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"Smart" harm reduction vending machines to improve public health: Evaluating the utilization

Alice Zhang [a,*], Jennifer Murphy [b], Paul M. Griffin [c], Marcia Goodman-Hinnershitz [d], Casey N. Pinto [e], Sarah M. Ballard [f], Patricia Sue Grigson [f], Sarah S. Kawasaki [g], Wen-Jan Tuan [a], Aleksandra E. Zgierska [h]

[a] Department of Family and Community Medicine, Penn State College of Medicine, Hershey, PA, USA
[b] Department of Criminal Justice, Penn State Berks, Wyomissing, PA, USA
[c] Department of Industrial Engineering, Penn State College of Engineering, University Park, PA, USA
[d] Council on Chemical Abuse, Reading, PA, USA
[e] Department of Public Health Sciences, Penn State College of Medicine, Hershey, PA, USA
[f] Department of Neuroscience and Experimental Therapeutics, Penn State College of Medicine, Hershey, PA, USA
[g] Department of Medicine, and Psychiatry and Behavioral Health, Penn State College of Medicine, Hershey, PA, USA
[h] Department of Family and Community Medicine, Public Health Sciences, and Anesthesiology and Perioperative Medicine, Penn State College of Medicine, Hershey, PA, USA

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ABSTRACT

Background: Low-barrier methods, including vending machines (VMs), for dispensing harm reduction (HR) items have become popular in the United States. Technological advances have enabled VM's advanced features (e.g., interactive touchscreens, client registration, cloud-based data collection). This report describes the evaluation outcomes from two "smart" VMs (sVMs) in community settings with the goal of reducing harms related to substance use, especially opioids.

Methods: Two sVMs, placed in central Pennsylvania's communities (one outside an urban hospital's emergency department; another inside a community organization's lobby in a small city), dispensed free HR items and provided information on, and linkages to, healthcare, social welfare, and other community services. Data on sVM utilization, collected from May 2024 to May 2025, were analyzed using descriptive statistics; test of proportions was used to compare the data across the two sites.

Results: Over one year, 2321 clients accessed the two sVMs, with an additional 4472 sessions with non-registered individuals viewing items or resources. The sVMs dispensed 11,327 items to 2321 registered clients, with hygiene kits (n = 3454), wound care kits (n = 1674), and safer sex kits (n = 1553) being most common. The sVMs dispensed 2755 drug testing strips and 1906 naloxone doses. Furthermore, 396 registered clients obtained information on existing resources/services. Across a total of 14,867 sessions, significant differences in usage were noted between the two sVMs.

Conclusions: Interactive sVMs can effectively dispense HR items and connect individuals to services, thereby having the potential to improve individual and public health. Contextual factors, such as location, may influence utilization.

1. Introduction

Fatal overdoses in the U.S. reached a historic high in 2023 with over 111,000 reported deaths in that year (Ahmad et al., 2025). While fatal overdoses have started to decrease recently, with 80,856 recorded for 2024 (Ahmad et al., 2025), these overdoses represent preventable mortalities. In response to the overdose crisis, communities have increasingly utilized low-barrier methods to distribute naloxone, a life-saving medication used for reversing an opioid overdose. Community distribution of naloxone can reduce the toll of overdose deaths (Fischer et al., 2025; Razaghizad et al., 2021; Vadiei et al., 2025). Some communities have implemented vending machines (VMs) as a low-barrier

* Corresponding author.
E-mail address: azhang@pennstatehealth.psu.edu (A. Zhang).

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distribution method for naloxone and other items useful for reducing substance use-related harms, such as sharps containers, drug testing strips, cookers, or wound care kits (Allen et al., 2022; Arendt, 2023; Bryant et al., 2025; Zhang et al., 2025).

