Title
Mobile Technology Use Among Persons who Inject Drugs in San Diego, California and Tijuana, Baja California, Mexico

Author
Collins, Kelly M.

Publication Date
2015

Peer reviewed|Thesis/dissertation

UNIVERSITY OF CALIFORNIA, SAN DIEGO
SAN DIEGO STATE UNIVERSITY

Mobile Technology Use Among Persons who Inject Drugs in San Diego, California and Tijuana, Baja California, Mexico

A dissertation submitted in partial satisfaction of the requirements for the degree Doctor of Philosophy

in

Public Health (Global Health)

by

Kelly M. Collins

Committee in Charge:

University of California, San Diego

Professor Richard S. Garfein, Chair
Professor Camille Nebeker
Professor Kevin Patrick

San Diego State University

Professor Hector Lemus
Professor Tom Novotny

2015

The Dissertation of Kelly M. Collins is approved, and it is acceptable in quality and form for publication on microfilm and electronically:

Chair

University of California, San Diego

San Diego State University

2015

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGEMENTS

This dissertation research was supported by NIDA T-32 Training Grant 2T32-DA023356. I would like to thank the study participants for their valuable contribution to this research. I would also like to extend a special thank you to my dissertation chair and primary mentor Dr. Richard Garfein. Dr. Garfein has been a constant source of support, guidance and encouragement since I began this journey; I would not be where I am today without his mentorship. I am also grateful for Dr. Steffanie Strathdee and study staff at both STAHR-II (U.S. National Institute on Drug Abuse [NIDA] Grant R01-DA03107401A1) and *Proyecto El Cuete* (U.S. National Institute on Drug Abuse [NIDA] Grant R37-DA019829), especially Jazmine Cuevas-Mota, and Fatima Munoz who provided invaluable logistical support to help me get this research study off the ground. Thanks to my Joint Doctoral Program in Global Health cohort (Jaime Arredondo, Lillian Perez, Meredith Meacham and Priya Bhat) for their constant solidarity and support. A special thank you to Anindita Dasgupta, Erin Conners and Richard Armenta for being true friends and colleagues through this process by providing incredible feedback and a safe place to vent dissertation worries and frustrations. Finally, I would like to thank my amazing husband, Aaron Collins and my son Ryder for their loving support and for helping me to remember what is important.

Chapter 2, in full, is a reprint of the material submitted to the Journal of Mobile Technology in Medicine: Collins KM, Abramovitz D, Meacham M, Gonzalez-Zuniga P, Patrick K, Garfein RS. “Mobile phone use among persons who inject drugs in Tijuana, BC, Mexico.”

Chapter 3, in full, is a reprint of the material being prepared for submission to the Journal of Drug and Alcohol Dependence: Collins KM, Armenta R, Cuevas-Mota J, Liu L, Strathdee SA, Garfein RS. “Factors associated with latent classes of mobile technologu use among persons who inject drugs in San Diego, CA.”

Chapter 4, in full, is a reprint of the material being prepared for submission to the Journal of Substance Use and Misuse: Collins KM, Armenta R, Cuevas-Mota J, Liu L, Strathdee SA, Garfein RS. “Longitudinal Correlates of smartphone ownership among persons who inject drugs in San Diego, CA.”

VITA AND PUBLICATIONS

VITA

2015 Doctor of Philosophy in Public Health (Global Health)
University of California San Diego, and San Diego State University. (San Diego, CA)

2011 Graduate Certificate in Multilateral Governance and International Affairs
Graduate Institute of International and Development Studies. (Geneva, Switzerland)

2010 Master of Public Health in Epidemiology
Concentration: Global Emergency Preparedness and Response
San Diego State University. (San Diego, CA)

2005 Bachelors of Science in Biology
Gonzaga University. (Spokane, WA)

PUBLICATIONS

1. Garfein R, Collins K, Munoz F, Moser K, Cerecer-Callu P, Sullivan M, Chockalingam G, Rios P, Zuniga ML, Burgos JL, Rodwell T, Rangel MG, Patrick K. "Tuberculosis Treatment Adherence Monitoring by Video Directly Observed Therapy—VDOT: A Binational Pilot Study" *International Journal of Tuberculosis and Lung Disease. (Accepted for Publication April 2015)*

2. Janssen WJ, McPhillips KA, Dickinson MG, Linderman DJ, Morimoto K, Xiao YQ, Oldham KM, Vandivier RW, Henson PM, Gardai SJ. "Surfactant proteins A and D suppress alveolar macrophage phagocytosis via interaction with SIRP alpha." *American Journal of Respiratory Critical Care Medicine.* 2008 Jul 15; 178(2): 158-167

PUBLISHED ABSTRACTS

3. Collins K, Munoz F, Moser K, Cerecer-Callu P, Raab F, Flick A, Rios P, Zuniga ML, Cuevas-Mota J, Burgos JL, Rodwell T, Rangel MG, Patrick K Garfein RG. "Experience with Mobile Tecnology among patients with tuberculosis in San Diego, California and Tijuana, Mexico." *Journal of Mobile Technology in Medicine.* 2013 Dec; 2(4S):13.

4. Garfein R, Collins K, Munoz F, Moser K, Cerecer-Callu P, Sullivan M, Chockalingam G, Rios P, Zuniga ML, Burgos JL, Rodwell T, Rangel MG, Patrick K. "High Tuberculosis Treatment Adherence Obtained Using Mobile Phones for Video Directly Observed Therapy: Results of a Binational Pilot Study" *Journal of Mobile Technology in Medicine. 2012* Dec; 1(4S):30.

PUBLICTIONS UNDER REVIEW

5. Zúñiga ML, Collins K, Muñoz F, Moser K, Rangel G, Cuevas-Mota J, Clark M, Burgos JL, Garfein RS. New Frontiers in TB Medication Adherence: Engaging patients and clinical staff in a video cell phone directly-observed therapy trial in the U.S.-Mexico border region. *Journal of Urban Health (submitted April 2015)*

6. Collins KM, Abramovitz D, Meacham M, Gonzalez-Zuniga P, Patrick K, Garfein R. "Cell Phone Use among Persons who Inject Drugs in Tijuana, BC, Mexico." *Journal of Mobile Technology in Medicine. Under Review (submitted December 2014)*

PUBLICAITONS IN PREPARATION

7. Armenta RF, Collins KM, Strathdee SA, Bulterys M, Cuevas-Mota J, Garfein R, "Prevalence and Correlates of Latent Tuberculosis Infection among Persons who Inject Drugs in San Diego, California" *Substance Use and Misuse. (in preparation)*

PRESENTATIONS

Peer-Reviewed Abstracts and Presentations at Scholarly Meetings
denotes oral presentation

1. *Garfein RS, Collins K, Cuevas-Mota K, Munoz F, Moser K, Chuck C, Higashi J, Flick A, Rios P, Raab F, Burgos JL, Patrick K. Three City Demonstration of Smart-Phone based Directly Observed Therapy for Tuberculosis Patients. Poster presentation at the Wireless Health Conference, Bethesda, MD, October 29-31, 2014.

2. Collins K, Munoz F, Moser K, Cerecer-Callu P, Sullivan M, Raab F, Flick A, Rios P, Zuñiga ML, Cuevas-Mota J, Burgos JL, Rodwell T, Rangel MG, Patrick K, Garfein RS. Experience with mobile technology among patients with tuberculosis in San Diego, CA and Tijuana, Mexico. Poster presentation at the mHealth Summit, Washington, DC, December 8-11, 2013.

3. Garfein RS, Collins K, Munoz F, Moser K, Cerecer-Callu P, Sullivan M, Raab F, Flick A, Rios P, Zuñiga ML, Burgos JL, Rodwell T, Rangel MG, Patrick K,. Use of Mobile Phones for Video Directly Observed Therapy among Tuberculosis Patients in High and Low Income Countries. Poster presentation at the Wireless Health Conference, Baltimore, WA, November 1-3, 2013.

4. *Garfein R, Collins K, Munoz F, Moser K, Cerecer-Callu P, Sullivan M, Chockalingam G, Rios P, Zuniga ML, Burgos JL, Rodwell T, Rangel MG, Patrick K. High Tuberculosis Treatment Adherence Obtained Using Mobile Phones for Video Directly Observed Therapy: Results of a Binational Pilot

Study. Presented at the 2012 Annual mHealth Summit. Washington D.C. December 3-5th 2012.

5. *Munoz F, Collins K, Moser K, Cerecer-Callu P, Sullivan M, Chockalingham G, Rios P Zúñiga ML, Burgos JL, Rodwell T, Rangel M, Patrick K, Garfein RS. Video-Directly Observed Therapy: A promising solution for monitoring TB and HIV treatment adherence for binational patients in the U.S.-Mexico border region. Presented at the 6th Annual CFAR (Center for AIDS Research) International HIV/AIDS Research Day. University of California San Diego, September 18, 2012.

6. Garfein RS, Collins K, Moser K, Cerecer-Callu P, Zúñiga ML, Muñoz F, Cuevas-Mota J, Burgos JL, Rodwell TC, Patrick K. "Binational Pilot Study of Directly Observed Therapy for Tuberculosis Treatment: A Potential Model for Monitoring HIV Treatment Adherence" Presented at the 7th International Conference on HIV Treatment and Prevention Adherence. Miami, FL. June 3-5, 2012

7. Garfein RS, Collins K, Moser K, Cerecer-Callu P, Zúñiga ML, Muñoz F, Cuevas-Mota J, Sullivan M, Chockalingam G, Rios P, Burgos JL, Rodwell TC, Patrick K. "Remote Directly Observed Therapy for Tuberculosis Using Mobile Phones – Results of a Binational Pilot Study." Presented at the 2012 American Thoracic Society Meeting. San Francisco, CA. May 20th 2012.

8. *Garfein RS, Patrick K, Moser K, Zuniga ML, Burgos JL, Cuevas-Mota J, Rodwell TC, Collins K, Raab F, Chockalingam G, Rangel G. "Mobile Phone-Based Video Directly Observed Therapy for Tuberculosis." Presented at the 2011 Annual mHealth Summit. Washington D.C. December 5-7th 2011.

9. Garfein RS, Patrick K, Moser K, Zuniga ML, Burgos JL, Cuevas-Mota J, Rodwell TC, Collins K, Raab F, Chockalingam G, Rangel G. "Mobile Phone-Based Video Directly Observed Therapy for Tuberculosis." Presented at the 2010 Annual mHealth Summit. Washington D.C. November 8-10th 2010.

10. *Collins KM, Novotny T, Condgon M, Igoe E. "Assessing Barriers to Health Care among Iraqi Refugees, San Diego County, CA, 2010." Presented at the Collaborating for Healthy Communication Conference, Hosted by the San Diego Refugee Forum. April 9th 2010.

11. Pauw P, Oldham KM, Wheeler B. "Ouabain Turnover in Madin-Darby Canine Kidney (MDCK) Cells." Presented at the Annual Murdock Charitable Trust Foundation Research Conference. Portland, OR October 2004

ABSTRACT OF THE DISSERTATION

Mobile Technology Use Among Persons who Inject Drugs in San Diego, California and Tijuana, Baja California, Mexico

by

Kelly M. Collins

Doctor of Philosophy in Public Health (Global Health)

University of California, San Diego, 2015

San Diego State University, 2015

Professor Richard S. Garfein, Chair

Mobile applications hold promise for improving healthy behaviors and increasing engagement in health care among persons who inject drugs (PWID). However, concerns about the availability and use of mobile technology among this population may inhibit innovation in this area. Feasibility and acceptability of using mobile technology must be assessed with this population. The goal of this dissertation is to identify the individual, social and contextual factors that influence mobile technology use among PWID, to inform the development of future mHealth research and intervention activities. This research addresses the following specific aims: Aim 1: To determine the prevalence and identify correlates of cell phone ownership among PWID living in Tijuana, BC, Mexico. Aim 2: To determine classes of mobile technology use behavior among PWID living in San Diego, CA and identify correlates associated with these classes. Aim 3: To determine the longitudinal correlates of smartphone ownership among PWID in San Diego, CA. To meet these aims, this dissertation used data from “The Study of Tuberculosis, AIDS and Hepatitis C Risk.” (STAHR II, PI: Garfein; R01DA03107401A1) in San Diego, and the “Proyecto El Cuete” study (PI: Strathdee; R37DA019829) in Tijuana. This research fills a gap in the existing knowledge about mobile technology use among PWID and may be used to inform the future development and implementation of mHealth research and interventions among this population.

CHAPTER 1: INTRODUCTION

OVERVIEW

Mobile Health (mHealth) applications, or the use of mobile and wireless devices to improve health outcomes, health care services and health research[1] are rapidly expanding in public health. Evidence has shown that mHealth tools have great potential for promoting positive behaviors such as controlling diabetes,[2,3] increasing exercise[2], supporting weight loss[4], and improving medication adherence.[5,6] Technology based interventions have also been shown to aid in decreasing negative behaviors such as smoking[7,8] and engaging in unprotected sex,[9] suggesting that mHealth tools could be used to decrease risk behaviors among people who inject drugs (PWID). Infectious disease transmission and overdose are common consequences of substance abuse.[10] PWID are also at high risk for hepatitis C virus (HCV) and human immunodeficiency virus (HIV) infection.[10-20] Preliminary analysis from an ongoing cohort study among PWID in San Diego, found the prevalence of HCV and HIV to be 65% and 9.6%, respectively. While behavioral interventions have helped to reduce risk in this population.[21-23] risky behaviors persist. For example, a 2010 cross-sectional study of 510 young adult PWID in San Diego, reported that 49% of participants receptively shared needles and that 68% shared injection paraphernalia.[24]

In addition to engaging in risky behaviors, PWID have also been shown to be at high risk for loss to follow up for disease treatment,[25,26] and have inadequate access to health care services.[27] Mobile technology may provide new intervention tools for reducing risk and increasing use of health services among PWID. Prior to the development and evaluation of mHealth-based research studies among PWID, studies that access their feasibility and acceptability are needed with this population. Thus, the purpose of this dissertation is to identify the prevalence and correlates of cell phone ownership, smartphone ownership, and mobile technology use among PWID in Tijuana (Chapter 2) and San Diego (Chapters 3 & 4). With a specific focus on understanding the structural and behavioral factors surrounding the use of mobile technology among PWID in San Diego and Tijuana, this dissertation will help researchers develop evidence-based, novel research studies that work to prevent the spread of disease, improve linkages to care, and increase adherence to treatment.

BACKGROUND

People who inject drugs (PWID) are at increased risk for Hepatitis C (HCV), Human Immunodeficiency Virus (HIV), and *Mycobacterium tuberculosis* (Mtb) infection.[10-20,28] Between 1.3%-1.9% of the U.S. population are infected with HCV,[29] with much higher prevalence among PWID. Preliminary analysis from STAHR II suggests an HCV prevalence of 65%, HIV prevalence of 9.6%, and latent TB infection (LTBI) prevalence of 24% among PWID in San Diego. Similar to other chronic conditions that rely on high adherence to prescribed treatment regimens or behavioral modifications, the foundations for treating HIV, HCV and LTBI require an “improved capacity for disease self-management” by patients.[30] Substance abusers, and more specifically PWID, are often hard to reach and difficult to keep connected with care.[27] mHeatlh tools have the potential to transform current approaches to disease management for PWID. Mobile technologies offer real-time patient engagement and monitoring and can help researchers to build customized motivational, educational and disease management support for marginalized and “hidden” populations[29] such as PWID. While promising, these approaches are still in the early stages of development; formative data, such as provided by this study, are needed to successfully inform future mHealth-based research and interventions among PWID.

Mobile Technology Use among Non-Injection Substance Users

Data regarding mobile technology use among substance using and other high-risk individuals suggest that these populations have access to mobile technology, though at a lower rate than the general US adult population.[31-33] For example, McClure et al. reported that 91% of substance users enrolled in drug treatment in Baltimore had access to a cell phone and 79% to text messaging.[31] Rice et al. (2011) found that among a study of homeless youth in Los Angeles (of which 55% used a substance in the past 30 days), 62% owned a cell phone, though they did not specify whether it was a feature or smartphone.[32] Milward et al. (2015) found that 83% of substance users enrolled in drug treatment in the United Kingdom owned a cell phone, and 57% of those had a smartphone.[33] Horvath et al. (2013) reported that among stimulant using (e.g., methamphetamine, amphetamine, cocaine, etc.) men who have sex with men (MSM), 46% had a mobile phone, 48% had a smart phone, and 87% used a social networking site regularly.[34] Lastly, Chander and colleagues (2012) reported that among current smokers living with HIV, 73% of respondents owned and used a cell phone, 39% reported text messaging, 48% used the internet, and 31% accessed email.[35] In contrast, the Pew Research Center Global Attitudes Project reported that over 91% of American adults owned a cell phone in 2014, and 58% owned a smartphone.[36] The low socio-economic status of many substance-using populations likely contributes to the lower percentage of cell phone and smartphone ownership.

mHealth Interventions among Non-Injection Substance Users

mHealth tools have been used in research studies with high-risk individual (e.g., substance users, female sex-workers, HIV positive individuals) including treatment recovery relapse,[37-39] reduction of sexual risk behaviors and STI incidence among adult men and women,[9,40] and supporting HIV anti-retroviral therapy (ART) adherence among non-injection substance abusers living with HIV.[6,41] Findings from these studies demonstrate that mHealth tools are feasible and acceptable for use among high-risk participants, though evidence of efficacy in controlled trials is pending. For example, Moore et al. reported preliminary evidence of feasibility and acceptability of an SMS intervention to gather data on methamphetamine use and to provide adherence reminders among persons living with HIV infection and recent methamphetamine use.[6] Additionally, Ingersoll et al. developed a personalized, bidirectional text messaging assessment to promote Anti-Retroviral Therapy (ART) adherence and abstinence from substance use among non-adherent substance users in Virginia; preliminary results from this randomized controlled trial (RCT) also demonstrated feasibility and acceptability among study participants.[41] Data on efficacy for both trials are not yet available.

Remote Ecological Momentary Assessment (EMA) has been used to assess relationships between mood and drug cravings among substance users enrolled in drug treatment and to assess HIV risk behaviors among female sex workers (FSW) in Indiana. For example, Epstein et al. (2009) demonstrated new field-deployable method for assessing mood and behavior as a function of neighborhood surroundings (geographical momentary assessment [GMA]). They collected time-stamped GPS data and EMA ratings of mood, stress, and drug craving of opioid-dependent polydrug users receiving methadone maintenance. The results of this study supported the feasibility of GMA and may have applications for development of individual- or neighborhood-level interventions among substance users.[38] Roth et al. (2013) tested the feasibility and acceptability of cell phone diaries to collect information about sexual events with 26 FSW over 4 weeks.[9] FSWs completed twice daily digital diaries about their mood, drug use, sexual interactions, and daily activities. Approximately 90% of expected diaries were completed by participants and compliance was stable over time. Sexual behavior was captured in 22% of diaries and participant satisfaction with diary data collection was high.[9]

Lastly, Philips et al. (2013) found that a video-based, smartphone-delivered HIV risk-reduction intervention was feasible and acceptable among individuals attending an addictions treatment clinic.[42] They concluded that video-based mobile HIV risk reeducation (mHIVRR) education delivered via smartphone was acceptable, feasible, and may increase HIV/STD risk reduction knowledge. Future RCT studies with pre-intervention assessments of knowledge are needed to confirm these findings.[42]

mHealth studies specific to persons actively injecting drugs (i.e., PWID not seeking drug treatment) are limited. One study suggests that although PWID may find mHealth tools acceptable, privacy and confidentiality are of the utmost concern.[43] This small pilot (n=10) among HIV positive PWID in China utilized the “Wisepill” wifi-enabled pillbox to monitor adherence to ART medications. Results demonstrated that while high mean adherence levels were obtained across participants using the device (>89%), 50% reported worrying that using the device could accidentally disclose their HIV status to onlookers; however, no disclosures were reported.[43]

While these studies demonstrate preliminarily evidence of feasibility, acceptability and efficacy among substance users in general, there is a need for feasibility and acceptability studies among actively injecting PWID (i.e., injectors not seeking drug treatment). Additionally, randomized controlled trials among substance users are also needed to confirm these results and support the use of mHealth strategies to reduce risk and increase HIV risk reduction knowledge among PWID.

