Understanding Naloxone Uptake from an Emergency Department Distribution Program Using a Low-Energy Bluetooth Real-time Location System

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Abstract

Introduction Emergency department (ED)-based naloxone distribution programs are a widespread harm reduction strategy. However, data describing the community penetrance of naloxone distributed from these programs are lacking. This study gauges acceptance of naloxone use and monitoring technology among people who use drugs (PWUD), and explores the use of real-time location systems (RTLS) in monitoring naloxone movements.

Methods A prospective observational study was conducted on a convenience sample of individuals ($N=30$) presenting to a tertiary-care academic medical center ED for an opioid-related complaint. A naloxone kit equipped with a low-energy Bluetooth (BLE) tracking system was employed to detect movement of naloxone off the hospital campus as a proxy for community penetrance, followed by a qualitative interview to gauge participant acceptance of naloxone use and monitoring technology.

Results Detection of BLE signals verified transit of 24 distributed naloxone kits off our hospital campus. Three participants whose BLE signals were not captured reported taking their kits with them following discharge, suggesting technological errors occurred; another three participants were lost to follow-up. Qualitative interviews demonstrated that participants accepted ED-based naloxone distribution programs and passive tracking technologies, but revealed concerns regarding hypothetical continuous monitoring systems and problematic interactions with first responders and law enforcement personnel.

Conclusions Based on acquired BLE signals, 80% of dispensed naloxone kits left the hospital campus. Use of RTLS to passively geolocate naloxone rescue kits is feasible, but detection can be adversely affected by technological errors. PWUD are amenable to transient monitoring technologies but identified barriers to implementation.

Keywords Technology · Harm reduction · Opioids · Naloxone · Digital health

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Introduction

Opioid overdoses and deaths continue to affect the USA at epidemic proportions; in 2017, 47,600 individuals died from drug overdoses involving opioids, a 43.8% increase from 2015 [1, 2]. Strategies to address this public health crisis include preventing exposure to opioids, encouraging safe prescribing, providing access to medications for opioid use disorder, and practicing harm reduction by distributing naloxone, an opioid receptor antagonist [3]. Naloxone is available through various distribution programs associated with hospitals, community action centers, and substance use disorder treatment centers [4, 5]. Studies suggest that these naloxone distribution programs are a cost-effective intervention and improve knowledge of how to recognize and respond to an opioid overdose [5–7]. However, additional study is needed to

better quantify their effects and further optimize benefits of these programs [4, 8].

The emergency department (ED) represents a unique site for a naloxone distribution program because people who use drugs (PWUD) that present for care frequently suffer from acute, life-threatening sequelae of opioid use such as overdoses, suicide attempts, and severe infections. The ED therefore represents a high-yield location for naloxone distribution to a vulnerable population that is at high risk for recurrent overdose.

The number of emergency department–based naloxone distribution programs in the USA continues to grow, yet the efficacy of these programs is unknown [9, 10]. Data from a recent survey-based study demonstrated that of 89 patients who presented to a single ED following an unintentional opioid overdose, only 31% reported having access to naloxone, yet 70% reported that this was not their first overdose [11]. The availability of naloxone to these individuals during episodes of opioid use is especially important as they represent a subpopulation that is at a striking risk for recurrent overdose [12]. Yet, there remain significant challenges in deploying take-home naloxone programs in the ED, including staffing, funding, and regulatory issues [13]. The time-pressured environment of the ED may prevent adequate naloxone teaching or opioid use counseling, and the uncertainty of post-discharge follow-up may decrease provider motivation for distributing naloxone in the ED. Additionally, the fate of naloxone kits when distributed to at-risk individuals from an ED-based harm reduction program remains unknown. That is, it is unclear if patients actually keep the naloxone kits they are given. Some authors have qualitatively documented the willingness of people who use opioids to accept and carry naloxone, but the objective documentation of naloxone retention after distribution has yet to be determined [14, 15].