VMs are a promising method for effective distribution of naloxone and other items as they can placed outside traditional service settings and be accessed even when businesses are closed (Allen et al., 2022; Cama et al., 2014; Dahlem et al., 2025; Kerr et al., 2022; Otiashvili et al., 2021). The relative anonymity afforded by VMs can help overcome stigma associated with substance use (Islam et al., 2008; Islam & Conigrave, 2007; Wagner et al., 2022). Since the 1990s, VMs have been used, primarily in Europe and Australia, as a harm reduction (HR) strategy for clean needle distribution (Cama et al., 2014; Day et al., 2016; Dodding & Gaughwin, 1995; Moatti et al., 2001; Stark et al., 1994). They have evolved over the years to provide other HR items, such as human immunodeficiency virus (HIV) self-tests, condoms, and even prescription opioids for safer use (Bardwell et al., 2023; Otiashvili et al., 2021; Stafylis et al., 2018), as well as other products to promote the overall health and wellbeing of people who use drugs. Existing studies have shown high acceptability of VMs (Dodding & Gaughwin, 1995; Lee et al., 2020; Stewart et al., 2023; Wagner et al., 2022), good reach to underserved populations (Cama et al., 2014; Day et al., 2016; Moatti et al., 2001; Stark et al., 1994; Vera et al., 2019), and heavy utilization for necessary items, particularly after-hours (Cama et al., 2014; Otiashvili et al., 2021; Stafylis et al., 2018; Uthurralt et al., 2022).

In the U.S., VMs have increasingly been used to distribute naloxone and other HR items. Preliminary research showed that VMs distributing naloxone may contribute to reduced overdose deaths (Allen et al., 2022; Arendt, 2023). Yet, despite their growing popularity, VMs are a relatively novel, understudied distribution method for naloxone and other HR items (Russell et al., 2023; Zhang et al., 2025). In addition, while VMs have been successfully placed in multiple communities in the U.S., their implementation may be challenging in some communities where stigma toward substance use is high (Stewart et al., 2023) or where resources and funding for community health programs may be limited (Khatri et al., 2024; Saloner & Lagisetty, 2025). Furthermore, much of the prior research focused on VMs that were retrofitted for HR items from food-and-drink dispensing machines, some of which required in-person registration at a HR or similar organization in order to access the VM. Requiring registration may pose a barrier to VM utilization (Herrera et al., 2026; Martin et al., 2025). Updated technology has allowed for a new generation of interactive "smart" VMs (sVMs) with the ability to anonymously register clients through the touchscreen without any in-person interaction, play educational videos, display local services and resources, "passively" and automatically collect data on sVM utilization, and administer survey questions to sVM clients. Research specific to sVMs is even more sparse.

Pennsylvania, like other states in the U.S., has been substantially impacted by the opioid and overdose crises. In 2024, approximately 3300 Pennsylvanians died from a drug overdose, of which 25% were opioid related (Ahmad et al., 2025; Goetz, 2025). Furthermore, many of Pennsylvania's counties and municipalities are rural (Rural Urban Definitions, 2025), and resident access to specialty addiction treatment, recovery and other resources can be challenging, despite the existing need for HR services (Brant & McCracken, 2025). Low-barrier, non-stigmatizing strategies, such as sVMs, can be particularly useful for increasing community availability of naloxone and other HR items. Therefore, we developed and implemented, with community partner involvement and input, two HR-focused sVMs in two Pennsylvania communities noted to be areas with higher rates of fatal opioid-overdoses based on the publicly available data. Given the relative scarcity of research on VMs in the U.S., particularly sVMs with interactive features, we evaluated the utilization of sVMs designed for reducing substance use related harm and addressing public health needs in south central Pennsylvania.

2. Methods

This report follows the SQUIRE 2.0 reporting standards (Ogrinc et al., 2015) and describes results from the first year of the two sVM operations, from May 14, 2024 through May 14, 2025. The Penn State College of Medicine Institutional Review Board reviewed this program and deemed it to constitute a public health initiative, with the survey questions determined to be exempt human subjects research.

2.1. Context

This program was conducted in south central Pennsylvania, a region impacted by the opioid crisis and substance use disorders (SUDs), with overdose deaths increasing from 2020 to 2023, much like in the rest of the U.S. (Pennsylvania Office of Drug Surveillance and Misuse Prevention (ODSMP), 2025). Harrisburg (Dauphin County) and Reading (Berks County) communities, with distinct demographic characteristics and SUD-related needs, were selected for the HR-focused sVM placement to maximize accessibility of HR strategies in underserved populations, while leveraging existing community connections.

