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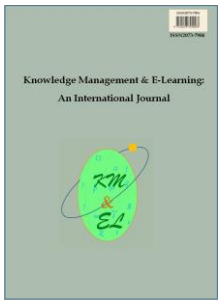

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The current state of knowledge on mobile health interventions for opioid related harm: Integrating scoping review findings with the patient journey

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Abstract: Opioid-related harm has become a major public health crisis around the world. There is a paucity of literature that examines the state of mHealth technologies in relation to the prevention and management of opioid-related harm. The purpose of this research is to examine the current state of knowledge with respect to mHealth technologies focused on opioid harm reduction and to identify gaps and technological opportunities. This research was conducted in two phases. The first phase involved the completion of a scoping review in six peer-reviewed research databases and grey literature searches in two search engines. The second phase involved the development of a Patient Journey Map to describe the findings of the scoping review in order to identify mHealth gaps and opportunities in relation to the recovery-oriented cascade of care. For the scoping review, nine articles met the inclusion criteria. These articles focused on accessibility, utilization, acceptability, feasibility and patient outcomes of mHealth interventions. These studies showed mHealth interventions are highly accessible, utilized and acceptable to opioid users, feasible to implement and can improve appointment adherence and patient outcomes. The Patient Journey Map demonstrates future mHealth interventions should focus on the prevention, diagnosis and post-recovery phases of the patient journey.

Keywords: Mobile health; Opioids; Prevention; Harm reduction; Information technology; Patient journey; Recovery-oriented cascade of care

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1. Introduction

Opioid-related harm such as addiction and overdose have become a major public health crisis around the world, especially in the United States and Canada (Canadian Institute for Health Information, 2018; Vadivelu et al., 2018). There have been considerable increases in the prescribing of opioids for a range of chronic non-cancer pain conditions (Degenhardt et al., 2019) which has led to higher numbers of prescription opioid misuse, abuse and opioid-related death cases in most developed Organisation for Economic Co-operation and Development (OECD) countries around the world (OECD, 2019). Aggressive promotion (Vadivelu et al., 2018; Degenhardt et al., 2019), treatment of pain as a human right (Weiner et al., 2017), under-regulation (Degenhardt et al., 2019), response to undertreatment (Weiner et al., 2017) and overprescribing of pharmaceutical opioids (Degenhardt et al., 2019) have been identified as the key drivers of opioid use. Globally, it has been estimated that there were approximately 109,500 deaths due to opioid overdoses in 2017; 43% of which were in the United States (Degenhardt et al., 2019). In 25 OECD countries, the average of opioid related deaths increased by 20% from 2011 to 2016, with the United States, Canada, Sweden, Norway, Ireland, and England & Wales being above the average (OECD, 2019).

Governments have been responding to the crisis by implementing several strategies. These strategies include public methadone clinics, antagonist therapy for opioid maintenance, education and guidelines for prescribers, prescription drug

monitoring programs, patient education programs, support for medications to reverse opioid overdose, education and training for caregivers on management of overdose as well as funding the development, implementation and dissemination of technologies that can be used to prevent an opioid overdose (National Academies of Sciences, Engineering & Medicine, 2017; Degenhardt et al., 2019). Technology-based interventions such as mobile phone interventions (mHealth) have gained significant attention as a potential intervention that can be used to enhance medical treatment for substance abuse. However, there is little knowledge on how mHealth technologies support individuals in the prevention and management of opioid related harm through each stage of their patient journey. This journey starts from the moment an individual becomes at risk, through to an addiction diagnosis, to treatment program initiation and retention, and to recovery (i.e., through the recovery-oriented cascade of care) (Yedinak et al., 2019). The purpose of this research is to examine the current state of the literature on mHealth technologies related to opioid related harm and identify gaps in the context of a patient journey map that is based on a recovery-oriented cascade of care (Yedinak et al., 2019).

2. Background

2.1. mHealth technology for substance abuse

mHealth technologies are widely available and are being used as an intervention to manage chronic conditions (Matthew-Maich et al., 2016), including the treatment of substance abuse. The World Health Organization defines mHealth as medical and public health practice that is supported by mobile devices including mobile phones, tablets, portable patient monitoring devices, personal digital assistants and other wireless devices (WHO Global Observatory for eHealth, 2011). mHealth technology uses voice and short messaging service (SMS) of mobile devices, applications (apps), internal sensors (acceleration, gyroscope, barometer) and additional peripheral wearable devices connected via Bluetooth technology (i.e., smartwatches and electronic wristbands) (Schaub, Yi-Chen, & Pirona, 2018).

Studies show that mHealth interventions improve smoking cessation (Free et al., 2011), medication adherence (Horvath et al., 2012; Vervloet et al., 2012), reduce the intention to abuse substances (Mason et al., 2014), and reduce substance use (Kazemi et al., 2017). mHealth technologies also encourage participation in extracurricular recovery behaviors (Gonzales et al., 2014) such as continued access to resources, case management, and acquiring information after leaving residential treatment (Muroff et al., 2017). mHealth interventions have been found to be accessible (McClure et al., 2013; Dahne & Lejuez, 2015; Tofighi et al., 2015), acceptable (Haug et al., 2015; Shrier et al., 2014; Masson et al., 2019; Tofighi et al., 2015), feasible (Shrier et al., 2014) and efficacious (Shrier et al., 2014). This evidence suggests mHealth technologies have tremendous potential for the prevention and management of opioid-related harm.

2.2. State of opioid epidemic

Opioid addiction is a major public health issue and is increasing pressure on health care systems around the world. In Canada, the Canadian Institute for Health Information (CIHI) reported that opioid-related harm increased emergency department visits and hospitalizations (CIHI, 2018). Between 2007–2008 and 2016–2017, the rate of hospitalizations due to opioid poisoning increased by 53% (CIHI, 2018). In 2016–2017,

more than half of hospitalizations for opioid poisonings were considered accidental and almost one-third were due to self-infliction (CIHI, 2018). In British Columbia, the death rate from opioid addiction was higher than deaths from COVID-19 (Clair, 2020).