Real-time location systems (RTLS) are devices that utilize radiofrequency identification (RFID), low-energy

Bluetooth (BLE), or global positioning satellite (GPS) systems to unobtrusively measure the transit of goods. These RTLS applications have been previously implemented in hospital-based settings to track the transit of supplies, individuals, and medications to their destination through a network of strategically placed readers [16, 17]. In the ED, RTLS has been successfully used to measure the presence of key personnel in critical resuscitation procedures, track the presence of sensitive equipment, and provide location tracking for patients [18–20]. It is plausible that an existing or de novo RTLS could be adapted into understanding the uptake and movement of naloxone distributed from the ED. Beyond providing information on naloxone distribution from an ED or hospital-based clinic, RTLS can be extended into the community to measure the long-term effectiveness of naloxone distribution programs. In this manuscript, we describe the novel implementation of a passive RTLS-equipped “smart naloxone kit” detected by specific, encrypted, paired BLE readers to measure the real-time uptake as a proxy measure of community penetration of take-home nasal naloxone distributed from an ED-based harm reduction program.

Methods

This observational study was approved by the University of Massachusetts Medical School Institutional Review Board. We developed a smart naloxone kit, which was comprised of a standard Food and Drug Administration–approved 2 mg/mL nasal naloxone syringe and atomizer, augmented by the addition of a BLE beacon (Fig. 1a). We purchased BLE beacons (Visybl Inc., Germantown, MD) powered by an internal battery with a 30-day battery life after activation. The beacons communicated with corresponding BLE readers (Fig. 1b and c) using a

Fig. 1 **a** Naloxone kit with nasal mucosal atomizer device augmented by BLE beacon, **b** BLE reader in protective casing, and **c** reader in casing after inclement weather.

radiofrequency signal at 2.4 GHz, the same frequency utilized by conventional cordless telephones. While there was initial concern for potential interference of electromagnetic radiation with medical equipment, subsequent research suggests that with proper design, RTLS using common projection frequencies are unlikely to cause interference with medical devices such as telemetry monitors and infusion pumps [19, 21].

Corresponding BLE readers can detect the presence of BLE beacons only when they are within a 20-m radius. Acquisition of the beacon signal from the reader was securely logged on the reader and downloaded through a secure web-based portal (Fig. 2). We placed BLE readers at strategic egress points from our hospital campus including major road intersections, a pedestrian pathway, and the campus bus stop to capture the transit of smart naloxone kits off the hospital campus (Fig. 3).

Pre-deployment Testing

Study staff reviewed a hospital map to identify pedestrian and vehicular egress paths representing access routes leading from our ED. BLE readers were placed at these locations in order to capture BLE beacons as they traversed the boundaries of our hospital campus (Fig. 3). To verify functionality of the RTLS, study staff placed an activated BLE beacon within the packaging of the naloxone kit and brought the kits in the vicinity of BLE readers placed at the identified egress points. Study staff sought to simulate how the smart naloxone kit would be carried in the real world by holding it in hand, placing it in a pocket, and storing it in a backpack, while moving in and

out of range of the BLE readers while on foot and in a car traveling at typical speed. Successful signal capture by the RTLS in each of these scenarios was noted when the kits were brought within range, as well as extinguishing of signal when the kits were removed.

As the selected locations tended to be remote from the main buildings, connection to the Wi-Fi network was not consistently available, and thus the decision was made to omit patient identifiers within the RTLS (i.e., no patient information stored on the BLE beacon) and to download detection events within 24 h of participant enrollment, during daily security checks.

Recruitment

We distributed smart naloxone kits to a convenience sample of adult patients aged 18 years or older who presented to our academic, urban ED (annual volume 130,000 patient visits) with an opioid-related chief complaint (e.g., overdose, request for detoxification program, opioid withdrawal). A member of the study team approached eligible participants who presented during the times when study staff were on duty, explained the study, and obtained written informed consent. Participants underwent a standardized naloxone training session modeled from [prescribetoprevent.com](https://www.prescribetoprevent.com), which included opioid overdose recognition and administration of intranasal naloxone [22]. Study staff then used a teach-back approach to confirm the participant's understanding of how to respond to an opioid overdose using the smart naloxone kit. Once the participant was deemed to be medically stable for discharge from the ED, they were provided with a smart naloxone kit. We contacted participants using standard text messages to

Fig. 2 Workflow of BLE naloxone kit.

Fig. 3 Campus map. Dark circles represent BLE readers at the (1) ambulatory entrance/exit from the ED, (2) bus stop/pedestrian walkway, (3) west campus intersection, (4) east campus rotary, and (5) restricted-access

ambulance entrance/exit. Dashed lines represent vehicle traffic pathways, and solid lines represent pedestrian traffic pathways.

schedule a follow-up qualitative interview at 2 weeks post-discharge to ascertain the participants' knowledge, attitudes, beliefs, and practices regarding the smart naloxone kit (Fig. 4).

