orientation (select all that apply), n [%]	
Gay	208 [77]
Bisexual	51 [19]
Straight	16 [6]
Other, lesbian, prefer not to answer	17 [6]
Region of residence, n [%]	
South	134 [49]
West	65 [24]
Midwest	46 [17]
Northeast	26 [10]
Racial identity (select all that apply), n [%]	
Black American non-Latinx	187 [69]
Latinx	48 [18]
White non-Latinx	27 [10]
Asian non-Latinx	9 [3]
Other non-Latinx, American Indian non-Latinx, Native Hawaiian non-Latinx, prefer not to answer	20 [7]
Financial situation, n [%]	
I have enough money to live comfortably	56 [21]
I can barely get by on the money I have	149 [55]
I cannot get by on the money I have	60 [22]
Prefer not to answer	6 [2]
Highest level of education completed, n [%]	
Did not complete high school or GED	16 [6]
Completed high school or GED	95 [35]
Some college, less than a bachelor's degree	102 [38]
Bachelor's degree or higher	58 [21]
Current work situation, n [%]	
Employed	142 [52]
Unemployed or laid off	91 [34]
Disabled or sick leave	17 [6]
Student	13 [5]
Other/Prefer not to answer	8 [3]

GED, General Educational Development; SD, standard deviation; IQR, interquartile range.

Table 2 Adherence to antiretroviral therapy and mobile technology vulnerability score

Adherence questions and mobile technology vulnerability score	N=254
How many time[s] per day do you have to take your HIV meds?, n [%]	
Once a day	246 [97]
Twice a day or more	8 [3]
In the last 30 days, how many days did you miss at least one dose of any of your HIV meds?, n [%]	
0	95 [37]
1–5	130 [51]
6–30	29 [11]
In the last 30 days, how good a job did you do at taking your HIV meds in the way you were supposed to?, n [%]	
Excellent	100 [39]
Very good	83 [33]
Good	31 [12]
Fair	23 [9]
Poor	14 [6]
Very poor	3 [1]

Table 1 (*continued*)

Table 2 (*continued*)

Table 2 (*continued*)

Adherence questions and mobile technology vulnerability score	N=254
In the last 30 days, how often did you take your HIV meds in the way you were supposed to?, n [%]	
Always	124 [49]
Almost always	74 [29]
Usually	32 [13]
Sometimes	18 [7]
Rarely	5 [2]
Never	1 [0.4]
ART adherence score	
Mean [SD]	84 [18.7]
Median [IQR]	87 [77–100]
Minimum score among respondents	0
Maximum score among respondents	100
Over the past 3 months, on how many occasions did you miss taking your HIV meds entirely for at least 4 days in a row?, n [%]	
Never	137 [54]
Once	31 [12]
Twice	22 [9]
Three times	25 [10]
More than three times	29 [11]
Don't know	8 [3]
Prefer not to answer	2 [0.8]
Mobile technology vulnerability score (N=252*)	
Mean [SD]	0.33 [0.26]
Median [IQR]	0.24 [0.12–0.53]
Minimum score among respondents	0
Maximum score among respondents	1

*, excludes two participants that answered "prefer not to answer" to individual MTVS questions. SD, standard deviation; IQR, interquartile range; MTVS, Mobile Technology Vulnerability Scale.

complete mobile technology vulnerability), participants had a mean MTVS of 0.33 (SD =0.26) (*Table 2*). A quarter of participants had MTVS above 0.53 (i.e., the highest quartile of mobile technology vulnerability). Among the 254 participants who responded to the MTVS questions, 14% had received formal assistance to pay for their phone service, 25% had had more than one mobile phone number, 14% had a stolen mobile phone at least once, 22% had lost their mobile phone at least once, and 39% had had their mobile phone service disconnected at least once due to not paying the bill in the past 6 months (*Table 3*). Nearly 41–43% of participants had used free internet services or free public Wi-Fi because they did not have mobile phone service or could not afford to use their data plan. About 28% of participants reported problems (such as missing an appointment, getting lost, being unable to pay a bill, etc.) because they did not pay their mobile phone bill resulting in their mobile phone service being disconnected.