2.3. Opioids and the patient journey

There is a recognition in the scientific and treatment communities that individuals who are addicted to opioids require varying types of interventions throughout the cascade of care (Yedinak et al., 2019). During treatment, the patient journey often begins when an individual reports addiction or opioid use (i.e. stage 0 in treatment). This is followed by a diagnosis of the disease (i.e. stage 1) and active treatment involving medication use (i.e. stage 2). When the individual has reached Stage 3 of the cascade of care, they have been in treatment for more than 180 days and are considered "retained". Recovery begins in Stage 4 when the individual identifies as having recovered. It is important to note that even individuals who have recovered from opioid addiction may feel they are at risk of relapse and could cycle back through a diagnosis of addiction, treatment initiation and recovery (Yedinak et al., 2019). The recovery cascade is a patient journey (i.e., the individual goes from not being addicted to recovering) and in some cases repeating some parts of the patient journey on the road to recovery (de Ridder et al., 2018). In recent years, patient journey mapping as a methodology that has been introduced to the health informatics literature. Patient journeys are an important way of diagramming the patient's travel through the health care system and assisting with understanding the barriers and challenges to obtaining care while at the same time identifying opportunities for the types of technologies and supports that can be integrated into a patient's journey (de Ridder et al., 2018).

3. Objective

The purpose of this paper is to provide an overview of the current state of knowledge on mHealth technologies related to opioid related harm and identify opportunities for research and development of mHealth technologies.

4. Methods

This study was conducted in two phases. The first phase of this study involved the execution of a scoping review to understand the current state of evidence-based mHealth interventions focused on the prevention and management of opioid related harm. The second phase of the study involved comparing the Patient Journey Map with the findings from the scoping review.

4.1. Phase 1: Scoping review

4.1.1. Search strategy

A scoping review of published and grey literature was considered to be an appropriate method for examining the published research related to mHealth technology interventions for opioid related harm. We used Arksey and O'Malley's (2005) scoping review framework and followed the five stages including: 1) identification of research questions;

2) identifying relevant studies; 3) study selection; 4) charting the data; and 5) collating, summarizing and reporting the results. This review focused on understanding the scope of the literature with respect to mHealth interventions for opioid related harm rather than the quality of the studies.

A systematic search of published research was done to find research about mHealth technologies for the prevention and management of opioid related harm. The search was conducted with no data restriction and included searches until July 31, 2018 in the following bibliographic databases: Medline (EBSCOhost), CINAHL (EBSCOhost), EMBASE (OVID), ISI Web of Sciences, HealthSTAR, Scopus, Cochrane Library (CCTR), and IEEE Explorer. These databases were selected since they store knowledge on informatics and health care. The search strategies were developed by an experienced library technician and further refined through team discussions. The search strategy used combinations of the following search terms/keywords: 'information technology', 'medical informatics', 'telemedicine', 'mobile applications', 'cell phone', 'tablet', 'smartphone', 'text messaging', 'computers, handheld', 'user-computer interface', 'telecommunications', 'mHealth', 'eHealth', 'telehealth', 'telecare', **'**analgesics', 'opioid', 'opiate alkaloids', 'opioid related disorders', 'narcotics', 'opiate', 'drug misuse', 'substance related disorders', 'abuse', 'substance abuse'. With these keywords, each string was built using AND and OR operators. The electronic database search was supplemented by a grey literature search using Google and Google Scholar with the same keywords. The final search results were exported into RefWorks.

4.1.2. Study criteria

An article was selected for inclusion from published and grey literature, if it met the following inclusion criteria: (1) mHealth technology was used for the intervention (e.g., mobile phone, tablets); (2) the target population for the intervention were using opiates or similar analogs; (3) it was published in English; and (4) it was peer-reviewed and published in a conference or journal in the designated time period; and (5) it was available in full-text. Exclusion criteria included: (1) reviews, theoretical papers, seminar papers or letters to the editor; (2) studies on interventions that are not connected to mobile technology (web programs, telemedicine); (3) abstract, study protocol or in press; (4) studies not available in full paper; and (5) studies that did not provide enough information for charting the data.

4.1.3. Study selection

The study selection process included four steps: 1) identification of relevant studies in the literature; 2) screening abstracts based on the criteria; 3) applying criteria to full papers; and 4) extracting data from included articles. For the first step, duplicates of articles were removed after the search strategy was executed. The first assessment of the relevance of the abstracts across all databases was done independently by an experienced academic librarian. For step 2, the authors applied the inclusion and exclusion criteria to the titles and abstracts. Studies that met the inclusion criteria were retained. Any discrepancies on the inclusion/exclusion of articles were discussed between two authors (MA, KG) until agreement was reached. For step 4, data from included studies was extracted into the data matrix (see Table 1) by MA. The extracted variables were discussed and agreed on by the first and second author (MA, EB), both experienced in conducting literature reviews. The data extracted included: citation, purpose of study, study design, study location, study participants, outcome measures, type of mobile device, device features/intervention, findings and key themes. The data extraction was completed by the first author (MA) and

verified by the second author (EB). Since the purpose of the study was to understand the state of knowledge with respect to mobile technology interventions for opioid related harm, data was synthesized narratively rather than quantitatively using the constant comparison method that involves data extraction, comparison and conclusion drawing (de Ridder et al., 2018).

5. Results: Characteristics of included publications

The literature search yielded a total of 373 citations in which 341 citations were from the databases search and 32 were identified through the grey literature or from reference lists of full-text articles (Fig. 1: PRISMA diagram below). After the removal of duplicates, 178 abstracts were screened based on the inclusion criteria. The screening of titles and abstracts resulted in 132 full-text articles that were deemed to be potentially relevant and exclusion of 46 studies. After careful review of 132 full-text articles, 9 studies fulfilled the eligibility criteria and were included in this review. Table 1 provides details on each study.