As compensation for their time and effort, participants were offered US\$40 in the form of gift cards to local retail

Fig. 4 Study schematic.

establishments upon completion of the study (i.e., at the conclusion of the qualitative interview).

Naloxone Kit Detection

Study staff utilized the following definitions to categorize detection of smart naloxone kits by the RTLS as binary events: (1) detection by either BLE reader no. 1 at the ambulatory entrance/exit to the ED or by the paired Visybl mobile phone application served as an internal control to verify that a particular BLE beacon was operational; and (2) detection by any of BLE reader nos. 2–5 served as an indicator that a particular BLE beacon (and associated naloxone kit) was carried across the boundaries of our hospital campus. Detection data was downloaded from the BLE readers no fewer than 6 hours and no more than 24 hours following participant enrollment and discharge from the ED.

Thematic Analysis from Exit Interviews

At the follow-up visit, trained research personnel conducted in-person semi-structured interviews using an interview guide developed based on the technology acceptance model framework (Appendix) [23]. Interviews were audio-recorded and transcribed verbatim by trained study staff (BPC). Thematic analysis was used to code and analyze exit interview data. The coding structure was developed by two investigators (JTL and SPC) based on deductive codes from the interview questions. Once the coding scheme was developed, interview transcripts were coded by two coders (BPC and JTL) independently, and notes were reviewed by the study team in aggregate.

Results

Participant Characteristics

Thirty-three eligible individuals were approached by study staff between January 2017 and February 2018. Three declined to participate, and thirty individuals consented to participate in the study (Fig. 5). Demographic characteristics of participants can be found in Table 1. Eleven participants reported having previously used naloxone on a victim of opioid overdose, while 17 reported they had not; two were not asked about prior naloxone use. Twenty-seven presented for evaluation of an opioid overdose, and three presented in opioid withdrawal or seeking treatment for opioid use disorder.

The three individuals who declined participation reported the following reasons for doing so: (1) “I have no need for [naloxone] because I’m not going to overdose... They are going to give me a methadone pill here,” (2) “[I’m] not going to do this again” after accidental overdose of prescribed pain medications, and (3) already having naloxone and already enrolled in two other research studies. No participants cited the actual technology as a reason for declining participation.

Naloxone Kit Detection

Of the 30 smart naloxone kits dispensed, we acquired an initial test signal (internal control) from 97% ($N = 29$) of BLE beacons while in the ED, suggesting a technology failure in one of the beacons. We captured 80% ($N = 24$) of dispensed beacons at key egress locations from our hospital campus, suggesting that these smart naloxone kits had actually been taken into the community. Six beacons were not detected by BLE readers at campus egress points. During follow-up interviews, the recipients of three of these beacons reported that they took the smart naloxone kits home with them upon discharge. The remaining

Fig. 5 Participant recruitment and BLE detection.

Table 1 Demographic characteristics of participants.

	<i>N</i> = 30
Median age, years (IQR)	35 (29, 41)
Sex, <i>N</i>	
Male	24
Female	6
Race/ethnicity, <i>N</i>	
White, non-Hispanic	24
White, Hispanic	2
Hispanic	2
Other/refused	2

three participants were lost to follow-up, and therefore we presume that these kits never left the hospital campus (Fig. 5).

Thematic Analysis from Exit Interviews

Of the 30 participants, 11 were successfully reached by phone: four agreed to return for the follow-up qualitative interview, with an additional seven declining because of logistical issues, such as lack of transportation or inability to leave their treatment program. Though we did not have a sufficient sample size to achieve thematic saturation, summary findings from our qualitative interviews revealed the following themes: perceptions of and interactions with naloxone, emergency medical services (EMS), and location-monitoring technologies.

Thoughts Regarding and Use of Bystander Naloxone

1. Wide-ranging thoughts on carrying naloxone rescue kits on their person. Some participants perceived limited use for naloxone because they use opioids at home only and not in public, some expressed that naloxone reminds them of their opioid use, and some stated that everyone should have access to naloxone.
 - (a) “I never had [a naloxone rescue kit], I do mine [opioids] at home, I don’t go out in public.”
 - (b) “I don’t want to see or think about anything associated with [heroin].”
 - (c) “Seems like every household should have [naloxone].”
2. One participant reported taking the smart naloxone kit home with them and subsequently using it to resuscitate an opioid overdose.
 - (a) “I took the Narcan® home with me and I used it on my friend right there.”