Study Setting

This dissertation research was conducted in the California/Baja California border region. The San Diego/ Tijuana border is the busiest land border crossing in the world, with a reported 56 million annual border crossings at the San Ysidro point of entry alone.[44] This includes 62,000 Tijuana residents who cross daily to San Diego for work.[44] The US/Mexico border region is a unique setting to study drug abuse. This region is situated along a major drug trafficking route; illicit drugs such as heroin, cocaine, and methamphetamine are readily available in San Diego and Tijuana, leading to a high prevalence of drug abuse in the region.[45] San Diego has an estimated 21,000 PWID living in the county. [46] According recent data, approximately 20-27% of San Diego based PWID report buying, using, and injecting drugs in Mexico.[45] Due to the high rate of border crossings between Tijuana and San Diego, there is potential for behavioral trends and disease to spread easily across the international border, which has contributed to a high prevalence of drug abuse in the region.[45] This dissertation uses the unique study setting as an asset to describe mobile technology use among a diverse, mobile population of PWID, many of whom cross the international border on a regular basis. This research also offers timely data about trends in mobile technology access and usage across various socio-demographic characteristics among PWID in San Diego and Tijuana.

CONCEPTUAL FRAMEWORK

The theoretical framework for the proposed study is adapted from the Gelberg-Andersen Behavioral Model for Vulnerable Populations to Health Services Utilization.[47-49] This framework theorizes that health service utilization can be predicted by a set of pre-disposing variables (e.g., socio-demographic and individual characteristics), enabling variables (e.g., barriers to care, health insurance, and sources of care), and need factors (e.g., illness).[47,49] In the context of this well-established framework, this study seeks to understand the pathway between individual or pre-disposing variables (i.e., demographic characteristics, drug use behaviors, and risky injection behaviors) and the enabling variable mobile technology use (i.e., cell phone access, mobile technology use, and/or smartphone ownership) (Figure 1). This conceptual framework will be used to describe the relationships between contextual and individual (or pre-disposing) factors that influence access to mobile technology use and determine if mobile technology facilitates use and access of health services in individuals who may not otherwise access these services. If PWID do not perceive disease risk or feel that they have the power to engage in safe practices, they are not likely to take measures to prevent disease transmission.[50-53] Use of mobile technology may heighten perceptions of disease severity, increase health literacy, and allow easier access of health services among PWID.

GLOBAL HEALTH IMPLICATIONS

The proposed study has important implications for informing future mHealth interventions in marginalized substance using populations. With a specific focus on understanding the structural and behavioral factors surrounding the use of mobile technology among PWID in San Diego and Tijuana, this study will help researchers develop evidence-based, novel research studies that work to prevent the spread of disease, improve linkages to care, and increase adherence to treatment. As cell phone use is becoming nearly ubiquitous both in resource-rich and resource-poor settings,[54] this dissertation serves as preliminary research to inform future studies regarding technology use, health outcomes, and actively using PWID.

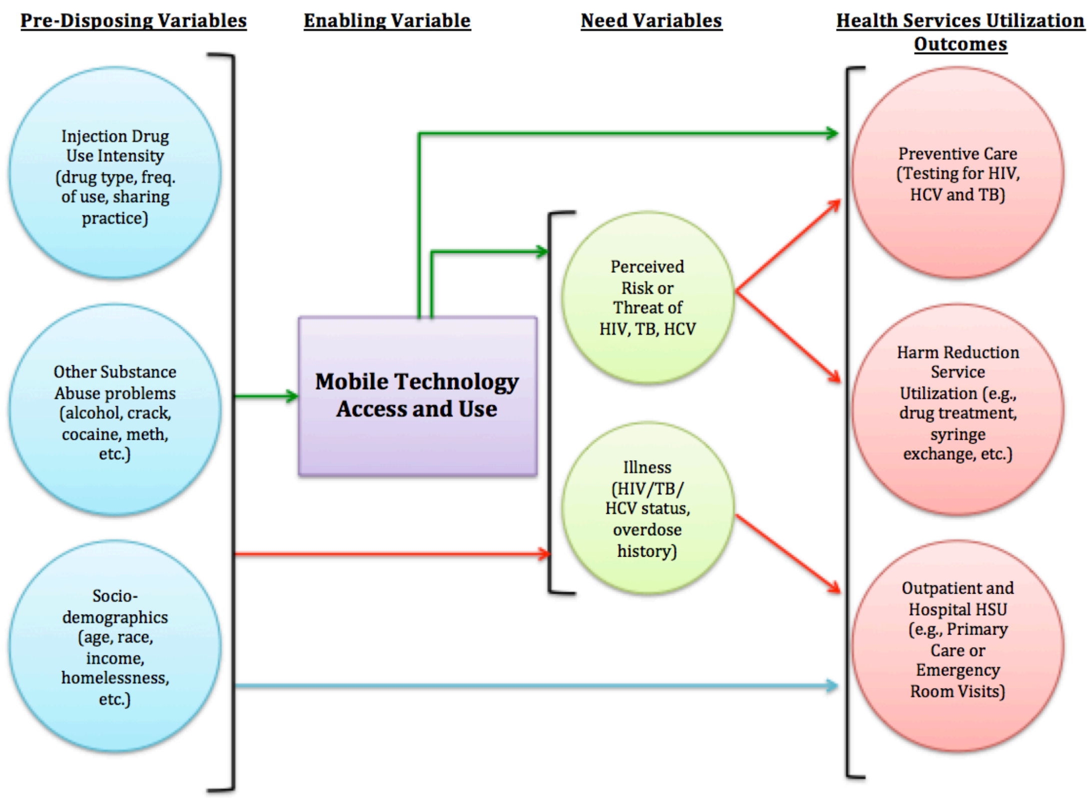

Figure 1.1. Gelberg-Andersen Behavioral Model for Vulnerable Populations to Health Services Utilization41-43 adapted for Mobile Technology Use among PWID.

REFERENCES

1. United States Department of Health and Human Services. 2010 [cited 2014 April 25]. Available from: http://www.hrsa.gov/healthit/mhealth.html.

2. Chomutare T, Fernandez-Luque L, Arsand E, et al. Features of mobile diabetes applications: review of the literature and analysis of current applications compared against evidence-based guidelines. J Med Internet Res. 2011;**13**(3):e65.

3. Ribu L, Holmen H, Torbjornsen A, et al. Low-intensity self-management intervention for persons with type 2 diabetes using a mobile phone-based diabetes diary, with and without health counseling and motivational interviewing: protocol for a randomized controlled trial. JMIR Res Protoc. 2013;**2**(2):e34.

4. Patrick K, Marshall SJ, Davila EP, et al. Design and implementation of a randomized controlled social and mobile weight loss trial for young adults (project SMART). Contemporary Clinical Trials. 2014;**37**(1):10-18.

5. Miller CW, Himelhoch S. Acceptability of Mobile Phone Technology for Medication Adherence Interventions among HIV-Positive Patients at an Urban Clinic. AIDS research and treatment. 2013;**2013**:6.

6. Moore DJ, Montoya JL, Blackstone K, et al. Preliminary Evidence for Feasibility, Use, and Acceptability of Individualized Texting for Adherence Building for Antiretroviral Adherence and Substance Use Assessment among HIV-Infected Methamphetamine Users. AIDS Res Treat. 2013;**2013**:1-11.

7. Johnston W, Lederhausen A, Duncan J. Mobile technology: a synopsis and comment on "mobile phone-based interventions for smoking cessation". Transl Behav Med. 2013;**3**(3):231-232.

8. Whittaker R, Maddison R, McRobbie H, et al. A multimedia mobile phone-based youth smoking cessation intervention: findings from content development and piloting studies. J Med Internet Res. 2008;**10**(5):e49.

9. Roth AM HD, Gunn JKL, Fortenberry JD, Garfein RS, Arno JN, Wiehe SE. Use of cell phone diaries to understand risk contexts of sexual events among female sex workers. *Joint Meeting of the 20th International Society for Sexually Transmitted Diseases Research and 14th International Union Against Sexually Transmitted Infections Meeting* Vienna, Austria2013.

10. Strathdee SA, Hallett TB, Bobrova N, et al. HIV and risk environment for injecting drug users: the past, present, and future. Lancet. 2010;**376**:268-284.

11. Strathdee SA, Lozada R, Pollini RA, et al. Individual, social, and environmental influences associated with HIV infection among injection drug users in Tijuana, Mexico. J Acquir Immune Defic Syndr. 2008;**47**(3):369-376.

12. Hatzakis A, Van Damme P, Alcorn K, et al. The state of hepatitis B and C in the Mediterranean and Balkan countries: report from a summit conference. Journal of viral hepatitis. 2013;**20 Suppl 2**:1-20.

13. Nelson PK, Mathers BM, Cowie B, et al. Global epidemiology of hepatitis B and hepatitis C in people who inject drugs: results of systematic reviews. The Lancet. 2011;**378**(9791):571-583.

14. Hammett TM, Johnston P, Kling R, et al. Correlates of HIV Status Among Injection Drug Users in a Border Region of Southern China and Northern Vietnam. Journal of Acquired Immune Deficiency Syndormes. 2005;**38**(2):7.

15. Mathers BM, Degenhardt L, Phillips B, et al. Global epidemiology of injecting drug use and HIV among people who inject drugs: a systematic review. Lancet. 2008;**372**(9651):11.

16. Needle RH, Coyle S, Cesari H, et al. HIV risk behaviors associated with the injection process: multiperson use of drug injection equipment and paraphernalia in injection drug user networks. Substance Use and Misuse. 1998;**33**(12):2403-2423.

17. Page JB, Shapshak P, Duran EM, et al. Detection of HIV-1 in Injection Paraphernalia: Risk in and Era of Heightened Awareness. AIDS patient care and STDs. 2006;**20**(8):576-585.

18. Thiede H, Hagan H, Campbell JV, et al. Prevalence and correlates of indirect sharing practices among young adult injection drug users in five U.S. cities. Drug and alcohol dependence. 2007;**91 Suppl 1**:S39-47.

19. Wodak A, Cooney A. Do needle syringe programs reduce HIV infection among injecting drug users: a comprehensive review of the international evidence. Substance use & misuse. 2006;**41**(6-7):777-813.

20. Yang C, Tobin K, Latkin C. Perceived serosorting of injection paraphernalia sharing networks among injection drug users in Baltimore, MD. AIDS and behavior. 2011;**15**(1):16-21.

21. Copenhaver MM, Johnson BT, Lee IC, et al. Behavioral HIV risk reduction among people who inject drugs: meta-analytic evidence of efficacy. J Subst Abuse Treat. 2006;**31**(2):163-171.

22. Latka MH, Hagan H, Kapadia F, et al. A randomized intervention trial to reduce the lending of used injection equipment among injection drug users infected with hepatitis C. American journal of public health. 2008;**98**(5):853-861.

23. Strathdee SA, Abramovitz D, Lozada R, et al. Reductions in HIV/STI incidence and sharing of injection equipment among female sex workers who inject drugs: results from a randomized controlled trial. PloS one. 2013;**8**(6):e65812.

24. Garfein RS, Rondinelli A, Barnes RF, et al. HCV infection prevalence lower than expected among 18-40-year-old injection drug users in San Diego, CA. J Urban Health. 2013;**90**(3):516-528.

25. Arnsten JH, Xuan L, Mizuno Y, et al. Factors Associated With Anti retroviral Therapy Adherence and Medication Errors Among HIV-Infected Injection Drug Users. J Acquir Immune Defic Syndr. 2007;**46**(S2):S64-S71.

26. Story A, Murad S, Roberts W, et al. Tuberculosis in London: the importance of homelessness, problem drug use and prison. Thorax. 2007;**62**(8):667-671.

27. Drumm RD, McBride DC, Metsch L, et al. 'The Rock Always Comes First': Drug Users' Accounts About Using Formal Health Care. J Psychoactive Drugs. 2003;**35**(4):461-469.

28. Deiss RG, Rodwell TC, Garfein RS. Tuberculosis and illicit drug use: review and update. Clinical infectious diseases : an official publication of the Infectious Diseases Society of America. 2009;**48**(1):72-82.

29. CDC Division of Viral Hepatitis. Statistics and Surveillance. Disease Burden from Viral Hepatitis A, B, and C in the United States 2007. 2007 [cited 2014 March 19]. Available from: http://www.cdc.gov/hepatitis/HCV/StatisticsHCV.htm.

30. Kirk GD, Himelhoch SS, Westergaard RP, et al. Using Mobile Health Technology to Improve HIV Care for Persons Living with HIV and Substance Abuse. AIDS research and treatment. 2013;**2013**:194613.

31. McClure EA, Acquavita SP, Harding E, et al. Utilization of communication technology by patients enrolled in substance abuse treatment. Drug Alcohol Depend. 2013;**129**(1-2):145-150.

32. Rice E, Lee A, Taitt S. Cell phone use among homeless youth: potential for new health interventions and research. J Urban Health. 2011;**88**(6):1175-1182.

33. Milward J, Day E, Wadsworth E, et al. Mobile phone ownership, usage and readiness to use by patients in drug treatment. Drug and alcohol dependence. 2015;**146**:111-115.

34. Horvath KJ, Carrico AW, Simoni J, et al. Engagement in HIV Medical Care and Technology Use among Stimulant-Using and Nonstimulant-Using Men who have Sex with Men. AIDS research and treatment. 2013;**2013**:121352.

35. Chander G, Stanton C, Hutton HE, et al. Are smokers with HIV using information and communication technology? Implications for behavioral interventions. AIDS Behav. 2012;**16**(2):383-388.

36. Pew Global Attitudes Project. Global Digital Communication: Texting, Social Networking Popular Worldwide. Pew Research Center, 2011.

37. Freedman MJ, Lester KM, McNamara C, et al. Cell phones for ecological momentary assessment with cocaine-addicted homeless patients in treatment. Journal of Substance Abuse Treatment. 2006;**30**(2):105-111.

38. Epstein DH, Willner-Reid J, Vahabzadeh M, et al. Real-Time Electronic Diary Reports of Cue Exposure and Mood in the Hours Before Cocaine and Heroin Craving and Use. Arch Gen Psychiatry. 2009;**66**(1):88-94.

39. Johnson EI, Barrault M, Nadeau L, et al. Feasibility and validity of computerized ambulatory monitoring in drug-dependent women. Drug and Alcohol Dependence. 2009;**99**(1–3):322-326.

40. Hensel DJ, Fortenberry JD, Harezlak J, et al. The feasibility of cell phone based electronic diaries for STI/HIV research. BMC Medical Research Methodology. 2012;**12**(1):75-86.

41. Ingersoll K, Dillingham R, Reynolds G, et al. Development of a personalized bidirectional text messaging tool for HIV adherence assessment and intervention among substance abusers. J Subst Abuse Treat. 2014;**46**(1):66-73.

42. Phillips KA, Epstein DH, Mezghanni M, et al. Smartphone Delivery of Mobile HIV Risk Reduction Education. AIDS research and treatment. 2013;**2013**:231956.

43. Bachman Desilva M, Gifford AL, Keyi X, et al. Feasibility and Acceptability of a Real-Time Adherence Device among HIV-Positive IDU Patients in China. AIDS Res Treat. 2013;**2013**:1-6.

44. SANDAG. San Diego Region - Baja California Ports of Entry Border Crossing Statistics. San Diego, CA2013. Available from: http://www.sandag.org/uploads/publicationid/publicationid_1424_17230.xlsx.

45. Volkmann T, Shin SS, Garfein RS, et al. Border crossing to inject drugs in Mexico among injection drug users in San Diego, California. J Immigr Minor Health. 2012;**14**(2):281-286.

46. Friedman SR, Tempalski B, Cooper H, et al. Estimating numbers of injecting drug users in metropolitan areas for structural analyses of community vulnerability and for assessing relative degrees of service provision for injecting drug users. Journal of urban health : bulletin of the New York Academy of Medicine. 2004;**81**(3):377-400.

47. Stein JA, Andersen R, Gelberg L. Applying the Gelberg-Andersen behavioral model for vulnerable populations to health services utilization in homeless women. Journal of health psychology. 2007;**12**(5):791-804.

48. Stein JA, Andersen RM, Robertson M, et al. Impact of hepatitis B and C infection on health services utilization in homeless adults: a test of the Gelberg-Andersen Behavioral Model for Vulnerable Populations. Health psychology : official journal of the Division of Health Psychology, American Psychological Association. 2012;**31**(1):20-30.

49. Andersen RM. Revisiting the Behavioral Model and Access to Medical Care: Does it Matter? Journal of Health and Social Behavior. 1995;**36**(1):1-10.

50. Adedimeji AA, Omololu FO, O. O. HIV risk perception and constraints to protective behaviour among young slum dwellers in Ibadan, Nigeria. Journal of Health Population and Nutrition. 2007;**25**(2):146-157.

51. Akwara PA, Madise NJ, A. H. Perception of risk of HIV/AIDS and sexual behaviour in Kenya. Journal of Biosocial Science. 2003;**25**(3):385-411.

52. Rhodes T, Singer M, Bourgois P, et al. The social structural production of HIV risk among injecting drug users. Journal of Social Science and Medicine. 2005;**61**(5):1026-1044.

53. Wagner KD, Lankenau SE, Palinkas LA, et al. The perceived consequences of safer injection: An exploration of qualitative findings and gender differences. Phychology, Health and Medicine. 2010;**15**(5):560-573.

54. Pew Global Attitudes Project. Emerging Nations Embrace Internet, Mobile Technology; Cell Phones Nearly Ubiquitous in Many Countries. Pew Research Center, 2014.

CHAPTER 2: CELL PHONE USE AMONG PERSONS WHO INJECT DRUGS IN TIJUANA, BC, MEXICO

ABSTRACT

Background: Persons who inject drugs (PWID) are at high risk for hepatitis C virus (HCV) and human immunodeficiency virus (HIV) infection, particularly in Tijuana, Mexico, where HCV prevalence among PWID is above 95%. PWID also demonstrate low access and use of health services. mHealth tools may prove effective for reducing disease risk and increasing use of health services by PWID. However, knowledge of cell phone penetration within this population is needed before designing such interventions. We aimed to determine the prevalence and correlates of cell phone use among PWID in Tijuana, Baja California, Mexico.

Methods: PWID enrolled in a cohort study were asked for detailed contact information at baseline —including a cell phone number if available—to facilitate retention. Interviews obtained socio-demographic data, health information, lifetime and recent drug use, and sexual risk behaviors. Logistic regression was used to assess factors independently associated with providing a cell phone number.

Results: Of 735 participants enrolled, mean age was 37 (range: 18-63), 62% were male, 96% were Hispanic, and 27% reported homelessness in the past six months. Sixteen percent provided a cell phone number at baseline. Years of education and monthly income ≥2500 pesos were associated with higher odds of reporting a cell phone number. Inversely, homelessness, daily injection drug use, and age (4% per year) were associated with lower odds of reporting a cell phone number.

Conclusion: Cell phone penetration is low among PWID in Tijuana. Provision of cell phones should be considered in the design of mHealth interventions targeting PWID.

INTRODUCTION

Risky injection practices such as sharing of needles and injection paraphernalia put persons who inject drugs (PWID) at high risk for hepatitis C virus (HCV) and human immunodeficiency virus (HIV) infection.[1,2] For example, in a 2008 cross-sectional study of 1056 PWID in Tijuana, Baja California, Mexico, 59% of participants reported lifetime receptive needle sharing.[2] Similarly, a 2010 cross-sectional study of 510 PWID in San Diego, CA, found that 49% of participants receptively shared needles and 68% shared injection paraphernalia.[3] In addition to engaging in risky behaviors, PWID are at high risk for loss-to-follow-up for treatment adherence[4] and demonstrate low access to and use of health care services.[5] Although behavioral interventions have been shown to help reduce infection risks in this population,[6] new methods of delivering such interventions to this ‘hidden’ population may be needed.