In Harrisburg, among its approximately 50,000 residents, 41.5% identify as Black or African American and 25.0% as Hispanic (Data USA, 2025a). In Reading, among its 95,000 residents, nearly 70% identify as Hispanic and 7.8% as Black or African-American (Data USA, 2025b). In both cities, approximately 30% of residents live below the poverty line and roughly 40% are covered by Medicaid (Data USA, 2025a, 2025b). In 2023, the rates of fatal overdoses (4 per 10,000) and the ED visits for overdoses (6.1 per 10,000) in Dauphin County exceeded the average state-level rates (3.6 and 5.8 per 10,000, respectively); Berks County also experienced fatal overdoses (2.6 per 10,000) (Pennsylvania Office of Drug Surveillance and Misuse Prevention (ODSMP), 2025).

With the community's guidance, the Harrisburg's sVM was placed in a covered outdoor courtyard adjacent to an emergency department (ED) entrance, and the Reading's sVM was placed inside a lobby of a community-based non-profit organization, which provides transitional housing, community programs and space for gathering, day care, and exercise facilities. Both locations afforded 24/7 access to sVMs, and were in high-traffic areas, on a bus route, with easy pedestrian access. Furthermore, they were located directly by the ED (Harrisburg) and near the county courthouse (Reading), allowing for high visibility and accessibility for individuals with health needs or those navigating the criminal legal system.

2.2. Program

2.2.1. Program design

The sVM program was led by faculty members from an academic institution, with community partners providing extensive input on the sVM location and operations. Community partners included healthcare providers, public health professionals, individuals with lived experiences of addiction and recovery, and representatives from local organizations focused on HR, recovery, addiction treatment, social welfare, and family support services. They were invited to participate in a community advisory board based on their ongoing work in the community related to either public health or SUD treatment. A multidisciplinary community advisory board of 20 individuals met virtually on a quarterly basis and was closely involved in the planning and implementation process, providing ongoing feedback. This input included naming the machine (Health to Go; Salud para Llevar in Spanish), advising on the types of items, information on the available resources and services, and on approaches to community outreach. The advisory board members also assisted with supplying locally produced educational videos on SUD and its treatment, and securing professional Spanish translation for all print, audio, and video content available through the sVMs. State and county government and public health organizations also provided some of the sVM items free-of-charge (e.g.,

naloxone, wound care items, safer sex items, and drug testing strips). Program funding was provided by an internal institutional grant and by grants from a non-profit foundation and the county-administered opioid remediation funds.

2.2.2. sVM operations

All sVM clients can view available items, including their detailed description, services, and educational videos. To obtain items, an individual must register, with one exception: the sVMs are able to dispense naloxone without requiring registration, thus enabling access to this life-saving medication.

To register, clients need to attest to being at least 18 years old and create a unique username, consisting of client-selected birth year, color, and icon (animal- or nature-themed). After username creation, implied consent is obtained to answer five optional demographic questions and any subsequent optional survey questions (see Document, Supplemental Digital Content 1, which contains the demographic registration questions). This process typically takes 1–2 min and is conducted entirely on the touchscreen. The registration is designed to preserve anonymity, and no identifiable personal health information is collected. On return visits, sVM clients enter their username to log in and obtain items.

sVMs are leased from the company whose personnel programmed each machine to tailor the content (items, community services, educational materials) to local community preferences; the developers were also readily available for consultation, input, troubleshooting and maintenance needs. The supply and operations of each machine are monitored remotely through its cloud-based data surveillance and collection system. For day-to-day operations, the items in the Harrisburg-based sVM are re-stocked by program team members; the Reading-based sVM is stocked by employees of the host organization. Host organizations provide electricity for sVMs. For data collection, the Reading-based sVM has wireless internet connectivity provided by the community-based organization, while the Harrisburg-based sVM has cellular connection. Both machines are available 24/7. However, between 11 pm and 7 am, access to the Reading-based sVM requires ringing a doorbell to be let into the facility's lobby.