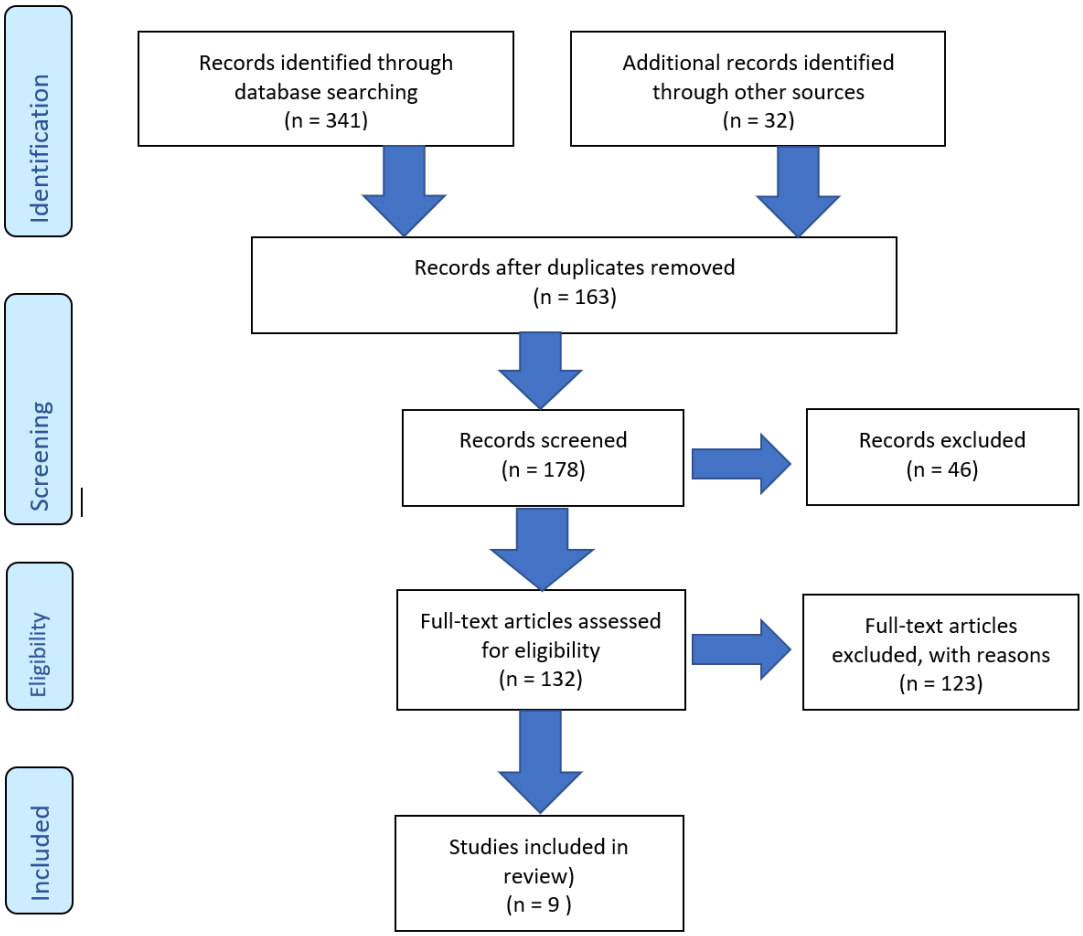

Fig. 1. Prisma diagram

Table 1
Data matrix

Citation	Purpose of Study	Study Design	Study Location	Study Participants	Outcome measure	Type of Mobile Device	Device Features/ Intervention	Findings	Key themes	Patient Journey Map
Tofighi et al., 2015	Examine mobile phone and text message use patterns	Cross-sectional Survey	Urban, Primary care office-based buprenorphine treatment setting in US hospital	Opiate dependent adults	Mobile phone/text message use patterns, preferences during recover	Mobile phone	Text Message	Nearly all reported mobile phone ownership. Due to phone turnover, up to date information needs to be obtained. Users were comfortable with text messages and supported the use of technology in case of relapse	Accessibility Acceptability Utilization	No
Brusoski & Rosen, 2015	Examine the impact of the intervention on user satisfaction, goal attainment and treatment engagement	Exploratory single case studies	Substance abuse treatment facility in a large Midwestern city in the US	Older adult African American methadone clinic patients	Participants memory function and goal attainment was assessed by asking them to recall goals from previous session and activities completed to reach goals Feasibility of teaching the tablet technology and video program was assessed through participant feedback on enjoyment and experience, goals, challenges and benefits Treatment engagement was assessed by tracking missed appointments	Tablet	Face to face video for psycho-educational intervention to provide coaching support for healthy living and aging	All participants used the technology and facilitated the meeting of treatment goals and engagement	Acceptability Feasibility Patient Outcomes: Treatment Adherence	No
Milward et al., 2015	Examine availability, usage, and acceptability of mobile phone based interventions using text message and smartphone apps	Cross-Sectional Survey	Community drug treatment services in the United Kingdom	Individuals in treatment of substance use disorders	Mobile phone availability Mobile phone use patterns Preferences	Mobile phone	Text Message/Geo-location	Majority have mobile phones/text message (not as many have smartphone apps) and use it for phone calls and text messages. Due to phone turnover, up to date information needs to be obtained. Majority were willing to be contacted by treatment	Accessibility Utilization Acceptability	No