3. One participant reported having some difficulty recalling how to assemble and use the naloxone rescue kit in an overdose scenario.

- (a) “I really didn’t know what I was doing... It was so hard to read that thing.”

Interactions with First Responders and Emergency Medical Services

1. Participants reported prior problematic interactions with first responders that made them reluctant to activate the emergency medical services system.
 - (a) “The cops are the first people on scene, and I remember them saying, ‘oh I’m not going to keep giving this guy Narcan®, I’m not wasting my Narcan® on them.’”
 - (b) “... Some abusive language from the rude a** EMT [emergency medical technician] the time I came to see you guys. He kept saying I was an addict, that I did a lot more [heroin] than I was saying.”
2. Participants expressed a reluctance to involve themselves as bystanders in an overdose situation, rooted in mistrust of first responders; however, some expressed that there may be protections for bystanders who assist.
 - (a) “... I’m gonna probably let that person die and I’m gonna leave, just ‘cause I don’t wanna go to jail.”
 - (b) “I mean, people don’t like the police. That’s the problem. They don’t trust them.”
 - (c) “As time goes on, and there’s more people dying of [overdoses] and stuff, I’m hearing you can call and they won’t arrest you.”

Willingness to Engage with Location-Monitoring Technologies

1. Participants were divided on whether they would use smart naloxone kits that activate EMS upon use.
 - (a) “I would never use it... The point of someone wanting to use Narcan® is because they want to avoid going the route of cops and ambulances and stuff.”
 - (b) “If you’re saving somebody’s life, I mean that’s all that really matters.”
2. Participants held mainly negative perceptions of smart naloxone kits with (1) the ability to transmit GPS coordinates when used, (2) city-wide location-monitoring

technology, or (3) continuous GPS tracking; though one participant found the concept to be acceptable.

- (a) “Let me tell you right now, anybody that I know would not allow this.”
- (b) “Most people don’t want to be followed... And I’m definitely someone who’s paranoid that somebody might be following me.”
- (c) “I feel like that even, no matter how much you guys reassured me it wouldn’t be it, I feel like there would be a way for you guys to track me when I’m picking up [my drugs].”
- (d) “No, no [I don’t mind] ‘cause I’m not really doing anything I’m not supposed to be doing.”

Technology-Related Challenges

Study staff encountered difficulties in connecting our RTLS to the hospital network, which presented challenges to execution of our study. For instance, although the BLE readers kept time-stamped records of when a particular beacon was within its detection radius, the internal clock was not maintained when the reader was powered down, and the hospital network’s firewall prevented synchronization during data downloads. Additionally, placement of readers remote from the main hospital buildings resulted in inconsistent Wi-Fi connectivity and necessitated manual download of data, which was inefficient and relatively labor intensive.

During routine security checks of the deployed readers, we discovered that one of the BLE readers had been removed from its secure casing. Recruitment was paused while we revised security protocols, and 11 days later, a replacement reader was re-provisioned to the location. Later in the study period, we discovered that one of the readers was no longer operational due to a corrupted memory card. While we worked with the manufacturer to troubleshoot, enrollment was once again paused to ensure we did not miss transit of a smart naloxone kit due to lack of a reader. The reader was removed from service, repaired, and recruitment resumed 21 days later.

Discussion

This investigation demonstrated that individuals with opioid-related complaints in the emergency department will accept and use an RTLS-equipped smart naloxone kit. Participants were accepting of the smart naloxone kit, with RTLS signals indicating that 80% of individuals ($N = 24$) carried the smart naloxone kit out of the ED and off our hospital campus. When the RTLS signal was taken in combination with self-report,

that proportion increases to 90% ($N = 27$). These data suggest that between 10% ($N = 3$) and 20% ($N = 6$) of study participants never took their smart naloxone kit off the hospital campus. Naloxone distribution programs are based upon the premise that saturating a region at risk for opioid overdose with naloxone is important in preventing subsequent opioid overdose deaths. Previously, the proportion of naloxone rescue kits from distribution programs actually available to the community of people who use opioids was based entirely upon self-report. This study provides a basis for others to further develop RTLS technologies to gauge the level of naloxone uptake in high-risk communities.