2.2.3. sVM-dispensed items

The selection of sVMs' to-be-dispensed items was determined in collaboration with the community advisory board to reflect local preferences, while addressing SUD, co-occurring conditions, and other public health needs in alignment with state laws and institutional regulations. The sVM clients can view the available items and their description (pictures, information, itemized contents) on the screen prior to "clicking" a button to dispense the item (see Photo, Supplemental Digital Content 2, which demonstrates list of items available in the sVM). Given recent legalization of drug testing strips in Pennsylvania and the relative novelty among the public, the drug testing kits also include an optional, brief educational video produced by a community partner, which can be played on the sVM's screen when accessing the drug testing kit; this video provides education on how to use these testing strips and interpret the results.

Community-prioritized items for the two sVMs included nasal naloxone (by itself or in a kit with a face shield), fentanyl and xylazine drug testing kits (5 strips each per kit), HIV self-tests, safer sex kits (external/internal condoms, dental dams, lubricant), pregnancy tests, wound care kits (band-aids, antibiotic ointment, gauze, sterile saline), hygiene kits (soap, washcloth, deodorant, toothbrush, toothpaste, socks, tissues, mouthwash, comb, nail clippers), menstrual kits (tampons, pads, liners, sanitary wipes, disposal bags), medication disposal bags, and seasonal items (e.g., cold and flu kits during the winter with tissues, disposable thermometer, cough drops, masks, hand sanitizer for symptom management).

sVM clients were initially able to request an unlimited number of items. However, due to the sVMs' popularity and the need to make the items available to a broader population, a set of dispensing limits was put in place in July 2024 (limiting an sVM client to two of each item per day). A second set of limits were placed in September 2024 for one hygiene or wound care kit per client per week due to popularity and cost of these items. Given the life-saving potential of naloxone, no limits were placed on naloxone dispensing; clients were also able to obtain "emergency" naloxone without sVM registration.

2.2.4. sVM service listings and educational videos

The sVM's touchscreen displays health education messages and videos featuring trusted local community members, such as addiction medicine physicians or individuals working with recovery organizations. The machines also serve as a resource hub and provide curated, up-to-date directories of local community services displayed on the touchscreen in both a list and map form, thereby helping connect sVM clients to medical, mental health and addiction treatment services; recovery resources; crisis services; housing, shelter and food assistance programs; and general community services (see Photo, Supplemental Digital Content 3, which demonstrates resource/service navigation in the map form). The directory of local and national resources and services was curated with the community advisory board's input; a designated community partner with social work experience reviews and updates the content quarterly. Health education messages and videos accessible through the sVM's touchscreen were adapted from the existing ones developed by the state and local public health agencies (see Document, Supplemental Digital Content 4). Individuals do not need a username to browse the resource/service directory or view the educational videos.

2.3. Measures

Demographic information, collected during registration, included gender (male, female, transgender/non-binary), race (American Indian/Alaska Native, Asian, Black or African American, Native Hawaiian/Other Pacific Islander, White, More than One Race, Other), ethnicity (Hispanic/Latino, Not Hispanic/Latino), employment (employed, homemaker, military, retired, student, unemployed, other), housing status (rent/own/live in family or friend's place, housing facility, unhoused, other) and age (inferred from the username's self-reported birth year). For all categories, aside from age, individuals could select more than one response.

Quantitative data on utilization, auto-collected by the sVM's inherent cloud-based data collection system, included numbers of sVM clients (registered and non-registered), sessions during which clients interacted with the machines and details of when (day, time) each sVM was accessed, number of times each item and service was viewed, and number and type of dispensed items.

2.4. Analysis

Descriptive statistics were applied to quantitative data and computed as means and standard deviations for continuous variables, and as counts and percentages for categorical variables. Differences in demographics between locations were assessed using a contingency table Chi-Square test for demographic categories; mean age was assessed using two-sample *t*-test, with two-sided significance level at $p < 0.05$. Difference in sVMs' utilization between the two locations was assessed using a test of proportions, also with two-sided significance level at $p < 0.05$.

2.5. Missing data

All "prefer not to answer" responses were omitted in their respective analyses, thus the denominator for each category only included those who provided a response. Two data collection issues also led to missing data. First, the default birth year during username generation was set at 1970. As a result, many individuals (n = 513) had 1970 as their birth year (e.g., 54–55 years old) compared to adjacent years of 1968 (n =

28), 1969 (n = 39), 1971 (n = 35), and 1972 (n = 36). To adjust for this, we set the number of individuals born in 1970 as the average of those born in adjacent years (n = 35) and removed 478 individuals reporting 1970 as their birth year from the data for age reporting only. Second, a temporary technical error led to the "Native Hawaiian/Other Pacific Islander" and "American Indian/Alaska Native" ethnicity options being occasionally automatically checked. Although the clients could uncheck these multi-choice options, responses regarding these two ethnicities were included in the other category for analysis.