Tijuana is thought to have approximately 10,000 injection drug users, with a high prevalence of heavy drug use in the Zona Norte *colonia*, or neighborhood, close to the U.S.—Mexico Border.[7] The Zona Norte is home to the largest red-light district (e.g., *zona roja*) in North America, known for its brothels, street prostitution, and illicit drug sales.[8] In addition, HIV and HCV rates among PWID living in Tijuana are approximately 4% and 95% respectively.[2,9] Successful treatment and prevention approaches to HIV and HCV in PWID require strict adherence to medication regimens and continuity in care as well as significant reductions in risk behaviors to prevent spread of infection to others.

mHealth—the use of mobile and wireless devices to improve health outcomes, health care services, and health research[10]—may offer some promise for reducing risk and increasing engagement in health care for this population. mHealth intervention strategies have proved effective in non-substance using populations to improve self-management of diabetes,[11] increase physical activity,[12] improve medication adherence,[13] and decrease smoking.[14] These strategies offer real-time patient engagement and monitoring support, and allow providers to build individually tailored motivational, educational, and disease management interventions. These strategies have also been used successfully in research among vulnerable populations, including those participating in addiction treatment,[15] sexually transmitted infection (STI) intervention programs,[16] and HIV anti-retroviral therapy (ART) adherence interventions (among non-injection drug users).[13,17] When assessing technology access and use among high-risk individuals, one study of substance users enrolled in drug treatment in Baltimore reported that 91% of participants had access to a cell phone and 79% to text messaging.[18] Another study assessing technology use among homeless youth in Los Angeles, of which 55% used a substance in the past 30 days, reported 62% of respondents owning a cell phone.[19] While mHealth tools have been successfully utilized among vulnerable populations, less is known about mHealth strategies to improve health outcomes among PWID specifically. One small study among HIV-positive PWID in China suggested that although PWID may find mHealth tools acceptable, privacy and confidentiality are of the utmost concern. [20]

Data regarding the use of mobile technology among current injection drug users are lacking. To successfully implement mHealth interventions among PWID, it is first necessary to know what proportion of PWID are already using cell phones and identify correlates of cell phone use. We assessed the prevalence and correlates of providing a cell phone number among PWID enrolled in a longitudinal cohort study of HIV risk behaviors in Tijuana, Baja California, Mexico. The results of this analysis will be valuable for informing the development and implementation of mHealth interventions among PWID.

METHODS

Study Population and Eligibility:

"Proyecto El Cuete IV" is a longitudinal cohort study of 735 PWID in Tijuana. Detailed methods are described elsewhere.[21] Participants completed behavioral risk assessment interviews and serologic testing for HIV at baseline and semi-annual follow-up visits from 2011 to 2013. Eligibility criteria included the following: 1) being at least 18 years of age, 2) having evidence of injecting illicit drugs within the past month confirmed by observation of track marks or other physical evidence of injecting, 3) being able to converse in English or Spanish, 4) currently residing in Tijuana with no plans to move away within 24 months from enrollment date, and 5) not currently participating in any intervention studies. Individuals with severe cognitive deficiencies who were unable, or those who were unwilling to provide informed consent were excluded. Individuals who were too intoxicated or sleepy to provide consent and complete the study procedures were asked to return at a later date. The Human Research Protections Program of the University of California San Diego and the Institutional Review Board at the Colegio de la Frontera Norte (COLEF) approved all study procedures.

Recruitment:

Recruitment involved targeted street-based outreach. Outreach teams established temporary mobile recruitment sites (such as vans and tents) in ten different *colonias* around Tijuana. Recruitment was also conducted out of the El Cuete field office located in the Zona Norte.

Data Collection:

After participants were screened for eligibility and provided informed consent, trained bilingual research assistants conducted behavioral risk assessment interviews in English or Spanish in a confidential setting. Interviews were administered using computer-assisted personal interviewing (CAPI) technology, which has been used previously for studies in Mexico and the United States.[21] Instruments at baseline assessed lifetime and recent experiences and behaviors. Following the interview, detailed locator information, including cell phone number if available, was collected at baseline and updated at subsequent visits. Since the validity of findings from this longitudinal study depended on achieving high retention rates, multiple methods of contacting the participant were employed.

Measures:

Socio-demographic measures included race/ethnicity, place of birth, education, language proficiency, citizenship and immigration status, marital status, living situation, incarceration, and reporting a landline phone number when asked for contact information. Drug use behaviors included lifetime and recent use of specific drugs, including drug of choice and frequency of injection, and sharing of syringes and/or other drug-related paraphernalia. Drug treatment and harm reduction measures included lifetime and recent experiences with voluntary and court-mandated drug treatment (e.g., methadone, outpatient vs. residential drug treatment, self-help groups), syringe exchange program (SEP) use, and obtaining syringes from a pharmacy or another safe source. Sexual risk behaviors included exchanging sex for money or other material goods. Other measures included, history of prior HIV diagnosis, and study retention at six months.

Data Analysis:

The outcome measure for this analysis was whether or not the participant had a cell phone, which was assessed by whether or not s/he provided a cell phone number at baseline (yes/no). Descriptive statistics of the socio-demographic and risk behavior variables were calculated for each of the two cell phone groups. Frequencies were calculated for the binary variables, whereas means and standard deviations were calculated for the continuous variables (Table 1). Covariates with a $p \leq 0.10$ in the bivariate analysis were included in the multivariable model building. Forward stepwise logistic regression was used to build these models, and variables with $p \leq 0.05$ were retained in the final model to determine odds ratios and 95% confidence limits for correlates of cell phone use. Multi-collinearity was assessed using variance inflation factors (VIF), and models were compared using likelihood ratio tests. Lastly, theoretical interactions were assessed, though none were found to be significant. SAS version 9.3 was used for all analysis procedures.

RESULTS

Sample Characteristics:

A total of 735 participants were enrolled in the El Cuete IV study, all of whom were included in this analysis. Overall, 117 (16%) provided a cell phone number at baseline. The cohort had a mean age of 37 years (range: 18-63), 62% were male, and 96% were Hispanic. Twenty-seven percent reported being mostly homeless in the past six months; 59% reported having ever lived in the United States, 49% had an average monthly income above 2500 pesos (~$200 USD), and participants reported a mean of eight years of education. Twenty-six participants (3.5%) tested HIV-positive at baseline.

Prevalence and Correlates of Owning a Cell Phone:

In bivariate analysis, reporting a cell phone number was associated with more years of education (OR 1.19 per year, 95% CI 1.05, 1.20), an average monthly income ≥2500 Pesos (OR 1.71, 95% CI 1.15, 2.56), and reporting a landline phone number (OR 5.35, 95% CI 3.50,8.16). Inversely associated were those who reported homelessness in the past 6 months (OR 0.38, 95% CI 0.22,0.66), ever incarcerated (OR 0.63, 05% CI 0.41, 0.96), HIV seropositive (OR 0.84, 95% CI 0.81, 0.86), daily heroin injection (OR 0.55, 95% CI 0.32, 0.95), daily injection of any hard drug (OR 0.27, 95% CI 0.13, 0.55), and injecting more than once per day with any hard drug (OR 0.40, 95% CI 0.22, 0.75) were less likely to report a cell phone number. Lastly, for every *ten-year* increase in age there was a 40% decrease (i.e., 4% per *year*) in likelihood of reporting a cell phone number (OR 0.96, 95% CI 0.94, 0.98).

While homelessness and reporting a landline phone number were both significant in the bivariate analyses, these variables were highly co-linear and could not be retained in the same multivariate model. Thus, the authors elected to retain homelessness in the final model for this analysis due to its importance as a risk factor among PWID. In the final multivariable model (Table 2), homelessness (AOR 0.44, 95% CI 0.25, 0.77), daily injection drug use (AOR 0.34, 95% CI 0.16, 0.71) and age (AOR 0.96 per year, 95 % CI 0.93, 0.98) were independently associated with lower odds of reporting a cell phone number; whereas years of education (AOR 1.11 per year, 95% CI 1.02, 1.18), and average monthly income ≥2500 pesos (AOR 1.51, 95% CI 0.99, 2.31) were associated with higher odds of reporting a cell phone number.

DISCUSSION

Overall, a low percentage (16%) of this cohort of PWID living in Tijuana, Baja California, Mexico provided a cell phone number when asked for contact information. In comparison, the Mexican National Census estimates that two-thirds (67%) of Mexicans owned a cell phone in 2010.[22] Cell phone penetration throughout Mexico has since risen, with 87% of Mexicans estimated to have access to a cell phone in 2013.[23] However, Tijuana is thought to have a higher percentage of PWID than any Mexican state—PWID in Tijuana are generally lower SES and more likely to be socially marginalized individuals.[2] This could partially account for the low cell phone coverage among the El Cuete study population.

Younger age was associated with reporting a cell phone number in the study population, which is consistent with the general younger Mexican population.[24,25] Additionally, participants with higher SES (e.g., more education and higher monthly income) were more likely to report a cell phone number, consistent with international polling about the growing use of technology in global emerging economies including Mexico.[24,25] Marginalized participants, including individuals who were poorer, homeless, and those engaging in daily injection practices, were significantly less likely to report a cell phone number. These persons may have less access to the resources required for owning and maintaining a cell phone and thus less likely to report a cell phone number. Researchers will need to consider cell coverage when developing mHealth intervention studies among PWID in Mexico because a high percentage of this population will be similarly resource-deprived.[2]

It was notable that none of the HIV seropositive participants reported a cell phone number to study staff. However, the low HIV prevalence in the study population may have precluded a significant finding for this variable in the final model.

Landline use in Mexico has fallen below 50% in recent years [22] and access to a phone, whether it's a landline or a cell phone, is important for a population such as this to stay in contact with health care providers. These individuals may have elected not to share this type of contact information due to stigmatization or privacy concerns related to cell phone use. More research is needed to understand how HIV-positive PWID in Tijuana access appointments, communicate with their provider, and manage HIV treatment.

Some limitations should be considered when interpreting these findings. This study did not specifically ask participants if they owned or had access to a cell phone. Instead, participants were asked to provide a cell phone number, if they had one, when providing locator information at the baseline and subsequent study visits. These participants may have owned or had access to a communal cell phone, but elected not to provide the number to study staff due to privacy concerns. This could potentially underestimate the proportion of participants who owned or had access to a cell phone. Nonetheless, from the perspective of conducting research, willingness to provide a cell phone number to study staff is critical to implementing mHealth interventions. In addition, the baseline cross-sectional data used in this analysis do not permit temporal correlations between reporting a cell phone number and the other study variables. All risk behaviors were self-report, which is subject to problems with recall; however, there is no reason to suspect that the associations were biased due to differential recall between participants with and without cell phones. Hence any associations would be biased toward the null.

Recall and social desirability bias may have resulted in an under-reporting of risk behaviors and thus biased the associations between cell phone number reporting and correlates towards the null. However, the short recall period (six months for substance abuse and injection behavior questions) used here minimized recall bias. To minimize socially desirable responses, interviews were conducted in private settings with trained interviewers. Additionally, due to the convenience sampling used to recruit study participants for El Cuete Phase IV, these data might not be generalizable across all PWID in Tijuana. However, sampling and recruitment were designed to reach a variety of PWID across varying backgrounds and socioeconomic status. Despite these limitations, this research yields significant information regarding cell phone use and the potential barriers to implementing mHealth research among PWID in the future.

CONCLUSIONS

mhealth interventions designed for PWID will need to consider levels of cell phone coverage for this poor, marginalized population. These findings, if replicated elsewhere, suggest that intervention studies may need to provide study participants with a cell phone and service plan to implement mHealth research or interventions among PWID. Because this is an area that is changing rapidly due to economic, social and cultural norms, reassessing this situation on a frequent basis is probably warranted. Lastly, more research may be needed among HIV-positive PWID to understand cell phone coverage among this population and determine how these individuals stay connected with care and any intervention research project staff.

ACKNOWLEDGEMENTS

The authors would like to thank the field staff and all of the participants in Tijuana for making this research possible. The authors also gratefully acknowledge the contributions by KC's dissertation committee: Dr. Tom Novotny, Dr. Camille Nebeker and Dr. Hector Lemus. This research is funded by the National Institutes of Health grant R37DA019829; KC is also supported by 2T32DA023356.

Chapter 2, in full, is a reprint of the material submitted to the Journal of Mobile Technology in Medicine: Collins KM, Abramovitz D, Meacham M, Gonzalez-Zuniga P, Patrick K, Garfein RS. "Mobile phone use among persons who inject drugs in Tijuana, BC, Mexico."

Table 2.1. Bivariate Analysis of socio-demographic characteristics, health outcomes and substance abuse risk/harm reduction behaviors by cell phone number reported at baseline among people who inject drugs in Tijuana, Baja California, Mexico, 2011-2012.

Variable	Total (n=735) N(%)†	No Cell # (n=619) N(%)§	Cell # (n=117) N(%)§	OR(95% C.I.)	P-value‖
Socio-demographic characteristics					
Mean Age (SD)	37.4(8.9)	37.9(8.9)	34.7(8.8)	0.96(0.94,0.98)	**<.001**
Mean Years of Education (SD)	8.0(3.0)	7.8(3.0)	8.8(3.1)	1.19(1.05,1.20)	**<.001**
Gender					
Male	456(62.0)	390(63.1)	66(56.4)	1.32(0.89,1.97)	.171
Female	279(38.0)	228(36.9)	51(43.6)		
Married/Com. Law	334(45.4)	272(44.0)	62(53.0)	1.43(0.96,2.13)	**.074**
Average Monthly Income					
≥2500 Pesos	362(49.5)	291(47.4)	71(60.7)	1.71(1.15,2.56)	**.008**
Homeless past 6 months	199(27.1)	183(29.6)	16(13.7)	0.38(0.22,0.66)	**<.001**
Hispanic/Latino	707(96.2)	594(96.1)	113(96.6)	1.14(0.39,3.35)	.810
Born in Tijuana	266(36.2)	217(35.1)	49(41.9)	1.33(0.89,1.99)	.162
Ever lived in U.S.	435(84.6)	370(85.9)	65(78.3)	0.60(0.33,1.07)	**.081**
Ever Incarcerated	548(74.7)	470(76.2)	78(66.7)	0.63(0.41,0.96)	**.030**
Retained in study at 6mos	572(77.8)	479(77.5)	93(79.5)	1.12(0.69,1.83)	.637
Reported landline phone # at baseline	131(17.8)	96(15.5)	58(49.6)	5.45(3.50,8.42)	**<.0001**
Health Outcomes					
HIV Seropositive	26(3.5)	26(4.21)	0(0)	0.84(0.81,0.86)	**.010**
Overdose past 6 months	74(10.1)	66(10.7)	8(6.8)	0.61(0.29,1.32)	.205
Lifetime overdose	401(54.6)	335(54.2)	66(56.4)	1.09(0.74,1.63)	.661
6 Month Harm Reduction Services Utilization ‡					
Used SEP	59(8.03)	52(8.41)	7(5.9)	0.69(0.31,1.57)	.375
Obtained syringe from pharmacist most often	305(41.5)	260(42.1)	45(38.5)	0.86(0.57,1.29)	.467
Used mostly a safe source of syringes	334(45.4)	286(46.3)	48(41.0)	0.81(0.54,1.21)	.295
Lifetime drug treatment	414(56.5)	352(57.1)	62(53.5)	.86(0.58,1.28)	.462
Risk Behaviors ‡					
Receptive syringe sharing	525(71.4)	439(71.0)	86(73.5)	1.13(0.72,1.76)	.587
Distributive syringe sharing	531(72.2)	445(72.0)	86(73.5)	1.08(0.69,1.68)	.740
Paraphernalia sharing	490(66.9)	411(66.6)	79(68.1)	1.07(0.70,1.63)	.754
Daily injector (any hard drug)	699(95.1)	596(96.4)	103(88.0)	0.27(0.13,0.55)	**<.001**

Table 2.1. Bivariate Analysis of socio-demographic characteristics, health outcomes and substance abuse risk/harm reduction behaviors by cell phone number reported at baseline among people who inject drugs in Tijuana, Baja California, Mexico, 2011-2012. (Continued)

Variable	Total (n=735) N(%)†	No Cell # (n=619) N(%)§	Cell # (n=117) N(%)§	OR(95% C.I.)	P-value‖
Daily heroin injection	652(88.7)	555(89.8)	97(82.9)	0.55(0.32,0.95)	**.031**
Daily methamphetamine injection	117(15.9)	104(16.9)	13(11.1)	0.62(0.33,1.14)	.120
Gave sex for money or something else needed	63(8.6)	51(8.3)	12(10.3)	1.26(0.65,2.46)	.484

† Column percentages. Totals may vary by subgroup due to missing data
‡ All substance use and risk /harm reduction behaviors refer to the past 6 months, unless otherwise indicated
§ Row percentages represent prevalence of reporting a cell phone at baseline within the groups
|| P-values are based on chi-square tests, non-parametric Wilcoxon rank sum tests or Fisher's Exact test, and demonstrate overall significance of differences between reporting a cell phone number (yes vs. no) by each variable

Table 2.2. Multivariable logistic regression analysis of factors associate with reporting a cell phone number at baseline among people who inject drugs in Tijuana, Baja California Mexico, 2011-2012.

Variable	**AOR (95%CI) †**	***P-value***
Age	0.96(0.94, 0.98)	<0.001
Years of Education	1.11(1.02, 1.18)	0.001
Average Monthly Income ≥2500 Pesos	1.51(0.99, 2.31)	0.054
Mostly homeless past 6 months	0.44(0.25, 0.77)	0.004
Daily injection of any hard drug	0.34(0.16, 0.71)	0.004

† *Variables adjusted for all other variables in the model*

REFERENCES

1. Strathdee SA, Hallett TB, Bobrova N, et al. HIV and risk environment for injecting drug users: the past, present, and future. Lancet. 2010;**376**:268-284.

2. Strathdee SA, Lozada R, Pollini RA, et al. Individual, social, and environmental influences associated with HIV infection among injection drug users in Tijuana, Mexico. J Acquir Immune Defic Syndr. 2008;**47**(3):369-376.

3. Garfein RS, Rondinelli A, Barnes RF, et al. HCV infection prevalence lower than expected among 18-40-year-old injection drug users in San Diego, CA. J Urban Health. 2013;**90**(3):516-528.

4. Arnsten JH, Xuan L, Mizuno Y, et al. Factors Associated With Anti retroviral Therapy Adherence and Medication Errors Among HIV-Infected Injection Drug Users. J Acquir Immune Defic Syndr. 2007;**46**(S2):S64-S71.

5. Drumm RD, McBride DC, Metsch L, et al. 'The Rock Always Comes First': Drug Users' Accounts About Using Formal Health Care. J Psychoactive Drugs. 2003;**35**(4):461-469.

6. Copenhaver MM, Johnson BT, Lee IC, et al. Behavioral HIV risk reduction among people who inject drugs: meta-analytic evidence of efficacy. J Subst Abuse Treat. 2006;**31**(2):163-171.

7. Strathdee SA, Fraga WD, Case P, et al. "Vivo para consumirla y la consumo papa vivir" ["I live to inject and inject to live"]: High Risk Injection Behaviors in Tijuana, Mexico. J Urban Health. 2005;**82**(3 Suppl 4):iv58-iv73.

8. Strathdee SA, Magis-Rodriguez C. Mexico's evolving HIV epidemic. JAMA. 2008;**300**(5):571-573.

9. White EF, Garfein RS, Brouwer KC, et al. Prevalance of hematitic C virus and HIV infection among injection drug users in two Mexican cities bordering the U.S. Salud Publica Mex. 2007;**49**(2):165-172.

10. United States Department of Health and Human Services. 2010 [cited 2014 April 25]. Available from: http://www.hrsa.gov/healthit/mhealth.html.

11. Ribu L, Holmen H, Torbjornsen A, et al. Low-intensity self-management intervention for persons with type 2 diabetes using a mobile phone-based diabetes diary, with and without health counseling and motivational interviewing: protocol for a randomized controlled trial. JMIR Res Protoc. 2013;**2**(2):e34.

12. Chomutare T, Fernandez-Luque L, Arsand E, et al. Features of mobile diabetes applications: review of the literature and analysis of current applications compared against evidence-based guidelines. J Med Internet Res. 2011;**13**(3):e65.