					for contact			provider. Almost half were less accepting of geo-location for treatment		
Tofighi et al., 2017	To assess patients': 1) willingness to receive text message reminder intervention; 2) rates of functioning mobile phones and telephone numbers; and 3) feasibility of text message appointment reminder system	Feasibility survey	Urban, Primary care office-based buprenorphine treatment setting in US hospital	Opioid dependent adults	Ease of use of the intervention Perceived usefulness in improving adherence to appointments Intention to use over time during follow-up visits or continuing with telephone call appointment reminders Perceived enjoyment and annoyance	Mobile phone	Text message appointment reminders	Text message reminders assisted patients with adherence to appointments and supported receiving these reminders Barriers to adhering to scheduled appointment times included transportation difficulties, not being able to take time off from school or work, long clinic wait-times, being hospitalized or sick, feeling sad or depressed, and child care.	Acceptability Feasibility of implementing program Patient Outcomes: Adherence to scheduled appointments	No
Guarino et al., 2016	To examine the feasibility, acceptability and efficacy of mobile phone-based psychosocial intervention	Mixed methods pilot study (survey, qualitative study) comparing standard Methadone Maintenance Treatment (MMT) to the intervention group	Outpatients in MMT in NYC in US	Opioid dependent adults in methadone maintenance treatment	Feasibility, acceptability, efficacy Treatment outcomes (opioid use (urine toxicology) and treatment retention Patient interest, use and satisfaction with treatment	Mobile Phone	Behavioural modification intervention Mobile App – Check-In Program / with web-based psychosocial program (Therapeutic Education System)	Almost all participants interested in using technology; used frequently; technology acceptable and perceived to be useful. High levels of satisfaction More retention and more opioid abstinence for greater number of weeks than MMT	Accessibility Utilization Acceptability Feasibility of implementing intervention Patient Outcomes: more retention and more opioid abstinence for greater number of weeks	No
McClure et al., 2013	To examine accessibility and usage of communication technology by patients with opioid use disorder	Survey	Urban, substance abuse treatment programs (drug-free, psychosocial or opioid-replacement therapy clinics) in US	Substance abuse treatment patients	Technology utilization	Communications Technology (mobile phones, computers, internet, and email)	Text message, internet, e-mail, computer use	Majority of participants have mobile phone and text messaging.	Accessibility Utilization	No
Boyer et al., 2012	To obtain user perspective on the iHealth technology	Focus Group	Veterans Administration Medical Centre drug treatment unit in Bedford US	Veterans with co-occurring disorders and post-traumatic stress disorder and opioid	Patient feedback on technology	Mobile Phone iHealth – technologies that incorporate	Behavioural modification intervention Smartphone	All participants had mobile phones and service plans. Preference for videos, apps, games, calming	Accessibility Acceptability	No

				abuse		artificial intelligence, continuous biophysical monitoring, wireless connectivity, and smartphone computation	app with sensor band that measures electrodermal activity, body motion, skin temperature, heart rate which measure arousal/stress. The smartphone app monitors and processes the user's physiology data Goal is to identify real-time drug cravings and deliver personalized multimedia drug prevention interventions at moment o greatest need	songs, media rather than text messages Preferences for revisions to wrist band to prevent stigma in public		
Shrestha et al., 2017	Examined interest in using mHealth technologies for HIV prevention	Cross-sectional Survey	Community-based Methadone Maintenance Program (MMP) in Connecticut US	High Risk HIV-negative adults who use drugs that met the DSM-V screening criteria for opioid use disorder and enrolled in MMP	Patient interest in: 1) receiving reminders; 2) receiving information on HIV risk reduction; and 30 assess HIV risk behaviours	Mobile phone	Text message, medical reminders and information	Majority expressed interest in receiving medication reminders, risk reduction information to prevent HIV	Acceptability	No
Tofighi et al., 2016	To examine acceptability and preferences for text message interventions to support buprenorphine treatment components	Cross-sectional survey	Urban, Primary care office-based buprenorphine treatment setting in US hospital	Office based buprenorphine treatment patients	Text message preferences support for TM delivery and content preferences	Mobile phone	Text message	High acceptability to the use of text messages. Most participants prefer receiving text messages for appointment reminders, supportive messages, informational content or tips about treatment and reduce relapse Participants prefer to receive relapse prevention messages during all phases of treatment; expressed interest in enhancing self-efficacy, social support, and frequent provider communication	Acceptability	No

All the studies were journal articles in which 8 studies were conducted in the United States and one study was undertaken in the United Kingdom. The publication dates of the studies ranged from 2012 to 2017. Seven of the studies used a cross-sectional

survey for their study design. One of the seven studies used mixed methods and included a qualitative study. The other two studies were qualitative studies, in which one study design included focus groups and another study included exploratory single case studies.

5.1. Results: Characteristics of the study population

In 6 studies, the study population included adults that were dependent on the use of opioids and in treatment. One study population focused on older adult African Americans, another focused on veterans and another focused on high-risk HIV-negative adults. The opioids that were used by participants included methadone and buprenorphine. The treatment setting varied across studies. Participants were being treated in a primary care office in the hospital (n = 3), substance abuse treatment facility (n = 3), outpatient methadone maintenance treatment program (n = 2), and veterans administration medical centre drug treatment unit (n = 1).

5.2. Results: Characteristics of mHealth interventions

In the majority of the studies, the mHealth device that was being utilized was the mobile phone (n = 8). Only one study utilized the tablet. Studies differed in terms of the features or interventions that were being studied. Most of the studies (n = 6) examined the text-messaging (TM) feature. Two studies assessed a behavioural modification intervention through a smartphone app. Another study assessed a psychoeducational intervention involving coaching support for healthy living through a face-to-face video.

5.3. Results: Outcome measures

The outcomes measures that were being assessed in these studies included accessibility, utilization, acceptability, feasibility and impact on patient outcomes. Five studies examined accessibility which examined the ownership characteristics of mHealth technologies. Four studies examined utilization, which assessed patient use of mHealth technologies. Eight studies examined acceptability which looked at whether patients were willing to use the technology during treatment. Two studies assessed feasibility and examined the capability to implement mHealth interventions. Three studies examined patient outcomes with respect to the goals of the mHealth interventions.

The following section summarizes and reports on the themes that emerged with respect to the outcome of mHealth interventions.

5.3.1. Accessibility

Five studies focused on the accessibility of mHealth technologies for opioid dependent adults. In these studies, the majority of opioid-dependent adults in treatment centres reported owing a mobile phone (Tofighi et al., 2015; Milward et al., 2015; McClure et al., 2013; Boyer et al., 2012; Guarino et al., 2016). The percentage of participants that reported owing a mobile phone ranged from 83% to 100% (Milward et al., 2015; McClure et al., 2013; Tofighi et al., 2015; Boyer et al., 2012; Guarino et al., 2016). The type of phone that was owned by study participants varied. Milward found that just under two-thirds (57%) of participants owned a smartphone, while two other studies found that most participants owned traditional phones (Guarino et al., 2016; Boyer et al., 2012). In one study, 60% of participants had pay-as-you go contracts (McClure et al., 2013) and 72% in another study (Milward et al., 2015).