3. Results

A total of 2321 individuals registered with and accessed the two sVMs during one year of their operations. The sVMs also recorded many sessions (n = 4472) where individuals did not register and browsed the sVMs' items (n = 1051; 23.5%) or the list of resources/services (n = 3229; 72.2%), which were both similar across the Harrisburg and Reading sites (Table 2).

3.1. sVM registered client demographics (Table 1)

Among the 2321 registered clients, 1246 (53.7%) used Harrisburg's and 1075 (46.3%) used Reading's sVM. The mean age of registered clients was 46.5 ± 15.2 years, and the majority identified as female (56.7%). Approximately 18% identified as Black or African American and 22% as Hispanic or Latino. Nearly a third (30.3%) identified as unhoused, with many (48.1%) reporting being unemployed. Compared to Reading, Harrisburg sVM's clients were more likely to identify as Black or African American ($p < 0.001$) and to own/rent their house ($p < 0.001$); both employed and unemployed individuals were more likely to access the Harrisburg sVM ($p < 0.001$; Table 1). Reading sVM's clients were more likely to identify as a sexual minority ($p < 0.001$) or Hispanic/Latino ($p < 0.001$), to be in the military ($p < 0.001$), and live in a housing facility (e.g., transitional housing, group homes, etc.) ($p < 0.001$; Table 1).

3.2. sVM utilization

3.2.1. sVM items (Table 2)

The sVMs recorded many sessions (n = 3229) where individuals browsed items without registration. Furthermore, among these sessions with non-registered clients, naloxone was dispensed 192 times, primarily in Harrisburg (n = 174; 90.6%). Altogether, 23,294 items were viewed and 11,327 were dispensed across both machines, with the frequency of viewing a certain item similar to the frequency of that item being dispensed.

Among 11,327 dispensed items, the highest items in demand included hygiene (30.5%), wound care (14.8%), safer sex (14.8%), and menstrual (11.9%) kits. They were followed by naloxone (8.4%; including kits dispensed to both registered clients and non-registered clients) and pregnancy tests (6.4%). The sVMs dispensed 1906 doses of naloxone (two doses per kit), and 2755 fentanyl and xylazine testing strips (five xylazine and five fentanyl testing strips per kit). A greater proportion of the Harrisburg sVM-dispensed items were related to HR and sexual health ($p < 0.001$); for Reading, a greater proportion was related to general health and basic needs ($p < 0.001$; Table 2).

3.2.2. sVM resources/services (Table 2)

There were many sessions with non-registered clients browsing for resources/services (n = 1051); of the registered clients, 396 used the sVM to browse for resources/services.

3.2.3. sVM sessions (Figs. 1 & 2)

Over one year, the sVMs logged 14,867 sessions for dispensing items or browsing. Most sessions took place in Harrisburg (58.8%), between 9 AM and 9 PM (64.2%; Fig. 1). Compared to Reading, the Harrisburg sVM was more frequently used after-hours (7 PM–6 AM; $p < 0.05$), while the Reading sVM was more frequently used during daytime ($p < 0.05$; Fig. 1). The pattern of sVMs' usage was consistent across the week (Fig. 2); Harrisburg clients tended to access the sVM more on Tuesdays

Table 1
Demographics of sVM clients reporting.