13. Moore DJ, Montoya JL, Blackstone K, et al. Preliminary Evidence for Feasibility, Use, and Acceptability of Individualized Texting for Adherence Building for Antiretroviral Adherence and Substance Use Assessment among HIV-Infected Methamphetamine Users. AIDS Res Treat. 2013;**2013**:1-11.

14. Whittaker R, Maddison R, McRobbie H, et al. A multimedia mobile phone-based youth smoking cessation intervention: findings from content development and piloting studies. J Med Internet Res. 2008;**10**(5):e49.

15. Epstein DH, Willner-Reid J, Vahabzadeh M, et al. Real-Time Electronic Diary Reports of Cue Exposure and Mood in the Hours Before Cocaine and Heroin Craving and Use. Arch Gen Psychiatry. 2009;**66**(1):88-94.

16. Roth AM, Hensel DJ, Fortenberry JD, et al. Feasibility and Acceptability of Cell Phone Diaries to Measure HIV Risk Behavior Among Female Sex Workers. Aids Behav. 2014;**18**(12):2314-2324.

17. Ingersoll K, Dillingham R, Reynolds G, et al. Development of a personalized bidirectional text messaging tool for HIV adherence assessment and intervention among substance abusers. J Subst Abuse Treat. 2014;**46**(1):66-73.

18. McClure EA, Acquavita SP, Harding E, et al. Utilization of communication technology by patients enrolled in substance abuse treatment. Drug Alcohol Depend. 2013;**129**(1-2):145-150.

19. Rice E, Lee A, Taitt S. Cell phone use among homeless youth: potential for new health interventions and research. J Urban Health. 2011;**88**(6):1175-1182.

20. Bachman Desilva M, Gifford AL, Keyi X, et al. Feasibility and Acceptability of a Real-Time Adherence Device among HIV-Positive IDU Patients in China. AIDS Res Treat. 2013;**2013**:1-6.

21. Robertson AM, Garfein RS, Wagner KD, et al. Evaluating the impact of Mexico's drug policy reforms on people who inject drugs in Tijuana, B.C. Mexico, and San Diego, CA, United States: a binational mixed methods research agenda. Harm Reduct J. 2014;**11**(4):14.

22. T.W.J. Mexico’s census: TVs outnumber fridges. The Economist. 2011 April 28:2.

23. Lonergan K. Mexico telecoms sector expands 10% in Q2 2013. Available from: http://www.bnamericas.com/news/telecommunications/mexico-telecoms-sector-expands-10-in-q2.

24. Pew Global Attitudes Project. Global Digital Communication: Texting, Social Networking Popular Worldwide. Pew Research Center, 2011.

25. Pew Global Attitudes Project. Emerging Nations Embrace Internet, Mobile Technology; Cell Phones Nearly Ubiquitous in Many Countries. Pew Research Center, 2014.

CHAPTER 3: FACTORS ASSOCIATED WITH LATENT CLASSES OF MOBILE TECHNOLOGY USE AMONG PERSONS WHO INJECT DRUGS IN SAN DIEGO, CALIFORNIA

ABSTRACT:

Background: New and innovative methods of delivering interventions are needed to further reduce risky behaviors and increase overall health among persons who inject drugs (PWID). mHealth interventions have great potential for reaching PWID; however, very little is known about mobile technology use and experience among PWID. Thus, we describe classes of mobile technology use among a cohort of PWID in San Diego, CA and identified factors associated with class membership.

Methods: Data were collected through a longitudinal cohort study examining drug use, risk behavior, and health status among PWID in San Diego. Latent class analysis (LCA) was used to identify patterns of mobile technology use (i.e., making calls, text messaging, and mobile internet access). Multinomial logistic regression was used to identify demographic characteristics, risk behaviors and health indicators associated with technology-use class.

Results: Latent class analyses testing 1, 2, 3, 4 and 5 classes were fit, with the 4-class solution fitting best. Class 1 was defined by minimal mobile technology use (22%, n=100); class 2 by primarily internet use (20%, n=95), class 3 by primarily phone calls and text messaging (17%, n=91) and class 4 by high mobile technology use (41%, n=175). In multivariable regression analysis, compared to minimal technology users (Class 1), higher technology users were more likely to be younger, have higher socioeconomic status, and inject methamphetamine daily.

Conclusion: Most PWID in San Diego are familiar with the technology used for mobile voice, texting and internet access, indicating that rapid uptake of mHealth interventions may be possible in this population. However, low experience with mobile technology among older and/or homeless individuals will need to be considered when implementing mobile technology-based interventions among PWID.

BACKGROUND

Injection drug use has been widely associated with risky behaviors such as sharing injection equipment (e.g., cookers, cotton and water) and drug paraphernalia (e.g., syringes and needles)[1]. These risk behaviors contribute to an increased risk for infection with blood borne pathogens such as Human Immunodeficiency Virus [HIV] and Hepatitis C Virus [HCV] among persons who inject drugs (PWID).[1] In addition to practicing risky behaviors, PWID have low access to health care services[2] and are at increased risk for loss to follow-up when being treated for disease.[3] Successful treatment and prevention approaches to HIV and HCV infection among PWID require continuity of care and high adherence to treatment regimens in addition to a sufficient reduction in risk behaviors. Although some intervention approaches have proven successful for reducing risk among PWID,[4,5] there remains a need for highly effective interventions. Novel approaches to intervention delivery are needed to increase prevention effectiveness among PWID.

The U.S. Department of Health and Human Services defines “mHealth” as the use of mobile and wireless devices to improve health outcomes, health care services, and health research.[6] There is great potential for mHealth interventions to reduce risk, improve linkages to health care, and increase continuity of care for PWID. Mobile technology-based strategies allow researchers to build motivational, educational, and disease management interventions specifically tailored to the target population. These methods have proven successful in research among various substance using populations. For example, ecological momentary assessment (EMA) has been used to identify mood associations with drug cravings among poly-drug users enrolled in methadone maintenance.[7] Also, text messaging-based interventions have been used to increase HIV anti-retroviral therapy (ART) adherence among non-injection substance users.[8,9] However, little is known regarding the feasibility and acceptability mHealth strategies to reduce risk and improve health outcomes among persons actively injecting drugs. One small study among HIV-positive PWID in China suggests that although study participants were able to use the mobile intervention technology successfully, privacy and confidentiality surrounding the intervention were of concern.[10]

mHealth based strategies are an emerging field with great potential to learn more about PWID and to deliver risk-reducing interventions in this populations. However, we first need to describe PWID in terms of mobile technology access and use to assess how common device ownership is, and determine which subgroups of PWID are commonly using mobile technology. Data regarding mobile technology use among other high-risk populations suggests there is some access to mobile technology among high risk individuals.[17-19] For example, a study of substance users enrolled in drug treatment in Baltimore reported that 91% of participants had access to a cell phone and 79% to text messaging.[11] Another study assessing technology use among homeless youth in Los Angeles—55% of whom used a substance in the past 30 days—found that 62% owned a cell phone.[12] Among current smokers living with HIV, 73% of respondents owned and used a cell phone, 39% reported text messaging, 48% used the internet, and 31% accessed email.[13]

There are no published data regarding mobile technology use specific to PWID in the U.S. Thus, this study aimed to: 1) categorize PWID based on their mobile technology use; and 2) identify socio-demographic, behavioral, and health-related factors associated with each category of mobile technology use among PWID living in San Diego. The findings of this study will help inform the development and implementation of research and interventions targeting PWID.

METHODS

Study Population and Recruitment

Data for this analysis came from an ongoing longitudinal cohort study of PWID (hereafter the STAHR-II study) in San Diego County. Details about the study design and population are described elsewhere.[14] Participants in the parent study were enrolled between June 2012 and January 2014. Eligibility criteria for STAHR-II includes: 1) ≥18 years of age 2) having injected drugs within the past 30 days, 3) reported they intend to reside in San Diego County for the next two years, 4) were willing to provide contact information to maintain contact with study staff, and 5) have their blood drawn for serological testing for HIV, HCV, and *Mycobacterium tuberculosis*. Participants were recruited using word-of-mouth referrals, targeted advertising and street outreach in areas with a high prevalence of drug use. Recruitment and study procedures took place at a storefront office and on a mobile unit that parked in multiple communities throughout the county to increase representativeness of PWID countywide. A bilingual (Spanish-English) outreach worker provided PWID with information about the study, and facilitated appointments for prospective participants.

Consented and enrolled participants underwent behavioral assessments and serologic testing at baseline and four semi-annual follow-up visits. Participants were compensated USD $25 for the baseline interview and $30 for the 6 month follow-up. All participants were offered referrals for drug treatment and other services in addition to counseling and educational materials. The Human Research Protections Program of the University of California San Diego and San Diego State University approved all study procedures.

Study Measures

Surveys were conducting using computer assisted personal interviewing (CAPI) technology. Trained interviewers read questions to participants in English or Spanish and entered participant responses onto a laptop computer. Baseline interviews measured socio-demographic information (i.e., age, sex, race/ethnicity, educational attainment, income, housing status, history of incarceration, country of birth, and marital and parental status), substance use history (i.e., specific drugs used within 6 months (and lifetime) including heroin, crack/cocaine, methamphetamine, prescription drugs, marijuana) by various routes of administration (i.e., snorting, smoking, swallowing, or injection), syringe and injection equipment sharing behaviors, sex in exchange for drugs or money, selling drugs for money, health and/or harm reduction services use (i.e. ER/hospital visits past 6 months, use of syringe exchange program, drug treatment), and health status (i.e., lifetime overdose and ever being diagnosed with a sexually transmitted infection [STI]). All behavioral questions referred to the 6-months prior to completing the baseline interview.

Mobile technology use variables included in this analysis were lifetime cell phone ownership, current cell phone ownership, current smartphone ownership, ever lost a cell phone, ever had a cell phone stolen, frequency of calling/texting on a cell phone, internet use past 6 months (yes/no), and medium of internet use in the past 6 months (i.e., desktop, laptop, television, game console, tablet, or cell phone internet access past 6 months).

In order to identify classes based on mobile technology use, we recoded each mobile technology variable into a binary variable. Frequency of voice calls and frequency of text messaging were two separate variables recoded from “average number of calls per day” and, “average number of texts per day,” to “calls daily” or "texts daily" (1=yes, 0=no). *Any* Internet use in the past 6 months was coded as "ever accessed the internet in the past 6 months" (1=yes, 0=no). *Mobile* Internet use was recoded into a binary variable from "how did you access the internet most in the past 6 months" (1=computer/laptop, 2=television, 3=tablet, 4=mobile phone, 5=game console, 6=other), to "accessed the internet on a cell phone or tablet, past 6 months" (1=yes, 0=no). *Computer* only internet use was recoded into a binary variable from "how did you access the internet most in the past 6 months" (1=computer/laptop, 2=television, 3=tablet, 4=mobile phone, 5=game console, 6=other), to "only accessed the internet on a computer/laptop, past 6 months" (1=yes, 0=no). Internet use questions were added to the baseline survey after initial study enrollment had already begun and the same questions were repeated at each semi-annual follow-up visit. Thus, participants who were missing data for 'ever accessed the internet, past 6 months,' 'accessed the internet on a cell phone or tablet, past 6 months,' or 'only accessed the internet on a computer/laptop, past 6 months' were filled in from identical questions in the 6-month follow-up interview using last observation forward. To reduce potential misclassification bias, we only included mobile technology use variables as indicators where at least 15% of participants reported their use for inclusion in the LCA.[15] Thus, the following variables were excluded from the LCA due to less than 15% prevalence: 1) used a tablet *only* to access the internet in the past 6 months (yes/no), and 2) used a cellphone *only* to access the internet in the past 6 months (yes/no).

Statistical Methods

A cross-sectional data set using both baseline and 6-month follow up data was created, and all participants who answered questions regarding mobile technology use in the baseline *or* 6-month follow-up interview (n=461) were eligible for this analysis. We then approached our analysis in two steps. First, we used latent class analysis (LCA) to identify categories of mobile technology use, based on patterns of voice, text, and internet use among the cohort members. Rather than simultaneously estimating the classes with covariates to predict the latent categorical variable,[16] we used a multistep approach for our LCA by running the indicators first and then adding the covariates/predictors in a multinomial logistic regression model after class membership had been established. This method has been used previously,[15] and classifies participants into groups for the latent categorical variable and then treats the groups as discrete entities in subsequent logistic regression analyses. Second, we used multinomial logistic regression to identify socio-demographic characteristics, HIV/HCV-associated risk behaviors, and health outcomes that were associated with class membership. We used the following four binary variables as indicators in our LCA to determine mobile technology use profiles among the cohort: 1) daily cell phone calls, 2) daily text messaging, 3) any mobile internet use in the past 6 months, 4) any internet use past 6 months. We then examined models with between one and five classes. Lower Akaike information criteria (AIC) and sample size adjusted Bayesian information criteria (sBIC) values and higher entropy values indicate better fit.[17] A non-significant bootstrap likelihood-ratio test (LRT) *p*-value indicates that increasing the number of classes does not improve the fit.[17-20] Based on the goodness-of-fit indices, we selected a four-class solution for the LCA.

Following LCA, multinomial logistic regression was conducted to identify factors associated with class membership. Bivariate analyses using Chi-square and Kruskal-Wallis tests were conducted first to determine demographic, behavioral, or health status indicators associated with each class. Statistical significance at the

$p<0.10$ level in bivariate analyses was used to determine which factors were considered for inclusion in the multivariable analysis. We used a backward model building approach, starting with a saturated model and manually removing variables with a non-significant p-value for all three comparisons one at a time. Variables achieving significance at the $p<0.05$ level and variables that produced a 10% or greater change between the crude and adjusted odds ratios (i.e., confounders) were retained in the final model. Models were checked for meaningful interactions though none were found to be statistically significant. Multi-collinearity was assessed using variance inflation factors (VIF) and in the case of collinearity, the most important variable was retained in the model. All analyses were performed with SAS version 9.3 (SAS, Cary, NC).[21]

RESULTS

Of the 574 participants enrolled in STAHR-II between June 2013 and January 2014, 461 (80.3%) provided responses to interview questions regarding mobile technology use at the baseline or 6 month follow-up visit, thus making them eligible for this analysis. There were no statistically significant differences in socio-demographics or risk behaviors between STAHR-II participants included and excluded in this analysis (data not shown). The majority of our sample was white (52.3%) and male (74.1%) with a mean age of 43.5 years (range: 18-70; SD=11.4). In terms of cell phone ownership, 92.4% reported ever owning a cell phone; 66.2% reported currently owning a cell phone and 28.6% reported currently owning a smart phone. Of current cell phone owners, 40% had a contract plan and 39% had pre-paid cell service. Seventy percent of participants reported ever losing a cell phone; 56% reported ever having one stolen. Seventy-two percent of participants reported accessing the internet in the past 6 months, of whom 63% accessed email, 42% used a social networking site, and 9% used the internet for finding sex partner; 23% of participants reported *never* using the internet before. Additional socio-demographic, HIV risk behavior, health services utilization, and health outcome factors stratified by class membership are displayed in Table 3.

Determination of class membership

Fit statistics for LCA models with between one and five classes are presented in Table 1. While a five-class solution was slightly better in terms of the standard goodness of fit indices for LCA (lower AIC, BIC and sample-size adjusted BIC), standard errors for class membership probabilities were larger and mean posterior probabilities were lower for the five-class solution. While the classes were not perfectly delineated (entropy value of 0.96, and a significant bootstrap LRT p-value indicates less than ideal classification quality), the four-class solution provided categories of mobile technology use that were more stable and intuitive among this cohort and were consistent with previously published parameters.[17, 22-23] Table 2 presents the conditional probability that respondents in each class indicated daily texting on a cell phone, daily calls on a cell phone, any internet access in the past 6 months, any mobile internet access in the past 6 months, and only accessing the internet on a computer in the past 6 months. Class 1 represents PWID who had a high probability of minimal mobile technology use, whereas Class 4 represents PWID who had a high probability of using all forms of mobile technology examined but a low probability of using a computer only to access the internet. Two other classes represent PWID who accessed the internet using a mobile device but did not use voice or text messaging (Class 2), and PWID who mainly used voice, text and only accessed the internet on a computer (Class 3). Of those who predominantly use mobile internet (Class 2), 75.9% used both a cell phone *and* another medium (computer/laptop, game console, or tablet) to access the internet in the past 6 months.

Bivariate analysis of factors associated with class membership

To identify factors associated with class of mobile technology use, bivariate analyses were performed. Results of the bivariate logistic regressions comparing the odds of being in Class 1-4 are displayed in Table 3. Socio-demographic differences by class were observed for age, educational attainment, income, homelessness, having children, and lifetime incarceration. Differences in risk behaviors between classes were observed for number of years injecting, sharing syringe, selling drugs, and injecting methamphetamine daily in the past 6 months. In terms of health-related behaviors and outcomes, differences in class membership were observed for having more than one emergency room visit in the past 6 months, and having ever overdosed. All p-values for significant differences were less than 0.05.

Multivariable analysis of factors associated with class membership

Using minimal mobile technology use (class 1) as the reference group, multinomial logistic regression analysis revealed that maximal mobile technology use (class 4) was positively associated with having more than a high school education (AOR=5.23, 95% CI=2.46, 11.09), selling drugs for money (AOR=3.30, 95% CI=1.53, 7.13), injecting methamphetamine daily (AOR=2.59, 95% CI=1.02, 6.59) and currently owning a smart phone (AOR=14.2, 95% CI=6.37, 31.60) compared to minimal mobile technology users (Table 3). Older age (AOR=0.92 per year, 95% CI=0.88, 0.95) and homelessness (AOR=0.30, 95% CI=0.16, 0.57) were associated with lower odds of being in Class 4 compared with Class 1. For class 2, subjects who reported having more than a high school education (AOR=2.66, 95% CI=1.13, 6.30), selling drugs for money (AOR=3.52, 95% CI=1.51, 8.23), and injecting methamphetamine daily (AOR=5.80, 95% CI=2.23, 15.1) were more likely to be predominantly mobile internet users when compared to minimal mobile technology users—older participants (AOR=0.91 per year, 95% CI=0.88, 0.95) had decreased odds of being mobile internet users when compared to minimal technology users. Compared to Class 1, participants in Class 3 were more likely to have higher than a high school education (AOR=2.62, 95% CI=1.25, 5.47) and inject methamphetamine daily (AOR=3.54, 95% CI=1.46, 8.60). Older participants (AOR=0.95 per year, 95% CI=0.92, 0.98) were less likely to be in Class 3 compared with Class 1.

DISCUSSION

Four distinct classes of mobile technology use were identified among PWID in San Diego: 1) minimal mobile technology users; 2) predominantly mobile internet users; 3) predominantly voice, text and connected internet users; and 4) maximal mobile technology users. This is the first study, to our knowledge, that classified PWID by mobile technology use behaviors, and identified factors associated with these classes. Compared to minimal mobile technology users, maximal mobile technology users were more likely to be young, have higher education, currently own a smart phone, and report selling drugs for money and inject methamphetamine daily in the past 6 months; they were less likely to be homeless. These findings provide novel insights about PWID that could be used to design technology-based HIV and HCV prevention interventions.

Most PWID in San Diego (92.4%) reported ever owning a cell phone, though current cell phone ownership was much lower at 66%, and just under a third of participants (28.6%) currently owned a smartphone. In contrast, Pew Research Center estimated that 90% of American adults owned a cell phone in 2014, and 58% owned a smartphone—among adults making less than $30,000/year, 47% owned a smartphone.[24] This disparity was not surprising given that PWID in this study were generally very low SES (61% consider themselves to be homeless). In multivariable analyses, minimal mobile technology users were more likely to be homeless than high mobile technology users, further demonstrating that low SES contributes to low access to mobile technology. Additionally, a majority of participants (70%) reported ever losing a cell phone. Given the low prevalence of smartphone ownership and high prevalence of lifetime cell phone loss among PWID in this study, device coverage will need to be considered when developing smartphone-based intervention or research studies among PWID.