Two studies examined the relationship between demographics and mobile phone ownership (McClure et al., 2013; Shrestha et al., 2017) and one study assessed employment, and individual situation with mobile phone ownership (McClure et al., 2013). Milward et al. (2015) found that mobile ownership did not differ by gender and age and McClure et al. (2013) found that African American participants were more likely to have text messaging (TM) capabilities on their mobile phones. However, employment was found to be a significant predictor of smartphone ownership (Milward et al., 2015), having a monthly service plan (Milward et al., 2015) and being less likely to change mobile phone numbers in the previous year (Milward et al., 2015). Conversely, homeless participants and individuals recently released from prison (Milward et al., 2015) were significantly less likely to own a mobile phone. Individuals that had recently completed drug detoxification were nearly three times more likely to have a contract phone (Milward et al., 2015).

Three studies identified changes in mobile phones and phone numbers amongst participants as a key challenge with the use of mHealth interventions. In one study, just over half of participants (54%) kept the same mobile phone number (Milward et al., 2015). This was higher than reported by McClure et al. (2013) who found that only 37% kept the same number over the year. In both studies, 15% (Milward et al., 2015) and 23% (McClure et al., 2013) of participants changed their phone number more than three times in the past year. Tofighi et al. (2015) found that respondents reported having on average 1.6 phone numbers within the last year. McClure et al. (2013) found that white participants were more likely to change mobile phone numbers fewer times throughout the year compared to African American participants. Participants contacting drug-free, psychosocial services compared to those on opioid replacement treatment were also less likely to have changed their phone number more than one time in the past year (McClure et al., 2013).

5.3.2. Utilization

Four studies focused on the utilization of mHealth technologies and its features for opioid dependent adults. These studies found that a high proportion of patients used mobile phones (Tofighi et al., 2015; Milward et al., 2015; McClure et al., 2013; Guarino et al., 2016). McClure et al. (2013) reported that 91% and Guarino et al. (2016) reported 92% of study participants utilized mobile phones. Milward et al. (2015) found less than half (44%) used phone and TMs equally, with 30% using it predominantly for phone calls and 26% using it predominantly for TMs. In terms of frequency, just over half of participants (55%) sent a TM every day, 24% sent a TM more than once a week but less than every day, 11% sent a TM less than once a week while 8% never used TM.

One study examined how TMs were being utilized amongst participants and found respondents utilized TM contact with 12-step group peers and sponsors (15%), friends (9%), counsellors (5%), and family members (3%) to assist with their recovery. Analysis of free-text responses of TM content most commonly pertained to supportive messages (65%), assisting peers into treatment (15%), sharing information about buprenorphine treatment (15%), and providing support to peers enrolled in substance abuse treatment that were at risk of relapse (5%) (Tofighi et al., 2015). One study examined the relationships between demographics and mHealth technology utilization. McClure et al. (2013) found that younger age predicted greater technology use in terms of weekly computer, internet, and e-mail use, and TM capabilities. Another study examined the utilization of a mobile phone-based psychosocial program called Check-In Program which trains individuals to acquire skills while at the same time reducing illicit

drug use through therapeutic support. The study found that the majority of participants were positively engaged with the program with most participants using it repeatedly, at various times and in a range of settings outside of the methadone maintenance treatment program (Guarino et al., 2016). The rate of usage of the program was relatively stable during the three months of the study.

5.3.3. Acceptability

Almost all of the studies (n = 8) examined the acceptability of mHealth interventions for treatment. Two studies focused on participant interest in mHealth interventions (Milward et al., 2015) whereas five studies focused on participant experience and acceptability of mHealth interventions during treatment (Tofighi et al., 2015, 2016, 2017; Guarino et al., 2016; Boyer et al., 2012) and one study examined participant satisfaction with the use of the tablet during their treatment (Brusoski & Rosen, 2015). When examining participant preferences, one study found that over half of participants (53%) preferred the mobile phone as the contact method, followed by text and letter equally (41%) (Milward et al., 2015). Eighty-six percent said they were willing to be contacted via mobile phone by their treatment provider.

In four studies, a high proportion of patients reported acceptability to using TMs during treatment (Tofighi et al., 2016, 2017; Milward et al., 2015; Shrestha et al., 2017). During a six-month follow-up of a TM reminder intervention, 95% of respondents reported TMs should be provided to all program patients (Tofighi et al., 2017). In another study, participants indicated being interested in receiving TM for appointment reminders (90%), supportive messages (70%), informational content or "tips" about buprenorphine treatment (76%), and to reduce risk of a potential relapse (90%) (Tofighi et al., 2016). A study amongst high-risk people who use drugs also found there was substantial interest in using mHealth-based approaches to receive HIV risk reduction information (65.8%) and to assess HIV risk behaviors (76.5%) (Shrestha et al., 2017).

Four studies examined the frequency of TMs that are acceptable to participants (Tofighi et al., 2016, 2017; Milward et al., 2015; Shrestha et al., 2017). Two studies found that a larger proportion of participants felt one-to-two messages per week was the preferred level of contact (Milward et al., 2015; Tofighi et al., 2016) while approximately 30% felt comfortable with three-to-four messages per week (Milward et al., 2015). Tofighi et al. (2017) found participants felt an average of two messages per week was acceptable (Tofighi et al., 2017). For reminders, participants were interested in receiving electronic medication reminders mostly on a daily basis (43.5%), followed by a weekly basis (22.3%), and monthly (5.8%) (Shrestha et al., 2017). One study found 36% of participants were interested in choosing the time of day they received messages (Milward et al., 2015).

In terms of the use of TMs during the phase of treatment, one study found that participants preferred to receive relapse prevention TMs during all phases: immediately after induction into buprenorphine treatment, a few months into treatment, and after discontinuing buprenorphine treatment (Tofighi et al., 2016).