Demographics	Both sites (n = 2321)	Harrisburg (n = 1246)	Reading (n = 1075)	*p*-Value[1]
Age[2], years, mean (SD)	46.5 (15.2)	46.5 (15.2)	46.4 (15.3)	0.924
Age[2], # (%)	(n = 1843)	(n = 1049)	(n = 794)	<0.001
18–24 years old	161, 8.7%	110, 10.5%	51, 6.4%	
25–34 years old	397, 21.5%	256, 24.4%	141, 17.8%	
35–44 years old	450, 24.4%	265, 25.2%	185, 23.3%	
45–54 years old	365, 19.8%	239, 22.8%	127, 16.0%	
55–64 years old	301, 16.3%	118, 11.2%	182, 22.9%	
65+ years old	169, 9.2%	61, 5.8%	108, 13.6%	
Gender[3], #, %	(n = 1904)	(n = 1013)	(n = 891)	<0.001
Female	1079, 56.7%	574, 56.7%	505, 56.7%	
Male	636, 33.4%	362, 35.7%	274, 30.8%	
Transgender/non-binary	189, 9.9%	77, 7.6%	112, 12.5%	
Race[3], #, %	(n = 1635)	(n = 942)	(n = 693)	<0.001
Asian	33, 2.0%	26, 2.8%	7, 1.0%	
Black or African American	293, 17.9%	228, 24.2%	65, 9.4%	
White	582, 35.6%	311, 33.0%	271, 39.1%	
More than one race	360, 20.0%	196, 20.8%	164, 23.7%	
Other	367, 22.5%	181, 19.2%	186, 26.8%	
Ethnicity[3], #, %	(n = 1964)	(n = 1025)	(n = 939)	<0.001
Hispanic or Latino	435, 22.1%	116, 11.3%	319, 40.0%	
Not Hispanic or Latino	1529, 77.9%	909, 88.7%	620, 66.0%	
Employment Status[3], #, %	(n = 1732)	(n = 912)	(n = 820)	<0.001
Employed	345, 19.9%	212, 23.2%	133, 16.2%	
Homemaker	56, 3.2%	34, 3.7%	22, 2.7%	
Military	146, 8.4%	15, 1.6%	131, 16.9%	
Retired	101, 5.8%	42, 4.6%	59, 7.2%	
Student	93, 5.4%	32, 3.5%	61, 7.4%	
Unemployed	778, 44.9%	437, 47.9%	341, 41.6%	
Other	213, 12.3%	140, 15.4%	73, 8.9%	
Housing Status[3], #, %	(n = 1626)	(n = 892)	(n = 734)	<0.001
Rent or own or live in a family/friend's place	849, 52.2%	492, 55.2%	357, 48.6%	
Housing facility	119, 7.3%	23, 2.6%	96, 13.1%	
Unhoused	493, 30.3%	307, 3.4%	186, 25.3%	
Other	165, 10.2%	70, 7.8%	95, 12.9%	

sVM = "smart" vending machine; SD = standard deviation.
[1] *p* value was determined using a two-sample t-test for continuous (mean age) and Chi-Square test for all remaining variables.
[2] Age was determined from birth year during username generation.
[3] Individuals could select more than one response; all "prefer not to answer" responses were omitted.

Table 2
sVM utilization.

Registered clients, # (%)	Both sites (n = 2321)	Harrisburg (n = 1246)	Reading (n = 1075)	*p* value[1]
Browsing resources/ services	396 (17.1%)	231 (18.5%)	171 (15.9%)	0.095

Number of sessions with non-registered clients, # (%)	Both sites (n = 4472)	Harrisburg (n = 3143)	Reading (n = 1329)	*p* value[1]
Browsing resources/ services	1051 (23.5%)	721 (22.9%)	330 (24.8%)	0.173
Browsing items	3229 (72.2%)	2248 (71.5%)	981 (73.8%)	0.118
Obtaining naloxone	192 (4.3%)	174 (5.5%)	18 (1.4%)	<0.001

Viewed items, # (%)[2]	Both sites (n = 23,294)	Harrisburg (n = 13,314)	Reading (n = 9980)	*p* value[1]
Harm reduction items				
Drug testing kits	1102 (4.7%)	832 (6.2%)	270 (2.7%)	<0.001
Medication disposal bags	490 (2.1%)	345 (2.6%)	145 (1.5%)	<0.001
Naloxone[3]	1547 (6.6%)	1135 (8.5%)	412 (4.1%)	<0.001
Wound care kits	3298 (14.2%)	1697 (12.7%)	1601 (16.0%)	<0.001
Sexual health items				
HIV self-tests	791 (3.4%)	564 (4.2%)	227 (2.3%)	<0.001
Pregnancy tests	1276 (5.5%)	985 (7.4%)	291 (2.9%)	<0.001
Safer sex kits	2883 (12.4%)	2124 (16.0%)	759 (7.6%)	<0.001
General health and basic needs items				
Cold and flu kits	1271 (5.5%)	492 (3.7%)	778 (7.8%)	0.94
Hygiene kits	8517 (36.6%)	4200 (31.5%)	4317 (43.3%)	<0.001
Menstrual kits	2119 (9.1%)	939 (7.1%)	1180 (11.8%)	<0.001