There were statistically significant differences in MTVS based on race/ethnicity and financial status. The mean MTVS among Black non-Latinx participants was 0.37, which was higher than the mean MTVS in Latinx participants (0.25) and mean MTVS in other race/ethnicity groups (0.27) (P=0.002, chi-squared =12.491 with 2 degrees of freedom). MTVS was significantly higher for respondents with lower financial status; mean MTVS among those who could not get by was 0.46, mean MTVS among those who could barely get by was 0.35, compared to the mean MTVS in those who had enough money at 0.16 (P=0.0001, chi-squared =45.148 with 2 degrees of freedom). There were no statistically significant differences in MTVS based on age groups (P=0.725, z-score =0.352) or gender (P=0.643, z-score =0.464). While MTVS was not associated with the ART adherence score (Spearman's rho =–0.0930; P=0.155), it was significantly associated with the number of days the individual missed at least one dose in the past 30 days (Spearman's rho =0.1831, P=0.005) and the measure for 4-day ART miss (Spearman's rho =0.149; P=0.033).

Discussion

This demographically diverse group of YLWH from the US experienced a fair amount of technology vulnerability and, over a period of 6 months, reported numerous changes in phone numbers, stolen or lost mobile phones, and disconnections of phone service due to not paying phone bills. This vulnerability had resulted in challenges such as missing appointments and being unable to pay other bills in nearly one-third of participants. Use of free internet services or free public Wi-Fi due to not having mobile phone service or being able to afford a data plan was common. Black participants and those more financially constrained had the highest levels of mobile technology

Table 3 Responses to mobile technology vulnerability survey (18) items (N=254)

Mobile technology vulnerability survey items	Yes (%)	No (%)	Prefer not to answer (%)
In the last 6 months, I was the only person who used this phone (not including lending to someone to make a brief phone call or to look something up on the internet)	88	12	0.4
At any time in the last 6 months, I received formal assistance to pay for my cell phone service (such as Lifeline Assistance Program/Obama Phone)	14	85	0.8
At any time in the last 6 months, I had more than one cell phone number	25	74	1
At any time in the last 6 months, my cell phone was stolen at least once	14	85	0.8
At any time in the last 6 months, I lost my cell phone at least once	22	76	1
At any time in the last 6 months, my cell phone service was disconnected (cut off) at least once because I didn't pay the bill	39	60	0.8
At any time in the last 6 months, I did not pay other bills (example: utilities, rent, etc.) so I could pay my cell phone bill	35	63	2
At any time in the last 6 months, I did not buy necessary items (example: food, clothes, meds, etc.) so I could pay my cell phone bill	35	64	2
At any time in the last 6 months, I did not pay my cell phone bill because I had to pay for other necessities or other bills	43	56	1
At any time in the last 6 months, I had to limit using my cell phone's data plan for any purpose (such as making calls, sending text messages, or using the internet) so that I could keep my cell phone bill low	24	75	1
At any time in the last 6 months, I used free internet services (such as Google Voice, WhatsApp, or Facebook Messenger's phone option) to make phone calls because I did not have cell phone service	41	57	2
At any time in the last 6 months, I checked email, sent text message, checked social media, searched the internet, or made a call on my cell phone using free public Wi-Fi because I could not afford to use my data plan	43	56	1
At any time in the last 6 months, I had to use a less reliable (example: Boost, Cricket, etc.) cell phone service because it was cheaper than other more reliable services	26	72	2
At any time in the last 6 months, I did not make an important phone call because I was frustrated with my phone's service	23	75	2
At any time in the last 6 months, I did not search for important information that I needed because I was frustrated with my phone's internet connection	26	72	2
Over the last 6 months, I had personal problems (such as missed an appointment, got lost, was unable to pay a bill, etc.) because my cell phone battery died	30	69	2
Over the last 6 months, I had problems (such as missed an appointment, got lost, was unable to pay a bill, etc.) because I didn't pay my cell phone bill and my cell phone service was cut	28	71	1