Two studies examined participant preferences with respect to TM content (Tofighi et al., 2015, 2016). In both studies participants were in favour of supportive messages in which their health care providers were regularly checking-in with their recovery and available during relapse. Tofighi et al. (2015) found nearly all respondents (94%) preferred having their providers' mobile phone number. Supportive content could include coping strategies (avoiding environmental cues), highlighting benefits of

abstinence, and encouraging 12-step group participation. Informational content preferences included: buprenorphine dosage adjustments during home induction; managing cravings; access to social support for health insurance, housing, employment; contact information for buprenorphine providers, psychiatrists, addiction counselors, and sober peers in recovery; and ways to link with sober social networks. Respondents also suggested including personalizing messages, avoiding repetition, and reinforcing benefits of buprenorphine treatment adherence. TM content considered to be unacceptable included consequence-driven messages reprimanding patients for red-flag behaviors (i.e., positive urine drug screens, missed appointments, diversion of buprenorphine; references to illicit substance use activities; and content that was judgmental or paternalistic) (Tofighi et al., 2016).

Three studies looked at the relationships between age, ethnicity, personal situation, medication use and treatment and TM acceptability. Older participants are significantly less receptive to receiving TM appointment reminders (Tofighi et al., 2016). However, another study found that older age and longer duration in buprenorphine treatment did not diminish interest in receiving TMs (Tofighi et al., 2017). Non-Caucasian respondents were more interested in receiving supportive TM and relapse prevention messages (Tofighi et al., 2016). In another study, being white and single was associated with significantly less interest in the use of mHealth for receiving HIV risk reduction information (Shrestha et al., 2017). Individuals with unstable housing were interested in TMs on relapse prevention (Tofighi et al., 2016) and those released from jail were highly acceptable to receiving TM reminders, supportive messages and informational content. Individuals who reported taking medication in the past 30 days or who were neurocognitively impaired were significantly more likely to be interested in using mHealth to receive medication reminders. Those with high perceived risk were significantly more likely to show interest in mHealth use to receive HIV risk reduction information. Participants who reported having visited a health care provider in the past 12 months and had moderate to severe depression were over three times more likely to show interest in using mHealth to be assessed for HIV risk behaviors (Shrestha et al., 2017).

Milward et al. (2015) explored the acceptability of geo-location features on mobile phones for the purpose of treatment and found that almost half of participants (46%) felt geo-location for treatment was unacceptable, while 27% considered it to be acceptable while the remaining participants had no opinion. Those who had finished drug detoxification were found to be nearly four times more likely to find geo-location as an acceptable (Milward et al., 2015).

Guarino et al. (2016) studied the acceptability of a mobile phone based psychosocial intervention called the Check-In Program. This program consists of two skills-based modules, a Functional Analysis module which aims to help individuals identify their patterns of problematic substance use and the specific triggers to substance use faced in daily life, and a Self-Management module which assists individuals in developing a plan to manage the triggers to substance use identified in the Functional Analysis module. Each module contains explanatory text defining key concepts (e.g., “triggers”, “self-management plan”), followed by an interactive exercise. A standardized, daily TM prompt is sent to each user’s mobile phone to encourage participation. The study found that the mobile intervention was acceptable to, and perceived as useful by, participants. Participants reported high levels of satisfaction with the program and rated it positively on measures of usefulness and ease of use. Participants also reported that the intervention contained a significant amount of new information and helped clarify misconceptions they had had about topics addressed in the program. Moreover, participants felt that using the Check-In program helped reduce both their drug cravings

and the likelihood they would use drugs, and strongly agreed that the program would be useful if it offered additional topic areas of skills-building and support.

Boyer et al. (2012) also conducted a study to examine user acceptability of a technology that incorporates artificial intelligence, continuous biophysical monitoring, wireless connectivity, and smartphone computation. The purpose of this technology is to detect drug cravings and prevent use. The study found that participants were more acceptable to methods for introducing behavioral interventions rather than TMs in the form of videos, apps, games, calming songs, or other media.

Brusoski and Rosen (2015) examined the impact of a face-to-face video program delivering 12 educational sessions on healthy living through the use of a tablet amongst older adult American African methadone clinic patients. The study found that participants were satisfied with using the tablet and wanted to learn more about it.

5.3.4. Feasibility

The feasibility of using mobile phone interventions was assessed in three studies (Tofighi et al., 2017; Guarino et al., 2016; Brusoski & Rosen, 2015). A study on the feasibility of a research team-run, TM appointment reminder program found that all participants received a TM reminder for their appointment and no reports of intrusion to patient privacy or disruption of daily activities due to the TM reminders was reported. The study also found that a key challenge of the intervention was that a large number of patients were excluded from receiving the reminders due to the lack of a working mobile phone or phone number at enrollment and frequent turnover of mobile phones and phone numbers during the study period. The authors concluded that patient engagement in TM interventions and feasibility can be addressed by frequent querying by study staff, encouraging patients to provide staff with updated phone numbers, and providing subsidized mobile phones and monthly payment plans (Tofighi et al., 2017).

The assessment of the feasibility of using the Check-In intervention found that MMT clients were able to master the technical skills needed to use the mobile tool after a moderate amount of initial instruction and ongoing coaching. The program was highly rated by participants for ease of use. The learning demands of the program did not substantially reduce the convenience and utility of the tool or dampen enthusiasm for using it by participants. Participants were also able to retain their study phone (or a single replacement phone) for the duration of the 3-month study which supports the feasibility of mobile-delivered interventions (Guarino et al., 2016).

Brusoski & Rosen's (2015) study on the feasibility of teaching older adults to use tablets in bi-weekly face-to-face video meetings with a trained counsellor on psycho-educational topics to enhance healthy behaviors in later life found that all participants were able to learn how to use the tablet technology despite having limited experience.