Consistent with recent Pew Research Center data[24], owning a smartphone significantly increased the odds of being in the maximal mobile technology use category in this study. Pew reported that in 2014, 81% of cell phone owners in the U.S. used their cell phone to send or receive text messages; in the case of smartphone ownership, 60% used their device to access the internet, and 52% to send or receive email.[24] Also consistent with recent data among U.S. adults,[24] mobile technology classes in this study were associated with differences in age and education. Higher educational attainment (specifically having higher than a high school education) and younger age increased the odds of higher mobile technology use across all classes when compared to minimal mobile technology users. These trends among PWID in San Diego are consistent with recent data among other high-risk populations in the U.S. (e.g., homeless youth, non-injecting substance users, smokers living with HIV), that demonstrate younger age and higher education are associated with increased cell phone ownership, cell phone use, and internet and email use.[11-13,25]

Injecting methamphetamine daily was associated with increased odds of higher mobile technology use across all classes compared to minimal mobile technology users. In contrast, daily heroin injection in this study was not associated with increased mobile technology use. The dynamics of each type of addiction may help explain this association. After the initial “rush” experienced immediately after using heroin, drowsiness occurs for several hours.[26] In contrast, methamphetamine (a.k.a., meth, or crystal meth) initially acts as a powerful stimulant, increasing the users wakefulness, attention and physical activity.[27] Methamphetamine has traditionally been used as an inexpensive alternative to cocaine that allows users to party all night long;[28] though more recently methamphetamine has moved into the work place to increase the users productivity and work very long hours.[29] Both drugs are highly addictive, but in the case of heroin, once a person becomes an addict, seeking and using their drug of choice to avoid withdrawal sickness becomes their highest priority. Individuals addicted to heroin may do anything in their power to obtain drugs and avoid withdrawal symptoms, including selling their phone or spending any available resources on drugs. In contrast, daily methamphetamine users may be higher functioning due to the stimulating effects of methamphetamine use and more able to obtain and maintain the resources to access a cell phone or use mobile technology than daily heroin users in our study.

Selling drugs in the past 6 months was associated with increased odds of being a high mobile technology user and a predominantly mobile internet user. Access to some form of mobile technology may be a high priority for individuals who sell drugs, as a communication technology equals access to their customers. As mobile phone have become nearly ubiquitous among all socioeconomic and demographic groups in the U.S., individuals who sell drugs are upgrading from what the New York Times called the "tool of today's dealer" in 1988 (the electronic "beeper", or pager)[30] and cell phones in the 1990's,[31] to smartphones and the internet to connect with customers and suppliers in the 21st century. Smartphones and other internet applications allow people to connect nearly instantaneously using a remote data connection, and often makes communication discreet and efficient. However, "smart" technology may be a privacy and/or legal risk for individuals who sell drugs, due to the easy traceability of GPS enabled devoices. For example in this study, 39% of current cell phone owners reported using a pre-paid cell phone plan. Pre-paid plans, or "go-phones," do not require a long-term contract or contact information to enable the device. Additionally, this type of plan permits the user to obtain a new phone number each time they pay for service. Further, a recent article in the online magazine *Vice* reported that street dealers in the UK are stocking up on "dumb" Nokia 8210 feature phones equipped with pre-paid voice plans and no internal GPS for law enforcement to track.[32] While PWID who sell drugs utilize mobile technology and thus may be reachable via mHealth interventions, confidentially may be of concern to this subgroup who engage in illicit behaviors.

Lastly, this study indicates that access to mobile technology and/or the internet (i.e., access to information) among PWID in San Diego may not be sufficient to deter them from engaging in high-risk behaviors. In some cases, access to mobile technology may increase risk behaviors, as evidenced by the fact that 9% of participants in this study used the internet to find sex partners. This is consistent with literature surrounding risk reduction among PWID demonstrating that information is a necessary intervention component, but may not be sufficient to achieve a significant reduction in injection-related risk among PWID.[33,34] For example, Strathdee et al. (2013) found that providing knowledge or information didactically to female sex workers in Tijuana was not as effective for decreasing risky injection practices as were interactive intervention techniques and policy measures that increased access to clean syrniges.[34] Technology-based interventions designed to reduce risk among PWID may need to do more than just provide access to information via mHealth tools to achieve a significant reduction in risk behaviors.

STUDY LIMITATIONS

These findings must be interpreted with some limitations. First, cross-sectional data from the baseline interview of the STAHR-II study was utilized for this analysis. Thus, we are unable to establish casual relationships or directionality between class membership and risk behaviors or health status. Since class membership--particularly in the rapidly expanding technology market--risk behaviors and health status are likely to change over time, future analyses are needed using longitudinal data to model whether class membership is stable and whether/how transitions between classes impact risk behaviors and health status over time. Since the mobile technology questions were added to the study part way through enrollment, 224 participants were not asked these questions at baseline. To minimize missing data, we used responses for these questions from 120 participants who returned for their six-month interviews. This could have resulted in some misclassification; however, the study was not designed to influence cell phone ownership, so any misclassification would likely be non-differential with respect to our study measures and bias our data in the direction of null findings. Further, our reliance on using recall-based survey methods may introduce bias into the data. However, a short recall period (six months) was used to minimize problems with recall. Also, to minimize socially desirable responses, interviews were conducted in private settings with trained interviewers. Finally, due to the convenience sampling used to recruit study participants for STAHR-II, these data might not be generalizable to all PWID in San Diego. However, sampling and recruitment were designed to reach a variety of PWID across varying backgrounds and socioeconomic status.

CONCLUSIONS

Overall, we found that the majority of PWID in San Diego currently own a cell phone; however smartphone device ownership was much lower, with less than a third of participants owning a smartphone at the time of this study. Our findings that younger and more educated PWID in San Diego were familiar with the technology used for mobile voice, texting and internet access, suggest that uptake of mHealth interventions may be successful in this population. Results also suggest that mHealth-based approaches may help interventionists reach a high-risk subgroup of PWID who are highly dependent on methamphetamine and may be hard to reach using traditional intervention approaches. However, device coverage should be considered when implementing mHealth interventions among PWID, as lower SES and mainly heroin using PWID may not benefit from such interventions unless they are provided with devices. Finally, while results of this analysis are specific to PWID, the methodology could be used to describe behaviors in other groups before implementing population-specific mHealth research or interventions in the future.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the STAHR-II staff without whom this analysis would not be possible. The authors would also like to thank the participants, community advisory board, and community collaborators for their invaluable support in conducting this study. Funding for this study was provided by the National Institutes of Drug Abuse (NIDA); R01-DA031074 and 2T32-DA023356.

Chapter 3, in full, is a reprint of the material being prepared for submission to the Journal of Drug and Alcohol Dependence: Collins KM, Armenta R, Cuevas-Mota J, Liu L, Strathdee SA, Garfein RS. “Factors associated with latent classes of mobile technology use among Persons who inject drugs in San Diego, CA.”

Table 3.1. Fit statistics of the latent class models among persons who inject drugs, San Diego, CA.

	Log likelihood	AIC	BIC	sBIC	Entropy	Bootstrap LRT *p*-value†
1 class	-1433.9	931.72	952.39	936.52	1.00	-
2 class	-1213.4	502.58	548.05	513.13	0.91	.001
3 class	-1120.7	329.21	399.48	345.43	0.95	.001
4 class	**-1042.8**	**185.46**	**280.52**	**207.53**	**0.96**	**.001**
5 class	-1006.9	125.58	245.45	153.41	0.95	.001

†Bootstrap LRT ran for 2,000 iterations.

Table 3.2. Latent class marginal and conditional probabilities for mobile technology use among persons who inject drugs, San Diego, CA.

Variable‡†	Class 1 28%(SE=0.02)	Class 2 14%(SE=0.03)	Class 3 18%(SE=0.02)	Class 4 41%(SE=0.03)
Mean Posterior Probabilities (SD)	98.6%(0.05)	98.4%(0.03)	99.9%(0.00)	97.3%(0.08)
Daily text messages	28.9%	1.5%	**53.0%**	**93.2%**
Daily phone calls	45.8%	6.6%	**55.5%**	**98.7%**
Any internet access§	0.5%	**94.2%**	**99.9%**	**97.4%**
Any mobile internet access§	0.8%	**86.0%**	0.0%	**94.8%**
Computer *only* internet access§	0.0%	0.0%	**99.3%**	0.0%

†All indicator variables included in the latent class analysis (LCA) were ≥15% prevalent. Variables were dichotomized (yes/no) for LCA.
‡Variables with <15% prevalence did not meet the inclusion criteria for the LCA.
§Variable assessd for past 6 months.

Table 3.3. Bivariate analysis of mobile technology use class by socio-demographic characteristics, HIV risk behaviors, health services utilization, and health outcomes among persons who inject drugs, San Diego, CA.

	All subjects (N = 461) N (%)[†]	**Class 1**[a] (N = 128) N (%)[§]	**Class 2**[b] (N=58) N (%)[§]	**Class 3**[c] (N=83) N (%)[§]	**Class 4**[d] (N = 192) N (%)[§]	**P - value**[‖]
Socio-demographic characteristics						
Gender (n=455)						
Male	337 (74.1)	96 (76.8)	47 (81.0)	60 (73.2)	134 (70.5)	0.358
Female	118(25.9)	29 (23.2)	11(19.0)	22 (26.8)	56 (29.5)	
Mean Age (SD)	43.5 (11.4)	49.9 (8.7)	39.6 (10.9)	44.7 (11.6)	39.9 (11.2)	**<.0001**
Race/Ethnicity						
White	241 (52.3)	53 (41.4)	33 (56.9)	49 (59.0)	106 (55.2)	0.227
Hispanic	141 (30.6)	50 (39.1)	18 (31.0)	22 (26.5)	51 (26.6)	
Black	41 (8.9)	15 (11.7)	3 (5.2)	5 (6.0)	18 (9.4)	
Other	38 (8.2)	10 (7.8)	4 (6.9)	7 (8.4)	17 (8.9)	
Educational Attainment						
< High School	153 (33.2)	59 (46.1)	22 (37.9)	30 (36.1)	42 (21.9)	**<.0001**
High school or equivalent	136 (29.5)	45 (35.2)	16 (27.6)	23 (27.7)	52 (27.1)	
> High School	172 (37.3)	24 (18.8)	20 (34.5)	30 (36.1)	98 (57.0)	
Income						
$0-10,000	319 (69.2)	95 (74.2)	41 (70.7)	64 (77.1)	73 (38.0)	**0.034**
>$10,000	142 (30.8)	33 (25.8)	17 (29.3)	19 (22.9)	119 (62.0)	
Source of Income (past 6 months) (n=444)						
Illegal Source	23 (12.5)	14 (11.1)	14 (25.0)	6 (7.7)	23 (12.5)	0.065
Irregular Legal Source	85 (46.2)	52 (41.3)	19 (33.9)	40 (51.3)	85 (46.2)	
Regular Legal Source	191 (43.2)	60 (47.6)	23 (41.1)	32 (41.0)	76 (39.8)	
Homeless, past 6 months	282 (61.2)	90 (70.3)	42 (72.4)	53 (63.9)	97 (50.5)	**<.001**
Have children	261 (56.6)	91 (71.1)	29 (50.0)	44 (53.0)	97 (50.5)	**0.002**
Country born						
U.S.	434 (91.1)	121 (94.5)	57 (98.3)	78 (94.0)	178 (92.7)	0.380
Mexico	11 (2.4)	5 (3.9)	0 (0)	1 (1.2)	5 (2.6)	
Other	16 (3.5)	2 (1.6)	1 (1.7)	5 (4.8)	9 (4.7)	
Ever Incarcerated	420 (91.1)	125 (97.7)	55 (94.8)	73 (87.9)	167 (87.0)	**0.005**
Married (vs. single)	408 (88.5)	114 (89.0)	51 (87.9)	79 (95.2)	164 (85.4)	0.139
Currently own smartphone	132 (28.6)	11 (8.6)	2 (3.5)	7 (8.4)	112 (58.3)	**<.0001**
Drug Use and Sexual Risk behaviors[‡]						
Mean years injecting drugs (SD)	21.1 (13.2)	27.8 (12.1)	19.1 (12.8)	21.6 (13.0)	16.9 (12.3)	**<.0001**
Shared injection paraphernalia, past 6 months	316 (68.6)	94 (73.4)	46 (79.3)	48 (57.8)	128 (66.7)	0.063
Shared syringe past 6 months (n=399)	167 (41.9)	41 (36.9)	17 (32.1)	38 (57.6)	71 (42.0)	**0.020**
Ever exchanged sex for drugs or money (n=458)	150 (32.8)	39 (31.0)	19 (32.8)	25 (30.1)	67 (35.1)	0.822
Used the internet to look for sex partners, past 6 months	40 (9.6)	1 (1.2)	9 (15.5)	5 (6.1)	25 (13.1)	**0.004**
Sold drugs for money, past 6 months	128 (27.8)	18 (14.1)	22 (37.9)	18 (21.7)	70 (36.5)	**<.0001**
Inject heroin daily (n=450)	169 (37.6)	50 (40.0)	25 (45.5)	28 (34.2)	66 (35.1)	0.450
Inject methamphetamie daily (n=449)	72 (16.0)	10 (8.1)	16 (29.1)	18 (22.0)	28 (38.9)	**0.002**
Health services utilization						
Used syringe exchange, past 6 months	160 (34.7)	39 (28.1)	20 (34.5)	31 (37.4)	73 (38.0)	0.304
≥1 Hospitalization, past 6 months	87 (18.9)	28 (21.9)	12 (20.7)	12 (14.5)	35 (18.2)	0.575
≥1 ER visit, past 6 months	170 (36.9)	42 (32.8)	26 (44.8)	20 (24.1)	82 (42.7)	**0.011**
Lifetime drug treatment	365 (79.2)	97 (75.7)	45 (77.6)	63 (75.9)	160 (83.3)	0.316

Table 3.3. Bivariate analysis of mobile technology use class by socio-demographic characteristics, HIV risk behaviors, health services utilization, and health outcomes among persons who inject drugs, San Diego, CA. (Continued)

	All subjects (N = 461) N (%)†	Class 1[a] (N = 128) N (%)§	Class 2[b] (N=58) N (%)§	Class 3[c] (N=83) N (%)§	Class 4[d] (N = 192) N (%)§	P - value‖
Health outcomes						
Ever diagnosed with STI (self-report)	184 (39.9)	48 (37.5)	21 (36.2)	37 (44.6)	78 (40.6)	0.680
Ever overdosed on opioids	186 (40.4)	64 (50.0)	27 (46.5)	30 (36.1)	65 (33.8)	**0.020**

[a] Class 1: Minimal mobile technology use
[b] Class 2: Predominantly mobile internet use
[c] Class 3: Predominantly voice, text and connected internet use
[d] Class 4: Maximal mobile technology use

† Column percentages. Totals may vary by subgroup due to missing data
‡ All substance use and risk /harm reduction behaviors refer to the past 6 months, unless otherwise indicated
§ Row percentages represent prevalence of reporting a cell phone at baseline within the groups
|| P-values are based on chi-square and Kruskal-Wallis tests, and demonstrate overall significance of differences between LCA classes by each variable

Table 3.4. Multivariable analysis of factors associated with mobile technology use class membership among persons who inject drugs, San Diego, CA.

Variable	**Class 2[ab] AOR (95% C.I.)[†]**	**Class 3[ac] AOR (95% C.I.)[†]**	**Class 4[ad] AOR (95% C.I.)[†]**
Education			
< High School (ref)	1.00	1.00	1.00
High school or equivalent	0.84 (0.35,2.01)	0.94 (0.46,1.93)	1.25 (0.60,2.59)
> High School	**2.66 (1.13,6.30)**	**2.62 (1.25,5.47)**	**5.23 (2.46,11.09)**
Age (per year)	**0.91 (0.88,0.95)**	**0.95 (0.92,0.98)**	**0.92 (0.89,0.95)**
Own smartphone	0.36 (0.07,1.78)	1.00 (0.35,2.85)	**14.2 (6.37,31.60)**
Homeless (vs. housed)	0.63 (0.29,1.37)	0.56 (0.29,1.07)	**0.30 (0.16,0.57)**
Sold drugs for money past 6 months	**3.52 (1.51, 8.23)**	1.83 (0.82,4.10)	**3.30 (1.53, 7.13)**
Inject methamphetamine daily past 6 months	**5.80 (2.23,15.10)**	**3.54 (1.46,8.60)**	**2.59 (1.02,6.59)**

[a] Class 1: Minimal mobile technology use (reference group)
[b] Class 2: Predominantly mobile internet use
[c] Class 3: Predominantly voice, text and connected internet use
[d] Class 4: Maximal mobile technology use
[†] Variables adjusted for all other variables in the model

REFERENCES

1. Strathdee SA, Hallett TB, Bobrova N, et al. HIV and risk environment for injecting drug users: the past, present, and future. Lancet. 2010;**376**(9737):268-284.

2. Drumm RD, McBride DC, Metsch L, et al. 'The Rock Always Comes First': Drug Users' Accounts About Using Formal Health Care. J Psychoactive Drugs. 2003;**35**(4):461-469.

3. Arnsten JH, Xuan L, Mizuno Y, et al. Factors Associated With Anti retroviral Therapy Adherence and Medication Errors Among HIV-Infected Injection Drug Users. J Acquir Immune Defic Syndr. 2007;**46**(S2):S64-S71.

4. Vera A, Abramovitz D, Lozada R, et al. Mujer Mas Segura (Safer Women): a combination prevention intervention to reduce sexual and injection risks among female sex workers who inject drugs. BMC Public Health. 2012;**12**(1):653-670.

5. Latka MH, Hagan H, Kapadia F, et al. A randomized intervention trial to reduce the lending of used injection equipment among injection drug users infected with hepatitis C. American journal of public health. 2008;**98**(5):853-861.

6. United States Department of Health and Human Services. 2010 [cited 2014 April 25]. Available from: http://www.hrsa.gov/healthit/mhealth.html.

7. Epstein DH, Willner-Reid J, Vahabzadeh M, et al. Real-Time Electronic Diary Reports of Cue Exposure and Mood in the Hours Before Cocaine and Heroin Craving and Use. Arch Gen Psychiatry. 2009;**66**(1):88-94.

8. Moore DJ, Montoya JL, Blackstone K, et al. Preliminary Evidence for Feasibility, Use, and Acceptability of Individualized Texting for Adherence Building for Antiretroviral Adherence and Substance Use Assessment among HIV-Infected Methamphetamine Users. AIDS Res Treat. 2013;**2013**:1-11.

9. Ingersoll K, Dillingham R, Reynolds G, et al. Development of a personalized bidirectional text messaging tool for HIV adherence assessment and intervention among substance abusers. J Subst Abuse Treat. 2014;**46**(1):66-73.

10. Bachman Desilva M, Gifford AL, Keyi X, et al. Feasibility and Acceptability of a Real-Time Adherence Device among HIV-Positive IDU Patients in China. AIDS Res Treat. 2013;**2013**:1-6.

11. McClure EA, Acquavita SP, Harding E, et al. Utilization of communication technology by patients enrolled in substance abuse treatment. Drug Alcohol Depend. 2013;**129**(1-2):145-150.

12. Rice E, Lee A, Taitt S. Cell phone use among homeless youth: potential for new health interventions and research. J Urban Health. 2011;**88**(6):1175-1182.

13. Chander G, Stanton C, Hutton HE, et al. Are smokers with HIV using information and communication technology? Implications for behavioral interventions. AIDS Behav. 2012;**16**(2):383-388.

14. Robertson AM, Garfein RS, Wagner KD, et al. Evaluating the impact of Mexico's drug policy reforms on people who inject drugs in Tijuana, B.C. Mexico, and San Diego, CA, United States: a binational mixed methods research agenda. Harm Reduct J. 2014;**11**(4):14.

15. Roth AM, Armenta RA, Wagner KD, et al. Patterns of drug use, risky behavior, and health status among persons who inject drugs living in San Diego, California: a latent class analysis. Substance use & misuse. 2015;**50**(2):205-214.

16. Vermunt JK. Latent Class Modeling with Covariates: Two Improved Three-Step Approaches. Political Analysis. 2010;**18**(4):450-469.