vulnerability. There was an association between MTVS and missed ART doses, in that the higher the vulnerability, the greater the number of days respondents missed at least one ART dose. Additionally, the higher the vulnerability, the more frequently respondents were non-persistent to their ART (i.e., missed taking ART at least 4 days in a row).

Given the presence of over 50,000 YLWH in the US (27) and sub-optimal HIV outcomes among YLWH (3-5), development and evaluation of interventions to achieve and maintain virologic suppression is a clinical and public health priority. Prior research has shown that ART adherence-promoting interventions that have led to a 10% increase in virologic suppression among YLWH have reduced onward transmission of HIV by 15% and

death by 12% over 12 months (8). Additionally, adherence-promoting interventions would be considered cost-effective even at a cost of $2,000 per month per person or efficacy as low as 1% increase in virologic suppression (8). Given that interventions using mobile technologies are increasingly examined as cost-effective mechanisms to improve HIV care outcomes (11,12), our findings suggest the need to measure mobile technology vulnerability as means to identify potential pitfalls, such as disconnection to phone services and being lost to follow-up.

Similar to the ability to use social services and healthcare information, access and skill to use mobile technology are considered to be foundational social determinants of health (28). The SARS-CoV-2 pandemic exposed many barriers to mobile technology access and use by underserved populations, such as low uptake of telehealth visits by underserved populations (29). Therefore, improving access to digital health technologies and improving connectivity of these technologies by expanding and streamlining federal programs for mobile phone and data access and increasing training and support for underserved populations to use mobile health tools are critical to achieving digital health equity.

While our study examined a novel scale on mobile technology vulnerability and its association with ART adherence measures, we need to acknowledge several limitations. This was a cross-sectional study with self-reported data; therefore, it is subject to recall and social desirability biases and we cannot establish cause and effect. However, self-reported ART adherence is generally overestimated (30,31), which would be expected to weaken its correlation with MTVS; therefore, there may be an even stronger correlation with the use of more objective measures of ART adherence (e.g., pharmacologic measures, medication event monitoring caps). The majority of study participants were cis-gender, gay, Black, and male YLWH, all of whom had access to mobile technologies to complete the survey and were able to complete the survey in English; therefore, findings may not be generalizable to individuals with other characteristics (e.g., those with limited access to mobile technologies or those who do not speak English). Finally, given the timeframe of our study, we were unable to disentangle the impact of the SARS-CoV-2 pandemic and the additional reliance on mobile technologies. Longitudinal studies using objective measures of ART adherence or viral load and in those with other characteristics and considering other potentially confounding sociodemographic factors can help overcome some of these limitations.

Conclusions

In a sample of demographically diverse YLWH across the US, we were able to describe variability in access to mobile phones and the association between a novel measure of mobile technology vulnerability and ART adherence. The MTVS may be a useful tool to identify populations who are experiencing vulnerabilities in their mobile technology access which may be associated with subsequent worse health outcomes. Given the ubiquity of mobile technology among young adults and health disparities experienced by YLWH, assessment of mobile technology vulnerability may be a useful and indirect, yet cost-effective and convenient, method of evaluating an individual's health outcomes and referring them for additional support.

Acknowledgments

We thank all of our participants, the UCSF Youth Advisory Panel (YAP) members who guided the research, and the Youth4Cure Scientific Advisory Board who provided consultations. Special thanks to Harrison Glazer for his guidance on advertising.

Funding: Research reported in this publication was supported by the National Institutes of Mental Health award number R21MH122280 (Saberi and Dubé). The National Institutes of Health had no role in this study besides financial support.

Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://mhealth.amegroups.com/article/view/10.21037/mhealth-21-54/rc

Data Sharing Statement: Available at https://mhealth.amegroups.com/article/view/10.21037/mhealth-21-54/dss

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://mhealth.amegroups.com/article/view/10.21037/mhealth-21-54/coif). PS, KD report research funding from the National Institute of Mental Health: R21MH122280. KD also reports honoraria for guest editing an edition of Current Opinion in HIV/AIDS Special Issue in Behavioral and Social Sciences (March - 2022 - digital health interventions included). The other authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the University of California, San Francisco Institutional Review Board (No. 20-29992) and electronic informed consent was taken from all the patients.

References

1. Zanoni BC, Mayer KH. The adolescent and young adult HIV cascade of care in the United States: exaggerated health disparities. AIDS Patient Care STDS 2014;28:128-35.
2. Lally MA, van den Berg JJ, Westfall AO, et al. HIV Continuum of Care for Youth in the United States. J Acquir Immune Defic Syndr 2018;77:110-7.
3. Ryscavage P, Anderson EJ, Sutton SH, et al. Clinical outcomes of adolescents and young adults in adult HIV care. J Acquir Immune Defic Syndr 2011;58:193-7.
4. Kapogiannis BG, Koenig LJ, Xu J, et al. The HIV Continuum of Care for Adolescents and Young Adults Attending 13 Urban US HIV Care Centers of the NICHD-ATN-CDC-HRSA SMILE Collaborative. J Acquir Immune Defic Syndr 2020;84:92-100.
5. Agwu AL, Bethel J, Hightow-Weidman LB, et al. Substantial multiclass transmitted drug resistance and drug-relevant polymorphisms among treatment-naïve behaviorally HIV-infected youth. AIDS Patient Care STDS 2012;26:193-6.
6. Crepaz N, Tang T, Marks G, et al. Durable Viral Suppression and Transmission Risk Potential Among Persons With Diagnosed HIV Infection: United States, 2012-2013. Clin Infect Dis 2016;63:976-83.
7. Bekker LG, Johnson L, Wallace M, et al. Building our youth for the future. J Int AIDS Soc 2015;18:20027.
8. Neilan AM, Bangs AC, Hudgens M, et al. Modeling Adherence Interventions Among Youth with HIV in the United States: Clinical and Economic Projections. AIDS Behav 2021;25:2973-84.
9. Pew Research Center. Mobile Fact Sheet 2021 [11/2/2021]. Available online: https://www.pewresearch.org/internet/fact-sheet/mobile/
10. Rideout V, Fox S. Digital Health Practices, Social Media Use, and Mental Well-Being Among Teens and Young Adults in the U.S.: Hopelab and Well Being Trust; 2018 [12/8/20]. Available online: https://assets.hopelab.org/wp-content/uploads/2020/08/a-national-survey-by-hopelab-and-well-being-trust-2018.pdf
11. Navarra AD, Gwadz MV, Whittemore R, et al. Health Technology-Enabled Interventions for Adherence Support and Retention in Care Among US HIV-Infected Adolescents and Young Adults: An Integrative Review. AIDS Behav 2017;21:3154-71.
12. Cheng LJ, Kumar PA, Wong SN, et al. Technology-Delivered Psychotherapeutic Interventions in Improving Depressive Symptoms Among People with HIV/AIDS: A Systematic Review and Meta-analysis of Randomised Controlled Trials. AIDS Behav 2020;24:1663-75.
13. Amico KR. Evidence for Technology Interventions to Promote ART Adherence in Adult Populations: a Review of the Literature 2012-2015. Curr HIV/AIDS Rep 2015;12:441-50.
14. Zulman DM, Verghese A. Virtual Care, Telemedicine Visits, and Real Connection in the Era of COVID-19: Unforeseen Opportunity in the Face of Adversity. JAMA 2021;325:437-8.
15. El-Nahal WG, Shen NM, Keruly JC, et al. Telemedicine and visit completion among people with HIV during the coronavirus disease 2019 pandemic compared with prepandemic. AIDS 2022;36:355-62.
16. Koay WLA, Prabhakar S, Neilan A, et al. Brief Report: Supporting Access to HIV Care for Children and Youth During the COVID-19 Pandemic With Telemedicine and Rideshare. J Acquir Immune Defic Syndr 2021;88:384-8.
17. Zhou X, Snoswell CL, Harding LE, et al. The Role of Telehealth in Reducing the Mental Health Burden from COVID-19. Telemed J E Health 2020;26:377-9.
18. Lisha NE, Neilands TB, Erguera XA, et al. Development of the Mobile Technology Vulnerability Scale among Youth and Young Adults Living with HIV. Int J Environ Res Public Health 2021;18:4170.
19. Laurenzi CA, du Toit S, Ameyan W, et al. Psychosocial interventions for improving engagement in care and health