Dispensed items, # (%)[2]	Both Sites (n = 11,327)	Harrisburg (n = 5553)	Reading (n = 5774)	*p* value[1]
Harm reduction items				
Drug testing kits	551 (4.9%)	400 (7.2%)	151 (2.6%)	<0.001
Medication disposal bags	192 (1.7%)	121 (2.2%)	71 (1.2%)	<0.001
Naloxone[3]	953 (8.4%)	655 (7.3%)	298 (5.2%)	<0.001
Wound care kits	1674 (14.8%)	672 (12.1%)	1002 (17.4%)	<0.001
Sexual health items				
HIV self-tests	280 (2.5%)	175 (3.2%)	105 (1.8%)	<0.001
Pregnancy tests	730 (6.4%)	525 (9.5%)	205 (3.6%)	<0.001
Safer sex kits	1553 (14.8%)	1043 (18.8%)	510 (8.8%)	<0.001
General health and basic needs items				
Cold and flu kits	590 (5.2%)	165 (3.0%)	425 (7.4%)	<0.001
Hygiene kits	3454 (30.5%)	1301 (23.4%)	2153 (37.3%)	<0.001
Menstrual kits	1350 (11.9%)	496 (8.9%)	854 (14.8%)	<0.001

sVM = "smart" vending machine.
[1] *p* value was determined using a test of proportions.
[2] Percentages reflect number of views or dispenses of an item over total number of items viewed or dispensed.
[3] Number of naloxone dispensed includes those dispensed by non-registered clients.

and Saturdays compared to those in Reading ($p < 0.05$; Fig. 2).

4. Discussion

4.1. Summary

We assessed the feasibility of deploying two interactive HR sVMs in two distinct south-central Pennsylvania communities affected by the opioid overdose crisis. In addition to dispensing "items", these sVMs featured touchscreen interfaces that allowed clients to view local services, watch educational videos, and hear recovery testimonials. The sVMs' advanced features supported robust data collection, including time of use, client registration status, and demographic data, thereby allowing us to evaluate sVMs' utilization. Their different placements further allowed us to explore how context influences use.

Over one year, more than 2300 registered clients accessed the sVMs, with over 1000 instances by non-registered individuals browsing for resources/services. There were nearly twice as many item views as items dispensed, reflecting strong interest in the sVMs' offerings. Hygiene-related kits made up about one-third of all items dispensed, alongside over 2700 drug testing strips and 1900 naloxone doses. Usage patterns varied by time and location, with Harrisburg's sVM having more after-hours activity, likely reflecting location, access schedules, and community needs.

4.2. Interpretation

sVMs expand on existing health promotion and HR VMs (Russell et al., 2023; Zhang et al., 2025), with similar interactive models emerging in Georgia (Europe) and Canada (North America), though data remain limited. Georgia's sVMs collected usage data and conducted touchscreen surveys, but dispensed different items and required in-person registration (Otiashvili et al., 2021). Over one year, Georgia's 10 sVMs served 1605 clients and dispensed 33,521 clean syringe kits (Otiashvili et al., 2021). Our sVMs had more registered clients, with comparable item distribution, although we were unable to include clean syringes in our sVMs due to current state laws prohibiting syringe exchange. Similar to Georgia's sVMs, our Harrisburg sVM saw increased use outside standard hours.