17. Nylund KL, Asparouhov T, Muthén BO. Deciding on the Number of Classes in Latent Class Analysis and Growth Mixture Modeling: A Monte Carlo Simulation Study. Structural Equation Modeling. 2007;**14**(4):556-569.

18. Gibson WA. Three multivariate models: Factor analysis, latent structure analysis, and latent profile analysis. Psychometrika. 1959;**24**:229-252.

19. Hagenaars JA, McCutcheon AL. Applied latent class analysis. Cambridge, MA: Cambridge University Press; 2002.

20. McCuthcheon AL. Latent class analysis. Newbury Park, CA: Sage.; 1987.

21. Lanza ST, Dziak, J. J., Huang, L., Wagner, A., & Collins, L. M. . PROC LCA & PROC LTA users' guide (Version 1.3.0). University Park: The Methodology Center, Penn State. ; 2012 [cited 2013 November 5]. Available from: http://methodology.psu.edu.

22. Ramaswamy V, DeSarbo, W.S., Reibstein, D.J., & Robinson, W.T. An empirical pooling approach for estimating marketing mix elasticities with PIMS data. Marketing Science. 1993;**12**:103-124.

23. Wurpts IC, Geiser C. Is adding more indicators to a latent class analysis beneficial or detrimental? Results of a Monte-Carlo study. Frontiers in psychology. 2014;**5**:920.

24. Pew Research Center. Mobile Technology Fact Sheet: Pew Research Center's Internet and American Life Project. 2014. http://www.pewinternet.org/fact-sheets/mobile-technology-fact-sheet/.

25. Collins K, Abravomitz D, Zuniga P, et al. Mobile Phone Use among PWID in Tijuana, BC, Mexico. Unpublished Data. 2015.

26. Goldstein A. Heroin addiction: neurobiology, pharmacology, and policy. J Psychoactive Drugs. 1991;**23**(2):123-133.

27. National Institute on Drug Abuse. Methamphetamine Available from: http://www.drugabuse.gov/drugs-abuse/methamphetamine.

28. Kelly BC, LeClair A, Parsons JT. Methamphetamine use in club subcultures. Substance use & misuse. 2013;**48**(14):1541-1552.

29. Costello D. Once a party drug, meth moves into the workplace. Los Angeles Times. 2004 September 13, 2005.

30. Sims C. Schools Responding to Beeper, Tool of Today's Drug Dealer, by Banning it. New York Times. 1988 September 25, 1988.

31. Natarajan M, Clarke RV, Johnson BD. Telephones as facilitators of drug dealing. European Journal on Criminal Policy and Research. 1995;**3**(3):137-153.

32. Zacharanda S. The UK's Drug Dealers Are Swapping Crack for Nokia 8210s. *VICE.* 2015. http://www.vice.com/read/the-uks-drug-dealers-love-the-nokia-8210-988. Accessed March 29, 2015.

33. Madray H, van Hulst Y. Reducing HIV/AIDS high-risk behavior among injection drug users: peers vs. education. Journal of drug education. 2000;**30**(2):205-211.

34. Strathdee SA, Abramovitz D, Lozada R, et al. Reductions in HIV/STI incidence and sharing of injection equipment among female sex workers who inject drugs: results from a randomized controlled trial. PloS one. 2013;**8**(6):e65812.

CHAPTER 4: LONGITUDINAL CORRELATES OF SMARTPHONE OWNERSHIP AMONG PERSONS WHO INJECT DRUGS IN SAN DIEGO, CALIFORNIA

ABSTRACT

Background: Mobile health (mHealth) intervention strategies have the potential to help facilitate a reduction in risk behavior, improve linkages to health care, and increase continuity in care among persons who inject drugs (PWID). To determine the feasibility of delivering such interventions using smartphone technology, we assessed smartphone ownership over time among a cohort of PWID in San Diego, CA.

Methods: Beginning in June 2011, PWID were recruited into a cohort study in San Diego, which included interviewer-administered risk assessments and serologic testing at baseline and semiannual follow-up visits. We analyzed longitudinal data from baseline, 6-, 12-, and 18-month study visits to determine factors associated with smartphone ownership using generalized estimating equations.

Results: Among the 291 participants who completed a 6-month follow up visit, 75% were male and had a mean age of 45.6 years (range: 19-70). In multivariable analysis, after adjusting for baseline smartphone ownership and time since last visit, smartphone ownership was independently associated with having more than a high school education (AOR=2.01 95% CI=1.31, 3.33) and being married or having a committed partner (AOR=0.61, 95% CI=0.43, 0.89). Homelessness (AOR=0.61, 95% CI=0.43,0.89) and injecting heroin daily (AOR=0.38, 95% CI=0.24, 0.62) were associated with lower odds of smartphone ownership. For each 5-year increase in age, there was an 11% decrease in the odds of owning a smartphone.

Conclusion: Findings suggest that younger PWID and those with a higher SES own smartphones. However, frequent heroin injectors with a more severe addiction and homeless PWID may not be reachable via smartphone based interventions that rely on a participant's own device. Provision of devices may be needed for some participants to ensure the generalizability of research studies and inclusivity of interventions involving smartphones among PWID.

INTRODUCTION

Persons who inject drugs (PWID) are at an increased risk for infection with blood borne pathogens such as human immunodeficiency virus [HIV] and hepatitis C virus [HCV]. [1] This disease risk has been attributed to risky injection behaviors such as sharing drug paraphernalia (e.g., cookers, cotton and water) and injection equipment (e.g., syringes and needles)[1]. PWID also have low access to health care services[2] and are at increased risk for loss to follow-up during treatment.[3] Some intervention approaches have proven successful for reducing risk and increasing access to care among PWID;[4,5] however, due to competing risks to safe injection behaviors, these interventions have not had lasting impacts on changing the culture of risky injection practices. For example, a 2010 cross-sectional study of 510 young adult PWID in San Diego, reported that 49% of participants receptively shared syringes and that 68% shared injection paraphernalia.[6] Thus, novel approaches to intervention delivery are needed to increase prevention effectiveness among PWID.

Mobile Health (mHealth) strategies, or the use of mobile and wireless devices to improve health outcomes, health care services, and health research,[7] have the potential to promote a reduction in risk behaviors and increase access and continuity of health care for PWID. However, little is known regarding the feasibility and acceptability of mHealth strategies to reduce risk behaviors and improve health outcomes among persons actively injecting drugs (i.e. those not seeking drug treatment). Technology based intervention methods have proven successful in research among various substance using populations. For example, text-messaging interventions have been used to successfully increase HIV anti-retroviral therapy (ART) adherence among non-injection substance users.[8,9] For example, Moore et al. reported preliminary evidence of feasibility and acceptability of an SMS intervention to gather data on methamphetamine use and provide adherence reminders among persons living with HIV infection and recent methamphetamine use.[8] Additionally, Ingersoll et al. developed a personalized, bidirectional text messaging assessment to promote ART adherence and abstinence from substances among non-adherent substance users in Virginia; preliminary results from this randomized controlled trial (RCT) also demonstrate feasibility and acceptability among study participants.[9] Primary outcomes of efficacy for both trials are not yet available. Additionally, Epstein et al. reported feasibility and acceptability of a smartphone based geographical momentary assessment (GMA) and ecological momentary assessment (EMA) to identify spatial and mood associations with drug cravings among poly-drug users enrolled in methadone matience.[10] Lastly, Philips et al. found that a video-based, smartphone-delivered HIV risk-reduction intervention was feasible and acceptable among individuals attending an addictions treatment clinic.[11] They concluded that video-based mobile HIV risk reeducation (mHIVRR) education delivered via smartphone was acceptable, feasible and may increase HIV/STD risk reduction knowledge. Future RCT studies with pre-intervention assessments of knowledge are needed to confirm these findings.[11]

Data regarding mobile technology use among other high-risk individuals suggests that these populations may have access to mobile technology.[17-19] For example, McClure et al. reported that 91% of substance users enrolled in drug treatment in Baltimore had access to a cell phone and 79% used their cell phones for text messaging.[12] Rice et al. reported that among a study of homeless youth in Los Angeles (of which 55% used an illicit substance in the past 30 days), 62% owned a cell phone, though they did not specify whether it was a smartphone.[13] In terms of cell phone ownership among PWID in San Diego, our previous research found that at baseline, 92% reported ever owning a cell phone; 66% reported currently owning a cell phone and 29% reported currently owning a smartphone. Of current cell phone owners, 40% had a contract plan and 39% had pre-paid cell service. Additionally, 70% of participants reported ever losing a cell phone, and 56% reported ever having a cell phone stolen.[14]

Correlates of smartphone ownership in this population have not been previously assessed; thus, this analysis aimed to: 1) quantify and characterize PWID who own smartphones in San Diego County, and 2) identify factors associated with smartphone ownership over time. We hypothesized that PWID who reported owning a smartphone would be younger and of higher socioeconomic status than those who do not report owning a smartphone. The results of this analysis will help elucidate how smartphone ownership differs among specific subgroups of PWID to determine if their use would be feasible when developing interventions to reduce risky behaviors and increase adherence to treatment and other services. It will also identify key groups of PWID who do not own smartphones and who may be excluded from future participation in these studies and/or interventions.

METHODS

Study Population and Recruitment

Data for this study come from the Study of Tuberculosis AIDS, and Hepatitis C Risk (STAHR-II) among PWID in San Diego County. STAHR-II is a prospective cohort study that enrolled participants between June 2012 and January 2014, as previously described.[15] Eligibility criteria included: 1) age $\geq$18 years; 2) injected drugs within the past month (confirmed by observation of track marks or other physical evidence of recent injection); 3) spoke English or Spanish; 4) San Diego County resident without plans to relocate over the next 24 months; 5) not participating in an intervention study related to their drug use or disease status; 6) agreed to a blood draw for serologic testing; and 7) willing to provide written informed consent. At enrollment, participants were screened for eligibility, study protocols were explained, and informed consent was obtained prior to data collection.

Behavioral assessment and serologic testing for HIV and HCV were completed at baseline and participants completed follow-up assessments every six months for a period of two years (five visits total). At each follow-up visit, eligible participants completed a behavioral assessment to assess changes in behaviors during the six months prior to each interview. To identify incident infections, if their previous test result was non-reactive, they also underwent serologic testing for HIV and HCV if their previous test result was negative to identify incident infections. The incentive schedule for each study visit has been previously described.[16] The institutional review board at the University of California San Diego approved this study.

Participants were recruited using targeted outreach including word-of-mouth, street outreach, and targeted advertising in areas known for high drug use. Interviews were conducted at a storefront office or in a mobile van that parked in neighborhoods throughout the county. During the baseline visit, all enrolled participants completed a standard contact sheet that included name, address, phone number, and contact information for the participant and up to three additional people for whom we had participant consent to contact to remind participants about their appointments. Additionally, information about locations the participant frequented, and defining marks such as tattoos and scars were also recorded to assist in retention efforts. All participants were given an appointment reminder card at each visit and sent reminder postcards two weeks prior to each visit. Birthday and holiday cards were also sent from the study to maintain rapport and contact with participants. To increase retention the outreach team also visited the local syringe exchange program weekly, and took the mobile unit to locations where participants were recruited.

Data Collection and Laboratory Methods

Interviews were administered using computer assisted personal interviewing (CAPI) software and were completed by trained interviewers who entered participant responses on a laptop computer. Methods describing HIV and HCV antibody testing have been reported elsewhere.[15] Participants received pre- and post-test counseling and test results were provided three weeks following each appointment. All participants testing negative for HIV and HCV at any visit were retested at subsequent follow-up visits. Those testing positive were referred to free or reduced cost health services (e.g., county clinics, community clinics, etc.). In addition, study staff referred participants to local social services if requested (e.g., housing, mental health services, food distribution centers, etc.)

Study Measures

The outcome of interest was smartphone ownership as measured at the 6-, 12-, and 18-month interview visits. Other measures for this study come from the 6-, 12-, and 18-month interviews with baseline measures used as covariates in the analysis. Baseline measures include age, gender, race/ethnicity, educational attainment, country born, marriage status, and smartphone ownership. Other socio-demographic measures included from the 6-, 12-, and 18-month interviews were: self-reported homelessness (e.g., considered themselves homeless in the past 6 months, 0=no, 1=yes), source of income (1=legal regular source, 2=legal irregular source and 3=illegal source) and average annual income (> $10,000 vs. <$10,000). Self-reported injection-related risk behaviors were assessed at each follow-up visit including the following: receptive syringe sharing (yes vs. no), cooker/cotton/rinse water sharing (yes vs. no), and selling drugs for money in the past 6 months (yes vs. no). In our 6-month data, approximately half of participants were missing data on sharing injection paraphernalia due to skip pattern errors. Therefore, we carried their baseline observation forward to account for missing data. Other substance use variables include the following: frequency of injecting heroin, methamphetamine, and crack/cocaine (daily vs. less than daily), and use of the syringe exchange program in the last 6 months. As sex workers may be more reliant on owning a smartphone to access clients, sexual risk behavior variables included engaging in sexual activities for money or other goods in the last 6 months. Health care utilization was assessed as any hospitalization or emergency department visits in the past 6 months. To assess health outcomes associated with smartphone ownership, opioid overdose and abscesses in the last 6 months (yes vs. no) were assessed. Also, HIV and HCV prevalence and incidence were included from serologic testing. Participants who tested HIV or HCV positive at baseline were considered prevalent cases. Those testing positive at any follow up visit were considered incident for that visit and prevalent thereafter. Because incident infections were low, this study only had power to assess associations with prevalent HIV and HCV infections at baseline.

Statistical Analysis

As the STAHR-II study was ongoing at the time of this analysis (with 6 and 12 month interviews closed to follow up), we used data from the 6-, 12-, and 18-month follow up visits for this analysis. The median number of follow-up visits was 2 and median time between follow up visits was 6.1 months. Follow-up rates were 51% at first follow-up visit and 49% at the second follow-up visit; 65% had completed at least one follow-up visit. Eighteen and 24-month follow-up visits are ongoing. Due to low study retention, we first compared the socio-demographic and behavioral characteristics to smartphone ownership at the 6-month follow-up visit, and conducted a naïve cross-sectional analysis not taking repeated measures into account. Pearson's chi-square tests were used for categorical variables and wilcoxon rank sum tests were used to compare continuous variables with our outcome. We then further examined bivariate associations between socio-demographic and substance use characteristics with smartphone ownership longitudinally. Our data included repeated measures at three time points; therefore, we used generalized estimating equations (GEE) with a logit link for binary outcomes to account for correlated data within participants. GEE methods provide standard errors for multiple observations per person using the variance-covariance matrix. The best fitting variance-covariance matrix was chosen based on parameters in the data by comparing the quasi-likelihood information criterion (QIC).[17] Based on these criteria, our models use the exchangeable variance-covariance matrix. Time was calculated as time since last visit, which ranged from 4 months to 18 months. Bivariate GEE models were controlled for time; multivariable models were controlled for baseline smartphone ownership and time. Variables that were significant with p=0.10 in bivariate analyses were considered for inclusion in multivariate logistic GEE analysis. Forward stepwise model building was conducted and confounding was assessed by determining changes in in the odds ratio of greater than 10%. Variables with a p-value<0.05 were maintained in the final model. All analyses were conducted using SAS software version 9.3 (SAS, Cary, NC).

RESULTS

Sample characteristics

Among those who completed the 6 months assessment, 75% were male with a mean age of 45.6 (sd 11.3; range 19-70). A majority of participants reported being homeless (60.0%) and 94% of participants reported a yearly income less than $10,000. Sharing of syringes and other injection paraphernalia was common; 27% and 67% of participants reported sharing any, respectively. Twenty-nine percent of participants injected heroin daily in the past 6 months; 10% injected methamphetamine daily. Further, 8% of participants overdosed on opioids in the past 6 months, and 34% reported having an abscess in the past 6 months. There was 1 incident case of HIV and 12 incident cases of HCV infection during the follow-up period. Additional characteristics of participants at each follow-up visit and a lost-to-follow-up analysis assessing differences in baseline characteristics between PWID who were lost to follow up and those who completed at least one follow up visit were reported elsewhere.[18]

Participants who reported smartphone ownership at their 6-month interview were slightly younger [mean age: 43.0 (sd=10.9) vs. 46.9 (sd=11.3)] than those who did not. Higher education (odds ratio [OR]=2.21, 95% confidence interval [CI]=1.20, 4.06), country of birth ("other" country vs. U.S.) [OR=4.7, 95% CI=1.38, 16.1] and HIV positivity (OR=2.95, 95% CI, 1.39, 6.25) were associated with higher odds of smartphone ownership. Conversely, those who were homeless (OR=0.50, 95% CI, 0.30, 0.83), injected heroin daily (OR=0.52, 95% CI, 0.29, 0.94), or had HCV infection (OR=0.38, 95% CI, 0.27, 0.66) were less likely to own a smartphone in the prior 6 months. There were no differences in gender, race/ethnicity, average income, or marital status among participants who reported smartphone ownership compared to those who did not.

Longitudinal correlates of smartphone ownership

Table 2 provides unadjusted longitudinal analyses using GEE to determine associations with smartphone ownership. A total of 93 (32%), 123 (46%), and 101 (46%) participants reported smartphone ownership at the 6-, 12-, and 18-month follow-up visits, respectively. Additionally, there were not a significant difference in reported smartphone ownership between visits among participants who returned for all three 6-, 12, and 18-months visits. Bivariate analyses indicate that PWID who reported smartphone ownership were more likely to be married or have a committed partner (OR=1.45, 95% CI=1.08, 1.95), transgender (OR=7.95, 95% CI=1.06, 57.8), have more than a high school education (OR=2.69 95% CI=1.74, 4.15), and have used their cell phone to access the internet (OR=6.06, 95% CI= 4.19, 8.87), make phone calls daily (OR=6.62, 95% CI= 4.16, 10.5), and text message daily (OR=5.38 95% CI= 3.65, 7.93) in the past 6 months. There was a 14% decrease in the odds of smartphone ownership for each 5-year increase in age (OR=0.85 per 5 years, 95% CI=(0.80, 0.93). Homelessness in the past 6 months (OR=0.64, 95% CI= 0.48, 0.88), injecting heroin daily in the past 6 months (OR=0.52, 95% CI= 0.36, 0.75), and HCV infection (OR=0.38, 95% CI= 0.26, 0.56) were inversely associated with smartphone ownership.

In multivariable analysis, after adjusting for ‘time since last interview’ and smartphone ownership at baseline (table 3), PWID who had more than a high school education (adjusted odds ratio [AOR]=2.01 95% CI=1.31, 3.33) and those who were married or had a committed partner (AOR=0.61, 95% CI=0.43, 0.89) were more likely to own a smartphone. Homelessness (AOR=0.61, 95% CI=0.43, 0.89) and injecting heroin daily (AOR=0.38, 95% CI=0.24, 0.62) were associated with lower odds of smartphone ownership. Also, for each 5-year increase in age, there was an 11% decrease in the odds of owning a smartphone.

DISCUSSION

This study found that less than half (32% to 46%) of PWID in San Diego owned a smartphone in the six months prior to each follow-up visit. Smartphone ownership was independently associated with higher educational attainment, younger age, being married or have a committed partner, being housed and injecting heroin less than daily.

In longitudinal analyses, individuals who reported homelessness were 40% less likely than their housed counterparts to report smartphone ownership. By contrast, it is estimated that over 58% of all adults and 47% of adults making less than $30,000 a year in the U.S. owned a smartphone in 2014.[19] Homeless PWID may have less access to the resources required for owning and maintaining a mobile device and service plan. While income is a significant factor in determining smartphone ownership, unstably housed persons may have difficulty protecting their device from theft and keeping it charged, which could also impact smartphone ownership. Our results indicate that due to the generally low SES of our study population and the fact that low SES is typical with other cohorts of PWID,[20] access to mobile technology will need to be considered when developing interventions for this population.