and behavioural outcomes for adolescents and young people living with HIV: a systematic review and meta-analysis. J Int AIDS Soc 2021;24:e25741.
20. Hightow-Weidman L, Muessig K, Claude K, et al. Maximizing Digital Interventions for Youth in the Midst of Covid-19: Lessons from the Adolescent Trials Network for HIV Interventions. AIDS Behav 2020;24:2239-43.
21. Saberi P. Research in the Time of Coronavirus: Continuing Ongoing Studies in the Midst of the COVID-19 Pandemic. AIDS Behav 2020;24:2232-5.
22. Reeder C, Neilands TB, Palar K, et al. Food Insecurity and Unmet Needs Among Youth and Young Adults Living With HIV in the San Francisco Bay Area. J Adolesc Health 2019;65:262-6.
23. Wilson IB, Lee Y, Michaud J, et al. Validation of a New Three-Item Self-Report Measure for Medication Adherence. AIDS Behav 2016;20:2700-8.
24. Parienti JJ, Paterson DL. Number of missed doses: why 1 × 7 does not make 7 × 1? AIDS 2012;26:1437-40.
25. Sauceda JA, Johnson MO, Saberi P. Nonadherence as 4-day Antiretroviral Therapy Interruptions: Do Depression and Race/Ethnicity Matter as Much in the Modern Antiretroviral Therapy Era? AIDS Behav 2016;20:2624-8.
26. Hussen SA, Chahroudi A, Boylan A, et al. Transition of youth living with HIV from pediatric to adult-oriented healthcare: a review of the literature. Future Virol 2015;9:921-9.
27. Centers for Disease Control and Prevention. HIV and Youth 2020 [11/2/21]. Available online: https://www.cdc.gov/hiv/group/age/youth/index.html
28. Sieck CJ, Sheon A, Ancker JS, et al. Digital inclusion as a social determinant of health. NPJ Digit Med 2021;4:52.
29. Uscher-Pines L, Sousa J, Jones M, et al. Telehealth Use Among Safety-Net Organizations in California During the COVID-19 Pandemic. JAMA 2021;325:1106-7.
30. Arnsten JH, Demas PA, Farzadegan H, et al. Antiretroviral therapy adherence and viral suppression in HIV-infected drug users: comparison of self-report and electronic monitoring. Clin Infect Dis 2001;33:1417-23.
31. Liu H, Golin CE, Miller LG, et al. A comparison study of multiple measures of adherence to HIV protease inhibitors. Ann Intern Med 2001;134:968-77.

doi: 10.21037/mhealth-21-54
Cite this article as: Saberi P, Eskaf S, Campbell CK, Neilands TB, Sauceda JA, Dubé K. Exploration of a Mobile Technology Vulnerability Scale's association with antiretroviral adherence among young adults living with HIV in the United States. mHealth 2022;8:23.