A second important finding is that even PWUD accept transient monitoring technologies. Participants’ willingness to engage with the smart naloxone kit is exemplified by an individual who, when informed that his kit was not detected by the BLE readers, insisted that he took his kit home, and even offered to return to campus and drive around so that the beacon’s signal could be captured. This suggests that participants may wish to use technology to connect to their clinicians and demonstrate their adherence to prescribed therapies. Despite acceptance of transient monitoring afforded by our RTLS, individuals continued to voice concerns regarding hypothetical, continuous *active* tracking of naloxone. These concerns centered around the fear that active tracking systems might be monitored by law enforcement, despite reassurances that geocoded data would not be shared. This suggests that PWUD may find passive technologies, such as RFID or BLE, more acceptable than continuous active tracking technologies like GPS in the monitoring of community-based harm reduction strategies such as naloxone distribution programs. Future expansion of RTLS systems into the community may therefore be acceptable to PWUD.

Consideration of such a hypothetical city-wide RTLS must take into account the advantages and disadvantages of particular technologies. In our study, we utilized BLE technology, which uses battery-powered beacons that simultaneously are highly energy-efficient and exhibit a high read range, which translates into a wide detection radius. An alternative technology is RFID, which utilizes unpowered (i.e., no battery) tags that are energized from radiofrequency waves emitted by an RFID reader and reflect these signals back to the source in order to be detected. This results in a limited read range when compared with an active technology such as BLE but has the advantage of being a much smaller form factor that can be seamlessly integrated into the object to be tracked (e.g., naloxone syringe). While RFID tags are cheaper than BLE beacons, the readers for RFID are more expensive than their BLE counterparts and have a smaller detection radius. Both RFID and BLE are, due to the frequency used, known to have difficulty penetrating certain materials, such as water and

human tissues, a shortcoming that can theoretically increase failure rate if the smart naloxone kit is carried on or close to a person's body. An advantage of RFID is the ability to tune the frequency to permit maximal transit through human tissues while maintaining a reasonable detection radius. It is unclear whether RFID may be more prone to failure than BLE when used in a smart naloxone kit, because the passive unpowered nature of RFID signal detection may adversely affect performance when the device is carried on a person. Finally, GPS technology is ubiquitous and familiar; however, it is likely to be a less acceptable solution when working with populations of PWUD, as our participants expressed significant reservations regarding use of devices that provide continuous location data rather than episodic location data as in the case of RFID or BLE.

While we acknowledge that our RTLS-equipped naloxone did not match the current gold-standard of self-report, we do note that this small pilot study is the first attempt to leverage RTLS to track naloxone retention from a naloxone distribution program, and that further refinements to such a system, both in the technology itself and in its deployment, may enhance its ability to accurately capture naloxone movements. Additionally, our ability to capture naloxone movement did not require user input. These lessons may be utilized in developing passive detection systems surrounding harm reduction in PWUD. Some of the challenges we encountered in executing our study likely resulted from the fact that our institution did not have pre-existing RTLS infrastructure. These barriers may be ameliorated or absent in an institution where there is an RTLS system already in place, as adapting the established system may prove easier than deploying an RTLS *de novo*. Notably, we have demonstrated that the use of an RTLS to passively geolocate opioid overdose rescue kits is feasible and acceptable to PWUD.

This study is an important first step towards deploying a wider naloxone detection system that can accurately pinpoint the location of distributed naloxone in a city. Passive detection with RTLS readers placed in areas of high concern for overdose may improve acceptance of such a monitoring technology while providing actionable data to direct overdose prevention and opioid education efforts into locations where they may be most in need. Additionally, a hospital-based RTLS system linked to a greater metropolitan level RTLS system to detect transit of naloxone kits from the hospital into the community may improve the resolution to which naloxone distribution programs can measure their effectiveness in providing naloxone saturation into their communities. Longitudinal monitoring of the movement of small objects across large cities has been performed in Seattle [24], and the same principles can be employed to determine the distribution patterns of naloxone rescue kits across a municipality. RTLS-equipped naloxone kits can provide location-based data complementary to that obtained from EMS calls for opioid

overdose; this information can help to reveal hidden populations that may be reluctant to engage with the medical system in traditional ways (e.g., calling 911 or coming to the ED) and may be utilized to better direct real-time interventions to prevent opioid overdose deaths, such as via novel mobile health interventions that might trigger a notification from a mobile application offering to call for help or prompt a phone call from a recovery coach to check in with the participant. Additionally, an attractive future direction is the development of a smart naloxone kit wherein the RTLS technology is activated only upon depressing the plunger or syringe to administer medication; this is advantageous in that a signal is sent to a reader, cellular phone or cloud-based mobile application only when the naloxone is used. This may offer insights into the appropriateness of naloxone use, as well as lend ecological context to ingestible or wearable biosensor-based mobile health interventions. By comparing the precise distribution wherein naloxone rescue kits are used with the location of 911 calls for opioid overdose, policymakers can introduce real-time overdose prevention strategies that correct any mismatch between low rescue kit concentration and high overdose prevalence. This capacity to continuously refine and optimize harm reduction efforts in real-time to emerging overdose “hot spots” represents an innovative response to the opioid overdose epidemic.