Smartphone ownership has become nearly ubiquitous in the U.S. among young, educated individuals. The Pew Research Center Global Attitudes Project reported that 83% of adults ages 18-29 years, and 71% of adults with more than a high school education had a smartphone in 2014.[19] Similarly, in this study, younger age and higher education (specifically having more than a high school education) were independently associated with an increased odds of smartphone ownership. This finding is consistent with our previous research showing that younger age and higher education were associated with high mobile technology use (e.g., voice, text, and mobile internet use) among PWID in San Diego.[14] Studies among other high-risk populations in the U.S. (e.g., homeless youth, substance users, people living with HIV), also show that younger age and higher education are associated with increased cell phone ownership and use.[12,13,21,22]

This study also found that those who were married or had a committed partner were more likely to own a smartphone than single PWID. In 2014, Pew found that compared to 91% of adults overall, 93% of those who were married or in committed relationships owned a cell phone.[23] Consistent with national data regarding marriage and wealth, in the context of this study, marriage may be acting as a proxy for stability and higher SES among PWID in San Diego. The National Longitudinal Survey of Youth (NLSY79), which tracks individuals in the 20s, 30s and early 40s, reported that married respondents experienced per person total net worth increases of 77% over unmarried respondents. They also found that wealth increased on average by 16% for each year that a person stayed married.[24] Also, according to the U.S. Census Bureau, in 2010 the median net worth for a married couple between the ages of 55 and 64 was approximately $261,000 compared to $71,000 for a single man heading a household, and $39,000 for a single woman heading a household.[25] Married PWID in this study potentially have more income available to afford the costs associated with smartphone ownership and thus more likely to maintain a device over time compare to single PWID.

Lastly, participants who inject heroin at least once daily were significantly less likely to own a smartphone. This finding is consistent with previous research that shows daily injectors were less likely to report a cell phone number among PWID in Tijuana.[22] Daily use of heroin indicates an established addiction to the drug. The National Institutes on Drug Abuse characterizes heroin addiction as a relapsing disease characterized by uncontrollable drug-seeking behavior, no matter the consequences.[26] Individuals experiencing this level of dependence may not likely make maintaining a smartphone or data plan a high priority over feeding their drug habit.

STUDY LIMITATIONS

These findings must be interpreted with some limitations in mind. First, our reliance on participant recall may have introduced bias into the data and lead to smaller odds ratios or weakened associations with smartphone ownership. However, a short recall period (six months) was used to minimize recall bias. Due to the convenience sampling method used to recruit study participants for STAHR-II, these data might not be generalizable across all PWID in San Diego. However, sampling and recruitment were designed to reach a variety of PWID across varying backgrounds and socioeconomic status to increase generalizability. Although our data are longitudinal, our results do not indicate causality between covariates and smartphone ownership. Also, while our data suffered from loss of follow-up, associations reported in these analyses are representative of participants retained in the study. Previously described loss to follow-up analyses detected no statistical difference in smartphone ownership over time, and minimal statistical differences in terms of other reported drug use and risk behaviors between those who were retained for at least one follow up visit and those who were lost to follow up.[18] Further, in our 6-month data, about half of participants were missing data on sharing injection paraphernalia and we carried their baseline observation forward to account for missing data. While carrying forward the last observation can produce biased results,[27] behaviors among PWID were fairly consistent across time in this study.

CONCLUSIONS

mhealth interventions designed for PWID will need to consider levels of cell phone coverage for this low SES, high risk population. While the finding that SES and housing status were associated with smartphone ownership was not unexpected, this is the first study to our knowledge to quantify this association among PWID. These findings, suggest that while young and more educated PWID do seem to have some familiarity with smartphone technology, frequent injectors with a more severe heroin addiction or more marginalized participants such as homeless PWID may not be reachable via smartphone-based interventions that rely on a participants' own devices. Researchers and interventionists should consider the need to provide devices and service plans to participants targeted for smartphone-based research and interventions among PWID.

ACKNOWLEDGEMENTS

We wish to thank the STAHR-II staff without whom this analysis would not be possible. The authors would like to thank the participants, community advisory board, and community collaborators for their invaluable contributions to this study. Funding for this study was provided by the National Institutes of Drug Abuse ([NIDA] R01 DA031074). KC received additional support from a NIDA training grant (T32 DA023356).

Chapter 4, in full, is a reprint of the material being prepared for submission to the Journal of Substance Use and Misuse: Collins KM, Armenta R, Cuevas-Mota J, Liu L, Strathdee SA, Garfein RS. “Longitudinal correlates of smartphone ownership among persons who inject drugs in San Diego, CA.”

Table 4.1. Descriptive statistics by smartphone ownership at 6-month follow-up visit among people who inject drugs: San Diego, CA

	Total N=291 N(%)[†]	Own Smartphone Yes N=93 N(%)[§]	No N=198 N(%)[§]	OR	(95%C.I.)	P-value[‖]
Socio-demographic factors						
Mean age, years (SD)	45.6(11.3)	43.0(10.9)	46.9(11.3)	0.70	(0.95, 0.99)	**0.005**
Gender						0.190
Male (Ref)	218(74.9)	67(72.0)	151(76.3)	-	-	
Female	69(23.7)	23(24.7)	46(23.2)	1.13	(0.63,2.00)	
Transgender	4(1.37)	3(3.2)	1(0.5)	6.76	(0.69, 66.2)	
Race/Ethnicity (n=290)						0.861
White (Ref)	146(50.3)	48(51.6)	98(49.8)	-	Ref	
Hispanic	84(29.0)	28(30.1)	56(28.4)	1.02	(0.58, 1.80)	
Black	32(11.0)	10(10.7)	22(11.2)	0.93	(0.41, 2.11)	
Other	28(9.7)	7(7.5)	21(10.7)	0.68	(0.27, 1.71)	
Annual Income (n=290)						0.906
$0-10,000 (Ref)	272(93.7)	87(93.6)	185(93.9)	-	-	
> $10,000	18(6.2)	6(6.5)	12(6.1)	1.06	(0.39, 2.93)	
Educational Attainment (n=290)						**0.031**
< High School (Ref)	95(32.8)	23(24.7)	72(36.6)	-	-	
High school or equivalent	91(31.4)	27(29.0)	64(32.5)	1.32	(0.69, 2.52)	
> High School	104(35.9)	43(46.2)	61(31.0)	2.21	(1.20, 4.06)	
Considered themselves homeless (vs. stably housed)	174(59.8)	45(48.39)	129(65.2)	0.50	(0.30, 0.83)	**0.007**
Country of birth (n=290)						**0.011**
U.S. (Ref)	272(93.8)	81(87.1)	191(97.0)	-	-	
Mexico	6(2.1)	4(4.3)	2(1.0)	4.7	(0.85, 26.3)	
Other	12(4.2)	8(8.6)	4(2.0)	4.7	(1.38, 16.1)	
Married or have a committed partner (vs. unmarried) (n=282)	113(40.1)	42(45.7)	71(37.4)	0.71	(0.43, 1.18)	0.183
Technology use-related factors[‡]						
Ever lost a cell phone (n=199)	52(26.1)	20(31.5)	32(30.2)	0.63	(0.33, 1.21)	0.164
Ever had a cell phone stolen (n=199)	43(21.6)	21(22.6)	22(20.8)	1.11	(0.57, 2.19)	0.755
Accessed the internet on a cell phone (n=289)	145(50.2)	78(83.9)	67(34.2)	10.0	(5.4, 18.7)	**<.0001**
Made calls daily on cell phone (n=260)	191(73.5)	89(96.7)	102(60.7)	19.2	(5.8, 63.2)	**<.0001**
Sent text messages daily on cell phone (n=259)	164(63.3)	82(90.1)	82(48.8)	9.6	(4.5, 20.3)	**<.0001**
Substance abuse-related factors[‡]						
Received something in exchange for sex (n=288)	23(8.0)	6(6.5)	17(8.8)	0.74	(0.28, 1.92)	0.530
Sold drugs for money (n=289)	61(21.1)	43(21.8)	18(19.6)	0.87	(0.47, 1.61)	0.661
Used syringe exchange program	168(57.7)	59(63.4)	109(55.1)	1.42	(0.85, 2.35)	0.177
Shared syringes						**0.002**
No (Ref)	92(31.6)	27(29.0)	65(32.8)	-	-	
Yes	78(26.8)	37(39.8)	41(20.7)	2.17	(1.16, 4.09)	
Unknown	29(31.2)	29(31.2)	92(46.5)	0.76	(0.41, 1.40)	
Shared other injection paraphernalia						0.883
No (Ref)	81(27.8)	26(28.0)	55(27.8)	-	-	

Table 4.1. Descriptive statistics by smartphone ownership at 6-month follow-up visit among people who inject drugs: San Diego, CA. (Continued)

	Total N=291 N(%)†	Own Smartphone Yes N=93 N(%)§	No N=198 N(%)§	OR	(95%C.I.)	P-value‖
Yes	197(66.7)	61(65.6)	133(67.2)	0.97	(0.56, 1.69)	
Unknown	16(5.5)	6(6.5)	10(5.1)	1.27	(0.42, 3.87)	
Injected methamphetamine daily, last 6 months	29(10.0)	12(12.9)	17(8.6)	1.60	(0.72, 3.45)	0.252
Injected heroin daily, last 6 months	84(28.9)	19(20.4)	65(32.8)	0.52	(0.29, 0.94)	**0.030**
Health care utilization and health status‡						
≥1 Hospitalization, past 6 months	68(23.4)	26(28.0)	42(21.2)	1.44	(0.82, 2.54)	0.205
≥1 Emergency Room visit, past 6 months	124(42.6)	37(39.8)	87(43.9)	0.84	(0.51, 1.39)	0.504
Baseline HIV Results						**0.006**
Non Reactive (Ref)	204(70.1)	54(58.1)	150(75.8)	-	-	
Prevalent	33(11.3)	17(18.3)	16(8.1)	2.95	(1.39, 6.25)	
Baseline HCV Results (n=279)						**0.002**
Non Reactive (Ref)	86(30.8)	38(44.7)	48(24.7)	-	-	
Prevalent	181(64.9)	42(49.4)	139(71.7)	0.38	(0.22, 0.66)	
Abscess	98(33.8)	30(32.3)	68(34.5)	0.90	(0.53, 1.53)	0.704
Overdosed on opioids	23(8.0)	6(6.5)	17(8.7)	0.72	(0.28, 1.90)	0.507

† All technology use, substance use, and health care behaviors refer to the past 6 months, unless otherwise indicated

‡ P-values are based on chi-square tests, non-parametric Wilcoxon rank sum tests or Fisher's Exact test, and demonstrate overall significance of differences between owning a smartphone (yes vs. no) by each variable.

Table 4.2. Bivariate analysis of factors associated with smartphone ownership at any follow-up visit among persons who inject drugs in San Diego, CA.

	OR‡	95% C.I.	P-Value
Socio-demographic characteristics			
Gender			
Male (Ref)	-	-	**-**
Female	0.83	(0.55, 1.25)	0.370
Transgender	7.95	(1.09, 57.8)	**0.041**
Age (per 5 years)	0.86	(0.80, 0.93)	**<0.001**
Race/Ethnicity			
White (Ref)	-	-	-
Hispanic	0.75	(0.49, 1.14)	0.180
Black	0.78	(0.40, 1.50)	0.454
Other	0.73	(0.40, 1.36)	0.324
Educational Attainment			
< High School (Ref)	-	-	-
High school or equivalent	1.49	(0.94,2.37)	**0.093**
> High School	2.69	(1.74,4.15)	**<.0001**
Annual Income			
$0-10,000 (Ref)	-	-	-
> $10,000	1.56	(0.97, 2.49)	**0.066**
Homeless (vs. housed)	0.65	(0.48, 0.88)	**<0.01**
Country of Birth (U.S. vs Mexico)	0.88	(0.26, 2.92)	0.829
Married or have a committed partner (vs. unmarried)	1.45	(1.08, 1.95)	**0.013**
Substance Use Related Factors†			
Used syringe exchange program			
Any vs. None	0.93	(0.68, 1.29)	0.677
Unknown vs. None	1.24	(0.79, 1.95)	0.347
Shared syringe			
Any vs. None	1.01	(0.73, 1.34)	0.970
Unknown vs. None	0.62	(0.44, 0.88)	**<0.01**
Received something in exchange for sex	1.06	(0.64, 1.77)	0.814
Sold drugs for money	1.12	(0.75, 1.66)	0.579
Injected heroin daily (vs. <daily)	0.52	(0.36, 0.75)	**<.001**
Injected methamphetamine daily (vs. <daily)	1.34	(0.85 2.11)	0.210
Health care utilization and health status†			
≥1 Hospitalization	1.08	(0.78, 1.50)	0.644
≥1 Emergency Room visit	0.81	(0.61, 1.07)	0.137
Hepatitis C results			
Non-reactive (Ref)	-	-	**-**
Prevalent	0.39	(0.26, 0.58)	**<.0001**
Abscess	0.85	(0.61, 1.19)	0.343
Overdosed on opioids	0.72	(0.42, 1.24)	0.238

† All technology use, substance use, and health care behaviors refer to the past 6 months, unless otherwise indicated
‡ Odds ratios are adjusted for time since last interview and generalized estimating equations analysis to adjust for intraclass correlations.

Table 4.3. Multivariable analysis of factors associated with smart phone ownership among persons who inject drugs, San Diego, CA.

Variable‡	AOR†	95% C.I.	P-Value
Age (per 5 years)	0.89	(0.81, 0.98)	0.014
Educational Attainment			
< High School (Ref)	-	-	-
High school or equivalent	1.35	(0.80, 2.27)	0.263
> High School	2.09	(1.31, 3.33)	<0.01
Homeless (vs. housed)	0.61	(0.43, 0.89)	<0.01
Married or have a committed partner (vs. unmarried)	1.48	(1.05, 2.09)	0.024
Injected Heroin Daily	0.38	(0.24, 0.62)	<0.001

† Odds ratios are adjusted for all other variables in the table and generalized estimating equations analysis to adjust for intraclass correlations.
‡ All variables were adjusted for baseline smartphone ownership and time since last interview

REFERENCES

1. Strathdee SA, Hallett TB, Bobrova N, et al. HIV and risk environment for injecting drug users: the past, present, and future. Lancet. 2010;376(9737):268-284.

2. Drumm RD, McBride DC, Metsch L, et al. 'The Rock Always Comes First': Drug Users' Accounts About Using Formal Health Care. J Psychoactive Drugs. 2003;**35**(4):461-469.

3. Arnsten JH, Xuan L, Mizuno Y, et al. Factors Associated With Anti retroviral Therapy Adherence and Medication Errors Among HIV-Infected Injection Drug Users. J Acquir Immune Defic Syndr. 2007;**46**(S2):S64-S71.

4. Vera A, Abramovitz D, Lozada R, et al. Mujer Mas Segura (Safer Women): a combination prevention intervention to reduce sexual and injection risks among female sex workers who inject drugs. BMC Public Health. 2012;**12**(1):653-670.

5. Latka MH, Hagan H, Kapadia F, et al. A randomized intervention trial to reduce the lending of used injection equipment among injection drug users infected with hepatitis C. American journal of public health. 2008;**98**(5):853-861.

6. Garfein RS, Rondinelli A, Barnes RF, et al. HCV infection prevalence lower than expected among 18-40-year-old injection drug users in San Diego, CA. J Urban Health. 2013;**90**(3):516-528.

7. United States Department of Health and Human Services. 2010 [cited 2014 April 25]. Available from: http://www.hrsa.gov/healthit/mhealth.html.

8. Moore DJ, Montoya JL, Blackstone K, et al. Preliminary Evidence for Feasibility, Use, and Acceptability of Individualized Texting for Adherence Building for Antiretroviral Adherence and Substance Use Assessment among HIV-Infected Methamphetamine Users. AIDS Res Treat. 2013;**2013**:1-11.

9. Ingersoll K, Dillingham R, Reynolds G, et al. Development of a personalized bidirectional text messaging tool for HIV adherence assessment and intervention among substance abusers. J Subst Abuse Treat. 2014;**46**(1):66-73.

10. Epstein DH, Willner-Reid J, Vahabzadeh M, et al. Real-Time Electronic Diary Reports of Cue Exposure and Mood in the Hours Before Cocaine and Heroin Craving and Use. Arch Gen Psychiatry. 2009;**66**(1):88-94.

11. Phillips KA, Epstein DH, Mezghanni M, et al. Smartphone Delivery of Mobile HIV Risk Reduction Education. AIDS research and treatment. 2013;**2013**:231956.

12. McClure EA, Acquavita SP, Harding E, et al. Utilization of communication technology by patients enrolled in substance abuse treatment. Drug Alcohol Depend. 2013;**129**(1-2):145-150.

13. Rice E, Lee A, Taitt S. Cell phone use among homeless youth: potential for new health interventions and research. J Urban Health. 2011;**88**(6):1175-1182.

14. Collins KM, Armenta RF, Liu L, et al. A Latent Class Analysis of Mobile Technology Use among Persons Who Inject Drugs in San Diego, CA: Informing Potential for mHealth Interventions. . Unpublished Data. 2015.

15. Robertson AM, Garfein RS, Wagner KD, et al. Evaluating the impact of Mexico's drug policy reforms on people who inject drugs in Tijuana, B.C., Mexico, and San Diego, CA, United States: a binational mixed methods research agenda. Harm reduction journal. 2014;**11**:4.

16. Robertson AM, Garfein RS, Wagner KD, et al. Evaluating the impact of Mexico's drug policy reforms on people who inject drugs in Tijuana, B.C. Mexico, and San Diego, CA, United States: a binational mixed methods research agenda. Harm Reduct J. 2014;**11**(4):14.

17. Pan W. Akaike's information criterion in generalized estimating equations. Biometrics. 2001;**57**(1):120-125.

18. Armenta RF, Lemus H, Strathdee S, et al. Predictors of prefilled syringe use among persons who inject drugs in San Diego, CA. Unpublished Data. 2015.

19. Pew Research Center. Mobile Technology Fact Sheet: Pew Research Center's Internet and American Life Project. Pew Research Center, 2014.

20. Strathdee SA, Hallett TB, Bobrova N, et al. HIV and risk environment for injecting drug users: the past, present, and future. Lancet. 2010;**376**:268-284.

21. Chander G, Stanton C, Hutton HE, et al. Are smokers with HIV using information and communication technology? Implications for behavioral interventions. AIDS Behav. 2012;**16**(2):383-388.

22. Collins K, Abravomitz D, Zuniga P, et al. Mobile Phone Use among PWID in Tijuana, BC, Mexico. Unpublished Data. 2015.

23. Pew Research Center. Couples, the Internet, and Social Media. How American couples use digital technology to manage life, logistics, and emotional intimacy within their relationships. 2014.

24. Zagorsky JL. Marriage and divorce's impact on wealth. Journal of Sociology. 2005;**41**:406-424.

25. Lin A. Why married people tend to be wealthier: its complicated. *TODAY Money.* 2013. http://www.today.com/money/why-married-people-tend-be-wealthier-its-complicated-1C8364877. Accessed March 30, 2015.

26. National Institute on Drug Abuse. Heroin. http://www.drugabuse.gov/publications/drugfacts/heroin. Accessed March 30, 2015.

27. Streiner DL. Missing data and the trouble with LOCF. Evidence-based mental health. 2008;**11**(1):3-5.

CHAPTER 5: DISCUSSION

MOBILE TECHNOLOGY USE AMONG PERSONS WHO INJECT DRUGS IN SAN DIEGO, CA AND TIJUANA, BC, MX.

OVERVIEW

This dissertation research was undertaken to better understand mobile technology use and smartphone ownership among PWID in San Diego, California and Tijuana, Baja California, Mexico. The following aims were addressed by this research: **Aim 1:** To determine the prevalence and identify correlates of reporting a cell phone number as contact information among PWID living in Tijuana. **Aim 2:** To determine classes of mobile technology use behavior among PWID living in San Diego, and identify correlates associated with these classes. **Aim 3:** To determine the longitudinal correlates of smartphone ownership among PWID in San Diego. This research fills a gap in existing knowledge regarding the prevalence of cell phone and smartphone ownership among PWID, and describes the use of varying mobile technologies (including voice, text and mobile internet use) in this high-risk population. The correlates of cell phone access, smartphone ownership, and the defined levels of mobile technology use among PWID can be used for informing the development and implementation of mHealth interventions in the future.