5.3.5. Patient outcomes

There were three studies that examined the impact of mHealth interventions on patient outcomes. The TM reminder intervention was found to be helpful in adhering to scheduled appointments by the majority of participants (95%) (Tofighi et al., 2017). The Check-In program on treatment outcomes, participants' opioid use (via urine toxicology) and treatment retention relative to the control group found that participants reported that the Check-In program helped to reduce drug cravings, and the likelihood of participants using drugs. Participants also stayed in treatment for a significantly longer duration than

participants in the control group and showed greater evidence of opioid abstinence for greater number of weeks (Guarino et al., 2016). The tablet intervention showed adherence to scheduled appointments with only a small proportion (13%) of individuals missing appointments. This study also found nearly half of study participants (44%) remembered their goals and 30% partially remembered their goals (Brusoski & Rosen, 2015). In addition, 59% of the time, participants reported completing the goals they had set for themselves during the week.

6. Phase 2: Patient journey mapping

During phase two of this project, we integrated the findings from the scoping review into a patient journey map (Parush, 2019) inspired by the recovery-oriented cascade care (Yedinak et al., 2019). The application of patient journey mapping to the scoping review on the prevention and management of opioid related harm represents a novel approach to visualizing and understanding gaps in the health technology in the health informatics research literature. The patient journey mapping process permits visualization of the stages at which mHealth applications are being used and where there are opportunities for further development.

6.1. Method

We created a patient journey map using the stages of recovery: at risk, diagnosed, initiated, retained and recovered from opioid addiction (de Ridder et al., 2018; Yedinak et al., 2019) (Refer to Fig. 2).

The results of our scoping review were used to identify how and where mHealth technologies were integrated into the recovery-oriented cascade of care and to identify gaps and technological opportunities that can improve the continuity of care (Househ et al., 2012; Kushniruk, 2019; de Ridder et al., 2018). It is important to note that none of the papers identified in our scoping review employed a journey mapping process to understand how mHealth applications can be integrated into the patient's journey (see Table 1). This is primarily due to the fact that these studies examined various factors in relation to a mHealth intervention at one point in the patient's journey.

6.2. Results

After integrating the findings of the scoping review in relation to the patient journey map, we found that most mHealth interventions were developed for use in hospital and/or community-based treatment settings (for the primary care setting or to support patients in an out-patient hospital setting) (Boyer et al, 2012; Brusoski & Rosen, 2015; McClure et al., 2013; Milward et al., 2015; Tofighi et al. 2016, 2017). mHealth interventions were primarily aimed at individuals that had started treatment for opioid addiction. Studies investigated the role of mobile behavioural modification programs, psychosocial programs and physiologic monitoring during treatment (Boyer et al., 2012; Milward et al., 2015) and the use of mobile phone TM functions to remind patients of their appointments, to provide social support and/or to provide educational information to patients while receiving treatment (Tofighi et al., 2015, 2016). mHealth interventions such as TMs were considered acceptable for the post-recovery stage.