An important unresolved barrier to widespread implementation of this and other novel mobile health technologies is the problem of safeguarding geographic data and electronic device information, especially in applications where the technology intervention will be utilized by a population engaged in illegal and highly stigmatized activities. This is of particular concern with respect to a smart naloxone kit because bystander naloxone will inherently be used on someone other than the individual who consented to use of the technology, and thus robust protections must be in place before widespread deployment of an RTLS-naloxone detection network to ensure that vulnerable populations are not placed at risk of legal repercussions for engaging in life-saving interventions (e.g., utilizing a take-home naloxone kit). A consensus guideline or statutory protection with respect to safekeeping of mobile health data, which represents protected health information, is necessary to guarantee that data intended to guide public health interventions cannot instead be coopted by law enforcement authorities for purposes of punitive action against an at-risk population.

Notably, in spite of the outstanding concern noted above, no participant cited the RTLS technology as a barrier to their use of the overdose rescue kit. One participant reported difficulty reading instructions for assembling the naloxone syringe and atomizer when responding to an overdose. This likely reflects the formulation of naloxone we employed for this project, and not the technology itself. Future iterations of RTLS-equipped naloxone would likely benefit, therefore,

from being coupled to newer formulations of naloxone that are ready-to-use (e.g., nasal spray style dispenser), which may help with ease of use by bystanders [25].

Finally, we note that the endorsement of transient monitoring technologies by PWUD is necessary, but not sufficient, for the success of a more widespread naloxone detection system. Partnership with public health and government entities is crucial, as the technical difficulties we encountered illustrate the importance of anticipating inevitable technical failures, as well as the requirement for continued upkeep of technologic components (e.g., software updates, hardware maintenance).

Limitations

The limitations of this investigation are as follows. First, participants who consent to participate in the study may be more willing to engage with novel technologies than the general population of PWUD. We note, however, that other investigators have found broad acceptance of ubiquitous monitoring technologies, even those with the capacity to identify illegal behavior [26]. In addition, we encountered a relatively high technology failure rate for detection of smart naloxone kits leaving the hospital campus. While this preliminary study serves to demonstrate a proof of concept, additional refinement and validation are required before a smart naloxone kit may be utilized as a sufficient proxy for community penetration. Furthermore, our small sample of majority white males (typical for PWUD who present to our center, but perhaps not representative of a nationwide sample) combined with a low follow-up rate for qualitative interviews limits the conclusions that may be drawn from this study. Finally, while we explored PWUD perceptions of smart naloxone kits, we note that attitudes and opinions of other impacted parties—notably, law enforcement and EMS—were not obtained. Thus, this work provides a proof of concept for the use of RTLS technology to define naloxone movements, but also makes clear that a larger study with a more robust RTLS system is necessary to draw generalizable conclusions about the interface between PWUD, naloxone, and geolocating technologies.

Conclusions

This study provides important preliminary information to address a significant knowledge gap about acceptance, uptake, and retention of bystander opioid overdose rescue kits as well as location monitoring technologies. Further study of technology-enabled rescue kits will be enhanced by learning how to best address participants' concerns about interactions with prehospital personnel and fears of law enforcement action when emergency medical services are activated in response to an opioid overdose. Widespread deployment of

naloxone equipped with a real-time location monitoring system will be contingent on incorporating feedback regarding willingness to adopt various technologies (e.g., BLE vs GPS), as well as continuing to foster relationships among emergency medical services, public health officials, and PWUD.

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Compliance with Ethical Standards This observational study was approved by the University of Massachusetts Medical School Institutional Review Board.