Cell Phone/Smartphone Ownership among PWID in San Diego and Tijuana

In accordance with the literature regarding cell phone ownership among other substance using populations,[1-3] cell phone access and smartphone ownership among PWID in San Diego and Tijuana was lower among PWID when compared to the general adult populations in each respective country.[4-6] Among PWID living in Tijuana, a low percentage (16%) provided a cell phone number when asked for contact information. In comparison, the Mexican National Census estimated that two-thirds of Mexicans owned a cell phone in 2010 (the year data collection began for the El Cuete IV study); [4] though cell phone penetration in Mexico has since risen to an estimated 87% in 2013.[5] The majority of PWID in San Diego (92.4%) reported *ever* owning a cell phone, though *current* cell phone ownership was much lower at 66%, and just under a third of participants (28.6%) owned a smartphone. In contrast, it was estimated that 90% of American adults owned a cell phone in 2014, and 58% owned a smartphone. Among adults with an average income below $30,000—a closer comparison to the average income level of PWID—smartphone ownership was lower at 47%.[6] The discrepancy in cell phone access between adults in the U.S. and Mexico and PWID in both countries are not unexpected as PWID in both of these samples are generally lower SES and more likely to be socially marginalized than the general population.[7,8] Given the low SES of both cohorts, and the comparatively low prevalence of cell phone access and smartphone ownership among PWID in this dissertation, device ownership will need to be considered when developing smartphone-based interventions among PWID.

Demographic Associations with Device Ownership and Mobile Technology Use

Smartphone ownership has become ubiquitous in the United States among young, highly educated individuals. The Pew Research Center Global Attitudes Project reported that 83% of young adults ages 18-29, and 71% of adults with more than a high school education had a smartphone in 2014.[6] In this dissertation, younger age was associated with: 1) increased odds of reporting a cell phone number among PWID in Tijuana in a cross-sectional logistic regression analysis (chapter 1); 2) increased odds of smartphone ownership among PWID in San Diego in a longitudinal logistic regression analysis (chapter 4); and 3) increased odds of higher mobile technology use compared to minimal mobile technology users across all classes in a Latent Class Analysis (LCA) among PWID in San Diego (chapter 3). In terms of education, in chapter 2 participants with more years of education were more likely to report a cell phone number in Tijuana. In chapter 4, having more than a high school education increased the odds of owning a smartphone when compared to PWID who do not in San Diego. Furthermore in chapter 3, having more than a high school education increased the odds of higher mobile technology use across all LCA classes when compared to minimal mobile technology users. These findings are consistent with recent data among other high-risk populations in the U.S. (e.g., homeless youth, substance users, smokers living with HIV), that demonstrate younger age and higher education are associated with increased cell phone ownership, cell phone use, internet and email use.[1-3,9]

In chapter 4, this dissertation found that those who were married or had a committed partner were more likely to own a smartphone than single PWID.[10] Similarly, Pew Research Center reported that compared to adults over all, cell phone ownership was slightly higher in adults who were married or in a committed relationship in 2014 (91% vs. 93%). Consistent with national data regarding marriage and wealth, in the context of this study, marriage may be acting as a proxy for stability and higher SES among PWID in San Diego. For example, the National Longitudinal Survey of Youth (NLSY79) reported that married respondents experienced per person total net worth increases of 77% over single respondents. They also found that wealth increases on average 16% for each year that a person stays married.[11] Also, according to the U.S. Census Bureau, in 2010 the median net worth for a married couple between the ages of 55 and 64 was approximately $261,000 compared to $71,000 for a single man heading a household, and $39,000 for a single woman heading a household.[12] Married PWID in this study potentially have more income available to afford the costs associated with smartphone ownership and thus more likely to maintain a device over time compare to single PWID.

Dissertation findings also highlighted that highly marginalized PWID participants in both cities, including individuals who were poorer and/or homeless were significantly less likely to report a cell phone number and/or own a smartphone. Homeless persons were also less likely to be a high mobile technology users compared to housed persons. Highly marginalized individuals such as homeless persons are not likely to have the income and/or structural resources required (i.e., a place to charge the phone) for owning and maintaining a cell phone, smartphone, or data plan. As a high percentage of PWID will be similarly resource-deprived,[7] these findings exhibit further evidence that researchers will need to consider device coverage when developing mHealth intervention studies among PWID, and consider providing a cell phone to future research study participants.

Drug Use Risk Behavior Associations with Mobile Technology Use

PWID engaging in daily heroin injection practices were less likely to report a cell phone number (chapter 2), own a smartphone (chapter 4), and be high mobile technology users when compared to minimal users (though this finding was not significant in the final model for chapter 3). Daily use of heroin may indicate a more severe addiction to the drug. The National Institutes on Drug Abuse characterizes heroin addiction as a relapsing disease characterized by uncontrollable drug-seeking behavior, no matter the consequences.[13] Individuals experiencing this level of dependence on heroin may not likely make maintaining a smartphone or data plan a high priority in light of their drug habit. This subset of PWID may do anything to obtain drugs, including spending all available monetary resources on drugs, or selling personal possessions (e.g., a smartphone) to buy drugs.

In the case of daily injection of methamphetamine, more frequent injection (i.e., higher dependence) was associated with more mobile technology use in chapter 3. Injecting methamphetamine daily was associated with *increased* odds of higher mobile technology use across all classes in chapter 3 compared to minimal mobile technology users. The dynamics of each type of addiction may help explain these associations. After the initial “rush” heroin users experience immediately after injecting, snorting or smoking heroin, drowsiness occurs for several hours.[14] In contrast, methamphetamine (a.k.a., "meth" or "crystal meth") initially acts as a powerful stimulant, increasing the users wakefulness, attention and physical activity and decreases fatigue.[15] Methamphetamine has traditionally been used as an alternative to cocaine that allows users to party all night long; [16] though more recently methamphetamine has moved into the work place to allow the user to work very long hours.[17] While both heroin and methamphetamine addicts are likely to do anything in their power to obtain drugs, methamphetamine users may be higher functioning due to the stimulating effects of the drug, and more able to obtain and maintain the resources to access a cell phone or use mobile technology than heroin users in our study.

Further, in chapter 4, selling drugs in the past 6 months was associated with increased odds of being a high mobile technology user and a predominantly mobile internet user. Access to some form of mobile technology is likely to be a high priority for individuals who sell drugs, as means to communicate with their customers. As mobile technology use has become pervasive among all levels of socioeconomic status' and demographic groups in the U.S., individuals who sell drugs are upgrading from the electronic pager[18] and cell phones[19] to smartphones and the internet to connect with customers and suppliers. However, "smart" technology may be a privacy and/or legal risk for individuals who sell drugs. In chapter 4, 39% of current cell phone owners reported using a pre-paid cell phone plan that allows for an easy phone number change rather than a contract carrier plan. Also, a recent article in the online magazine *Vice* reported that street dealers in the UK are stocking up on "dumb" Nokia 8210 feature phones equipped with pre-paid voice plans and no internal GPS for law enforcement to track.[20] Findings presented in this dissertation demonstrate that PWID who sell drugs utilize mobile technology and thus may be reachable via mHealth interventions. However, privacy and confidentially are likely be of concern to this subgroup who engage in regular illicit behavior.

Lastly, this dissertation indicates that access to mobile technology and/or the internet (i.e., access to information) among PWID in San Diego (chapter 3) is not a deterrent to high-risk behaviors. In some cases access to mobile technology may increase risk, as evidenced by the fact that 9% of PWID in the STAHR-II study reported using the internet to find sex partners. These findings are consistent with the literature surrounding risk behavior reduction and knowledge that demonstrates information is necessary but not sufficient to achieve a significant reduction in risk among PWID.[21,22] For example, Strathdee et al. found that providing knowledge or information didactically among female sex workers in Tijuana was not as effective for decreasing risky injection practices as were interactive intervention techniques and access to clean syrniges.[22] mHealth interventions designed to reduce risk among PWID may need to do more than provide access to information via mobile health tools to achieve a significant reduction in risk behaviors in future interventions (i.e., provide risk prevention messages *and* practical information such as where or how they can access clean syringes).

LIMITATIONS

Generalizability

The data used for chapter 2, were collected as part of *Proyecto El Cuete IV* (ECIV) in Tijuana, Mexico. The data used for chapters 3 and 4 were collected as part of the *Study to Assess HIV, Hepatitis C, and Tuberculosis* (STAHR II) among PWID in San Diego. ECIV and STAHR II are longitudinal studies among PWID in Tijuana and San Diego, and highlight important behaviors that influence disease transmission among PWID in the U.S./Mexico border region. Because both studies used a convenience sample conducted among PWID, results are only generalizable to similar populations of PWID in either the U.S. or Mexico. Further, both studies recruited PWID who reported injecting illicit drugs in the past thirty days and who had no plans to move out of their respective city within the next two years, therefore the results from all chapters only represent recent injectors with plans to stay in Tijuana or San Diego. Additionally, participants' in both studies were not recruited specifically based on their cell phone access, mobile technology use or smartphone ownership; therefore our results may not represent all PWID who use mobile technology and/or own a mobile phone in this region.

Statistical power

The findings reported in chapter 4 used all longitudinal data available to date from STAHR-II for the analyses. While we would have liked to assess the association of smartphone ownership and HIV and HCV transmission longitudinally, incident cases of infection were low, thus we did not have the power to assess these associations.

Measurement

The outcome measure of "reporting a cell phone number" (yes/no) used for the logistic regression analysis in chapter 2 did not specifically ask participants if they owned or had access to a cell phone. Instead, participants were asked to provide a cell phone number, if they had one, when providing locator information at the baseline and subsequent study visits. These participants may have owned or had access to a communal cell phone, but elected not to provide the number to study staff due to privacy concerns. This could potentially underestimate the proportion of participants who owned or had access to a cell phone. Nonetheless, from the perspective of conducting research, willingness to provide a cell phone number to study staff is critical to implementing any type of intervention and ECIV study staff were consistent in collecting at least one form of contact information from each participant; thus, we felt confident that if a participant had access to a cell phone number, it would have been recorded in the locator information.

The cross-sectional nature of the data used in chapters 2 and 3 do not permit temporal correlations between outcome variables and the other independent study variables. All risk behaviors in both studies were self-report, which is subject to problems with recall; however, there is no reason to suspect that the associations were biased due to differential recall between participants with and without cell phones (in chapter 2) or who did and did not use mobile technology (in chapter 3). Additionally, any associations would be biased toward the null. Recall and social desirability bias may have resulted in an under-reporting of risk behaviors and thus biased the associations towards the null in chapters 2-4. However, the short recall period (six months for substance abuse and injection behavior questions) used for both ECIV and STAHR-II minimized recall bias. Lastly, to minimize socially desirable responses for risk behaviors in both studies, interviews were conducted in private settings with trained interviewers.

RECCOMENDATIONS AND FUTURE RESEARCH NEEDS

In chapter 2, it was notable that none of the HIV seropositive participants reported a cell phone number to study staff. The low HIV prevalence in the study population may have precluded a significant finding for this variable in the final model. Landline use in Mexico has fallen below 50% in recent years [4] and access to a phone, whether it is a landline or a cell phone, is important for people living with HIV to stay in contact with their health care provider. More research is needed to understand how HIV-positive PWID in Tijuana access appointments, communicate with their provider, and manage HIV treatment.

Additionally, in the cross-sectional bivariate analysis in chapter 4 (results shown in table 4.1.), both HCV and HIV seropositive were inversely associated with smartphone ownership. Due to power limitations discussed previously, longitudinal associations with smartphone ownership were not assessed with incident HIV or HCV in this analysis; however, future research that includes smartphone ownership as a covariate with these disease outcomes may be needed to determine if smartphone access is lower among PWID who are HIV or HCV seropositive.

CONCLUSIONS

Findings from this dissertation research expand current knowledge of the relationship between individual level factors such as socio-demographics, risk behaviors and health outcomes and mobile technology use among PWID in both high and low-resource settings. Findings suggest that younger, more educated and higher SES PWID in Tijuana and San Diego have access to mobile technology, suggesting that uptake of mHealth interventions may be successful in this population. Results also suggest that mHealth based approaches may help interventionists reach a high-risk subgroup of PWID who are highly dependent on methamphetamine and who may be hard to reach using traditional intervention approaches. However, frequent heroin injectors and/or homeless PWID may not be reachable via mHealth strategies that require a participant’s own device for study eligibility. Lastly, as the cost of mobile technology decreases, and device ownership continues to spread across the traditional “digital divide,” more subgroups of PWID may be reachable via mHealth tools.

REFERENCES

1. Rice E, Lee A, Taitt S. Cell phone use among homeless youth: potential for new health interventions and research. J Urban Health. 2011;**88**(6):1175-1182.

2. Milward J, Day E, Wadsworth E, et al. Mobile phone ownership, usage and readiness to use by patients in drug treatment. Drug and alcohol dependence. 2015;**146**:111-115.

3. McClure EA, Acquavita SP, Harding E, et al. Utilization of communication technology by patients enrolled in substance abuse treatment. Drug Alcohol Depend. 2013;**129**(1-2):145-150.

4. T.W.J. Mexico's census: TVs outnumber fridges. The Economist. 2011 April 28:2.

5. Lonergan K. Mexico telecoms sector expands 10% in Q2 2013. Available from: http://www.bnamericas.com/news/telecommunications/mexico-telecoms-sector-expands-10-in-q2.

6. Pew Research Center. Mobile Technology Fact Sheet: Pew Research Center's Internet and American Life Project. Pew Research Center, 2014.

7. Strathdee SA, Lozada R, Pollini RA, et al. Individual, social, and environmental influences associated with HIV infection among injection drug users in Tijuana, Mexico. J Acquir Immune Defic Syndr. 2008;**47**(3):369-376.

8. Strathdee SA, Hallett TB, Bobrova N, et al. HIV and risk environment for injecting drug users: the past, present, and future. Lancet. 2010;**376**:268-284.

9. Chander G, Stanton C, Hutton HE, et al. Are smokers with HIV using information and communication technology? Implications for behavioral interventions. AIDS Behav. 2012;**16**(2):383-388.

10. Pew Research Center. Couples, the Internet, and Social Media. How American couples use digital technology to manage life, logistics, and emotional intimacy within their relationships. 2014.

11. Zagorsky JL. Marriage and divorce's impact on wealth. Journal of Sociology. 2005;**41**:406-424.

12. Lin A. Why married people tend to be wealthier: its complicated. *TODAY Money.* 2013. http://www.today.com/money/why-married-people-tend-be-wealthier-its-complicated-1C8364877. Accessed March 30, 2015.

13. National Institute on Drug Abuse. Heroin. http://www.drugabuse.gov/publications/drugfacts/heroin. Accessed March 30, 2015.

14. Goldstein A. Heroin addiction: neurobiology, pharmacology, and policy. J Psychoactive Drugs. 1991;**23**(2):123-133.

15. National Institute on Drug Abuse. Methamphetamine http://www.drugabuse.gov/drugs-abuse/methamphetamine.

16. Kelly BC, LeClair A, Parsons JT. Methamphetamine use in club subcultures. Substance use & misuse. 2013;**48**(14):1541-1552.

17. Costello D. Once a party drug, meth moves into the workplace. Los Angeles Times. 2004 September 13, 2005.

18. Sims C. Schools Responding to Beeper, Tool of Today's Drug Dealer, by Banning it. New York Times. 1988 September 25, 1988.

19. Natarajan M, Clarke RV, Johnson BD. Telephones as facilitators of drug dealing. European Journal on Criminal Policy and Research. 1995;**3**(3):137-153.

20. Zacharanda S. The UK's Drug Dealers Are Swapping Crack for Nokia 8210s. *VICE.* 2015. http://www.vice.com/read/the-uks-drug-dealers-love-the-nokia-8210-988. Accessed March 29, 2015.

21. Madray H, van Hulst Y. Reducing HIV/AIDS high-risk behavior among injection drug users: peers vs. education. Journal of drug education. 2000;**30**(2):205-211.

22. Strathdee SA, Abramovitz D, Lozada R, et al. Reductions in HIV/STI incidence and sharing of injection equipment among female sex workers who inject drugs: results from a randomized controlled trial. PloS one. 2013;**8**(6):e65812.

APPENDIX I

Table 4.4. Supplementary tables: Comparing participants who have completed at least one follow up visit to those who have not completed any follow up visits at baseline.

Variable	Total n=574	≥1 Follow up n=376	LTF n=198	p-value
Demographics				
Mean age, years (mean, sd)	43.34(11.7)	44.51(11.29)	41.11(12.18)	0.001
Male gender				0.79
Male	418(72.9%)	272(72.5%)	146(73.7%)	
Female	149(26.0%)	98(26.1%)	51(25.8%)	
Transgender male-to-female	5(0.9%)	4(1.1%)	1(0.5%)	
Transgender female-to-male	1(0.2%)	1(0.3%)	0(0.0%)	
Race/Ethnicity				0.29
White, non-Hispanic	292(50.9%)	196(52.1%)	96(48.5%)	
Hispanic	178(31.0%)	107(28.5%)	71(35.9%)	
Black, non-Hispanic	50(8.7%)	36(9.6%)	14(7.1%)	
Other	54(9.4%)	37(9.8%)	17(8.6%)	
Monthly Income (>10,000 vs. <=10,000)	182(31.8%)	112(29.9%)	70(35.5%)	0.17
Single vs. Married	509(89%)	329(88%)	180(91%)	0.22
Education level (>=HS vs. <HS)	378 (66%)	247(65%)	131 (66%)	0.83
Homeless (yes vs. no)	351(61%)	227(60%)	124(63%)	0.60
Traveled to MX, last 6 months	161(28.3%)	112(29.8%)	49(25.5%)	0.29
Used/Injected drugs in MX, last 6 months	102(18.0%)	72(19.1%)	30(15.6%)	0.30
Mobile technology (n=564)				
Ever owned a cell phone	521(92.4%)	343(92.2%)	178(92.7%)	0.83
Currently own a cell phone	379(67.2%)	254(68.3%)	125(65.1%)	0.45
Owned a smart phone at baseline	157(27.8%)	100(26.9%)	57(29.7%)	0.48

Table 4.4. Supplementary tables: Comparing participants who have completed at least one follow up visit to those who have not completed any follow up visits at baseline. (Continued)

Variable	Total n=574	≥1 Follow up n=376	LTF n=198	p-value
Drug Use				
Mean years injecting (mean, sd)	20.80(13.44)	21.50 (13.23)	19.48 (13.78)	0.07
Mean age first injection, years (mean, sd)	22.53(8.22)	23.01 (8.66)	21.63 (7.24)	0.16
Injected heroin, last 6 months	374(68.0%)	226(62.1%)	148(79.6%)	<0.001
Injected crack, last 6 months	86(15.5%)	53(14.5%)	33(17.3%)	0.39
Injected methamphatamine, last 6 months	359(64.9%)	250(68.7%)	109(57.7%)	0.01
Used two or more drugs simultaneously, last 6 months	166(28.9%)	101(26.9%)	65(32.8%)	0.13
Used syringe exchange program in the last 6 months (yes vs. no)	236(41.1%)	165(43.9%)	71(35.9%)	0.06
Shared syringes, last 6 months (yes vs. no)	289(59.2%)	189(59.6%)	100(58.5%)	0.81
Shared any injection paraphernalia, last 6 months (yes vs. no)	394(68.2%)	251(66.2%)	143(71.9%)	0.26
Health care utilization and health status				
Any ER visit, last 6 months	195(34.2%)	138(36.7%)	57(29.2%)	0.07
Any hospital visit, last 6 months	98(17.2%)	70(18.6%)	28(14.4%)	0.20
Had an abscess, last 6 months	131(27.0%)	82(26.0%)	49(28.7%)	0.53
Overdosed, last 6 months	45(7.9%)	29(7.7%)	16(8.1%)	0.86
HIV results (positive vs. negative; n=553)	52(9.4%)	43(11.8%)	9(4.8%)	0.007
HCV results (positive vs. negative; n=552)	365(66.1%)	241(66.4%)	124(65.6%)	0.85
TB results (positive vs. negative; n=502)	120(23.9%)	80(23.6%)	40(24.5%)	0.82
Need for drug treatment (Any need vs. no need)	421(74.1%)	265(71.2%)	156(79.6%)	0.03