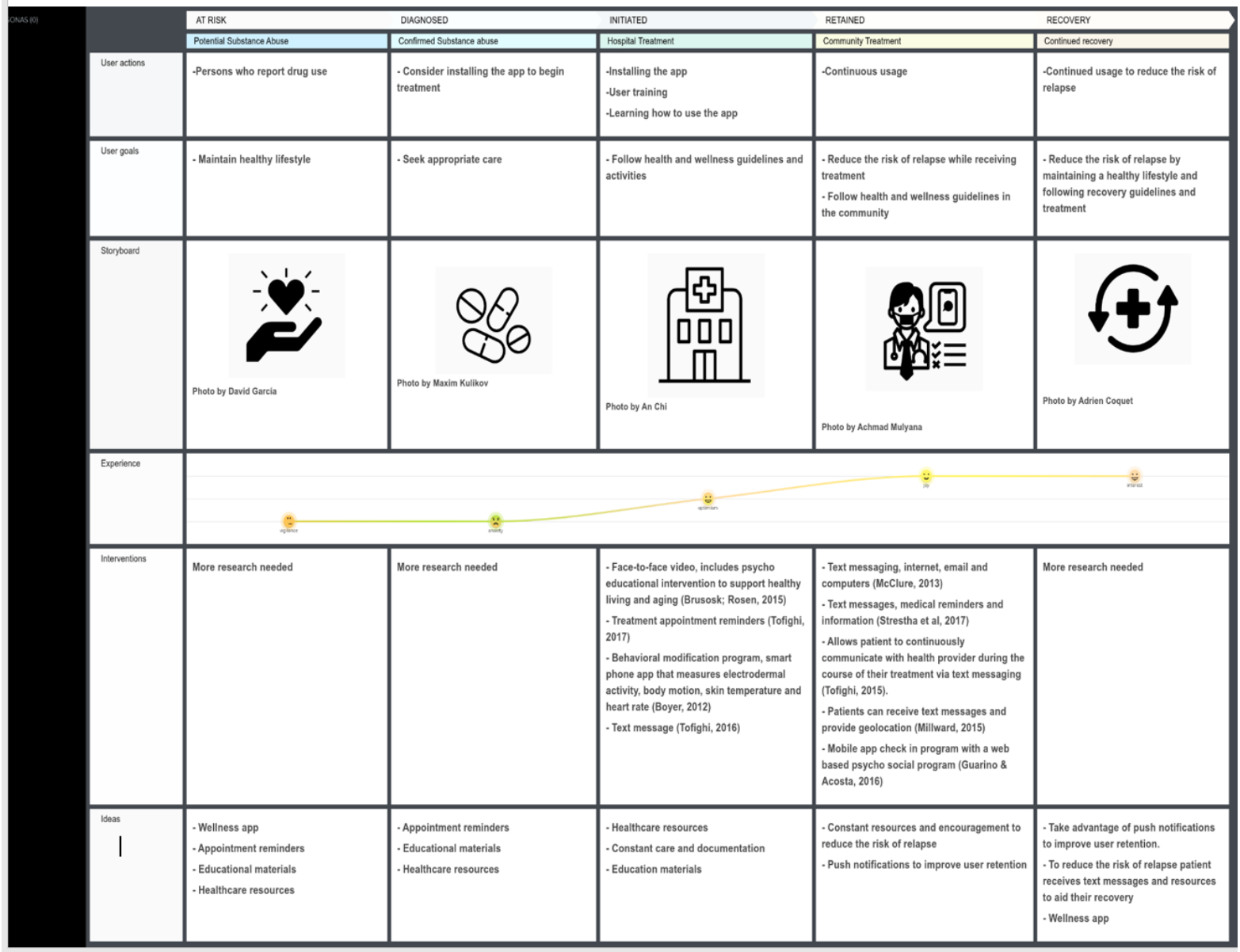

Fig. 2. Patient journey map integrated with the recovery-oriented cascade

After applying the patient journey mapping process to the scoping review findings, we found that the majority of studies focused on interventions for those newly diagnosed with an opioid addiction or those in the recovery stage of their addiction. This highlights gaps in technology interventions at the stage: when individuals are at risk, when opioid addiction can be prevented; during diagnosis; and when individuals have completed the recovery stage and are at risk of opioid addiction after treatment is completed. During the phase at which individuals are at risk, interventions can focus on identifying vulnerable people to prevent opioid addiction. This could include connecting potential users to providers, information or support groups. During the diagnosis phase,

interventions would focus on supporting patients before admission to a treatment program. For example, patients may wish to engage with supports while waiting for treatment and begin learning about opioid addiction by working through an educational program before treatment begins. During the recovery stage, mHealth interventions could be similarly designed to prevent addiction by those at risk of relapse.

7. Discussion

This scoping review shows that mHealth applications have considerable promise with respect to the utilization, acceptability, and feasibility of mHealth technology in relation to the prevention and management of opioid related harm. Studies showed that most individuals with an opioid addiction owned and used a mobile phone. However, access to mobile phones was a barrier for various populations including the homeless and prison population. Another challenge of mobile phones is there is constant turnover and changes in phone numbers.

Studies show that a high proportion of individuals used mobile phones and associated features such as TMs and behavioural programs (Tofighi et al., 2015; Milward et al., 2015; McClure et al., 2013; Guarino et al., 2016). There was high acceptability for using mobile phones and tablets as well as TMs and behavioural interventions to support recovery from an opioid addiction. However, there was less acceptance of using mHealth interventions with geo-location features on mobile phones during treatment.

This review found it is feasible to implement mHealth interventions during treatment and recovery. A few studies showed that patients were able to master the skills needed to use programs on mobile phones and tablets (Guarino et al., 2016; Brusoski & Rosen, 2015). High turnovers in mobile phones and phone numbers is a challenge to feasibility and can be remedied by having program staff frequently query patients, encouraging patients to provide updates to staff or providing subsidized mobile phones and monthly payment plans for patients (Tofighi et al., 2017).

In terms of the impact of patient outcomes, this review indicates that mHealth interventions such as mobile TMs and tablet programs can facilitate compliance with scheduled appointments (Tofighi et al., 2017). The use of programs can result in positive health outcomes. The Check-In program helped to reduce drug cravings and the likelihood of participants using drugs. Participants also stayed in treatment for a significantly longer duration than participants in the control group and showed greater evidence of opioid abstinence for greater number of weeks (Guarino et al., 2016). A tablet intervention resulted in participants completing the goals they had set for themselves during the week (Brusoski & Rosen, 2015).

From the patient journey mapping process, we found that mHealth interventions were focused on the treatment phase. This research shows there are significant gaps in the use of technology to support individuals' during the prevention phases when individuals are at risk, when individuals are newly diagnosed or when they have recovered. The substance abuse literature suggests this gap can be addressed by developing mHealth interventions that are aimed at disseminating information on pharmacology, effects and health risks to individuals (WHO Global Observatory for eHealth, 2011). Interventions should also focus on assisting health care professionals with monitoring users' adherence to treatment through videos involving observed therapy, reporting by patients on side effects or symptoms and communication between providers and patients (WHO Global Observatory for eHealth, 2011). Interactive drug prevention apps are also being used to target youth through interactive comics/cartoons, telling stories of recovery, quiz games,

and role play games (Kapitány-Fövény et al., 2018). During the diagnosis phase, there may be opportunities to leverage built-in smartphone sensors in the devices to diagnosis the condition (Baxter et al., 2020). Interventions could also focus on supporting patients before admission to a treatment program. For example, mHealth interventions could provide educational programs for individuals before treatment begins and facilitate connections with peers through intra-app messaging, help icons, videoconferencing, community chats or forums (Tofighi et al., 2019). During the recovery stage, mHealth interventions similar to the prevention and diagnosis phases can be used to prevent addiction by those at risk of relapse. mHealth interventions should also focus on collecting real-time statistical data on the incidence and prevalence of harm (i.e. overdose data) to provide continuous information to policymakers, for the purpose of preventing future epidemics (Aggarwal & Borycki, 2019).

From a mHealth design perspective, Patient Journey Mapping can be integrated with prototyping mHealth app designs. Traditional approaches to engaging patients in the co-design of mobile software apps often involves patients identifying the key features of software applications that would support the development and self-monitoring of wellness activities (Elrefaey et al., 2015; Kushniruk & Borycki, 2015). This may involve patient participation in co-design exercises using paper prototyping techniques, followed by successive iterations of prototyping using wireframes to refine mobile software application design with patients. To better support this process, and to ensure that software apps are being created by taking into account the full cascade of recovery, we suggest following a two-stage process. In first stage a patient journey map could be generated in a participative, co-design process between the patient and health professionals that follow the stages of the cascade of recovery. The second stage of the process could involve iterative, participative, co-design of the mobile apps taking into consideration the patient's addiction journey. Here, the software app changes over time in response to the patient's progression through the cascade of recovery. Such participative co-design activities would allow health technology designers to develop a more tailored and addiction recovery phase specific software features and functions that would support the patient over the course of their recovery.

Future research should focus on identifying possible technology interventions across all stages of the cascade of recovery, taking into account the characteristics of the individual. Here, patient oriented, patient journey mapping, and participative designs approaches would allow for the development and testing of technology interventions (applications) that would respond to the differing needs of individuals who are moving through the phases of being "at risk" through to "recovery".

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