Conflicts of Interest None

Abbreviations *ED*, emergency department; *BLE*, low-energy Bluetooth; *RTLS*, real-time location system; *PWUD*, people who use drugs; *EMS*, emergency medical services; *EMT*, emergency medical technician

Appendix. Semi-structured Interview Agenda

Geographic patterns of emergency department–based naloxone distribution

The intent of these semi-structured interviews is to gather information regarding participant attitudes towards BLE-tagged medication tracking and take-home naloxone use for response to an opioid overdose. This information will be taken into consideration as we continue to investigate the efficacy of emergency department–based naloxone distribution in preventing opioid overdose deaths. This agenda is intended to guide study staff through the key content areas of data collection for this project, ensuring that the same content is discussed in each semi-structured interview. It is not a rigid script that must be adhered to verbatim. This will allow the study staff flexibility to adapt and clarify questions to suit the needs of different study participants. Similarly, questions need not be asked in this particular order. Instead, the study staff will adapt the conversation as needed according to the narrative from each study participant, pursuing both the research topics as well as any relevant emergent themes that evolve from the discussion.

Welcome

Intent: The goal of section A is to welcome study participants, and explain the purpose of this interview.

1. Welcome the participant to the Clinical Research Center
2. Introduce yourself
3. Explain that we will be audio recording the interview so we can analyze themes from their stories later and that
 - a. All recorded data is in no way linked to the study participant
 - b. We will not be using their name in the recording
4. Explain that all answers will be confidential
5. Study participants are the only ones who can help us better understand the patterns and practices of naloxone (Narcan®) use in people who are most likely to encounter opioid overdoses
6. Remind participants to not use their names, or the names of anyone else (for example, the name of a physician that prescribed them an opioid medication, or the name of their drug dealer)
7. Answer any questions

Experience with naloxone

Intent: The goal of section B is to determine participants' experience with naloxone and opioid overdose, either their own or in friends, family, or acquaintances. Study staff will explain that it is important to understand the context of a participant's experiences as we explore attitudes towards naloxone use and availability. This may be an emotionally charged topic; study staff will encourage participants to share as much of their experiences as they feel comfortable sharing. We encourage study staff to use the term "Narcan®," as participants may not be familiar with the generic term "naloxone."

1. Have you ever been given Narcan® for an overdose?
 - (a) Where was it given and who gave it? (e.g., hospital, by EMS or firefighters, by a friend or bystander)
 - (b) How was it given to you? (e.g., intravenous, intramuscular, intranasal; the participant may not know if they were unconscious at the time of administration)
 - (c) How many times have you been given Narcan®?
2. Have you ever given Narcan® to someone else?
 - (a) How did you administer it? (e.g., intravenous, intramuscular, intranasal)
 - (b) Did you bring them to the hospital after giving Narcan®?
 - (c) How many times have you given Narcan® to another person?
 - (d) How comfortable do you feel giving Narcan® to another person?
3. Where do you obtain Narcan®? (outside of this study, if participant has received Narcan® in the past)

4. Where do you store Narcan®?
 - (a) Probe: Do you carry it with you? (All the time? Sometimes? When you plan on using or expect to use heroin?)
5. Have you ever been in a situation when you were present with someone when they overdosed, but there was no Narcan® available?

Attitudes towards BLE-tagged naloxone

Intent: The goal of section C is to explore acceptance and use of BLE-tagged naloxone kits. Study staff will explain that this information will be helpful in future studies to ensure that participants feel comfortable with the technology used to study naloxone distribution patterns.

1. Explain your understanding of how the tag on the Narcan® you were given works. *(It should have been explained to participants when they are given naloxone that the BLE tag triggers a stationary reader when it comes in close proximity, and does not actively transmit information about the kit or participant's location)*
2. Did you have any concerns or worries about taking the tagged Narcan®? What were they?
3. Do you still have the Narcan® you were given as part of this study?
 - (a) Was the Narcan® used on you or another person for an overdose?
 - (b) Where do you keep the tagged Narcan®? Do you carry it with you?
4. Would you accept tagged Narcan® if you knew it would be detected at locations away from the hospital?
 - (a) Probe: Would you accept Narcan® that transmitted its location?
 - (b) Probe: Would you accept Narcan® that alerted 911 when it was used?
5. What assurances would you need to use a BLE or geolocating Narcan® syringe?

Closing and follow-up

Thank you for participating in this interview. The audio recording will now end. We appreciate all the information and feedback you have given us.

1. Answer any lingering questions

2. Turn off voice recorder
3. Give participants parking voucher and remainder of study compensation

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