Compared to existing VMs with non-interactive features, our sVMs had more registered clients. Ohio's HR-focused VM had 637 clients over one year and Rhode Island's five VMs had 485 registered clients over two years, both requiring external registration (Arendt, 2023; Shaw et al., 2025). In contrast, our machines' built-in anonymous registration and data collection likely lowered access barriers and enabled better tracking. For example, the demographic data obtained from the sVMs revealed that fewer people of color are accessing our sVMs machines compared to the larger population proportion, highlighting the need for future targeted outreach to increase the sVMs' reach. Item demand varied, with our sVMs dispensing similar or fewer naloxone doses and test strips than VMs with non-interactive features (Arendt, 2023; Martin et al., 2025; Shaw et al., 2025). sVM location and hosting organizations may have influenced differences in HR-related item demand. Other machines dispensing more overdose prevention items were located at HR-related or syringe exchange organizations (Arendt, 2023; Shaw et al., 2025), while our sVMs' public access and locations likely led to broader item distribution. The high distribution of hygiene and menstrual kits may also reflect community's unmet basic needs, e.g., due to employment, financial, or housing instability. Reading's sVM dispensed more self-care items, reflecting the hosting organization residential programs' needs. Wound care kits, originally intended for xylazine-

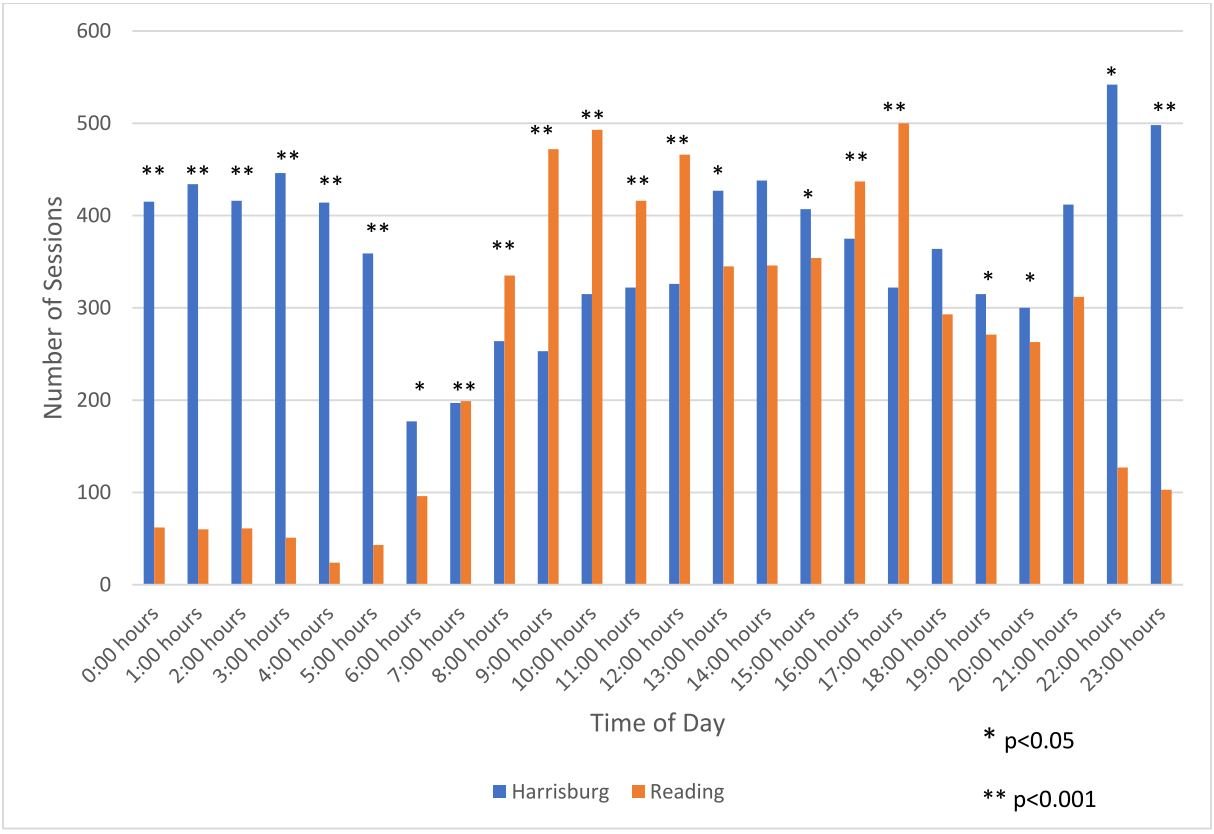

Fig. 1. Number of sVM sessions by time of day over 1 year. sVM = "smart" vending machine. *p* value: test of proportions was used.

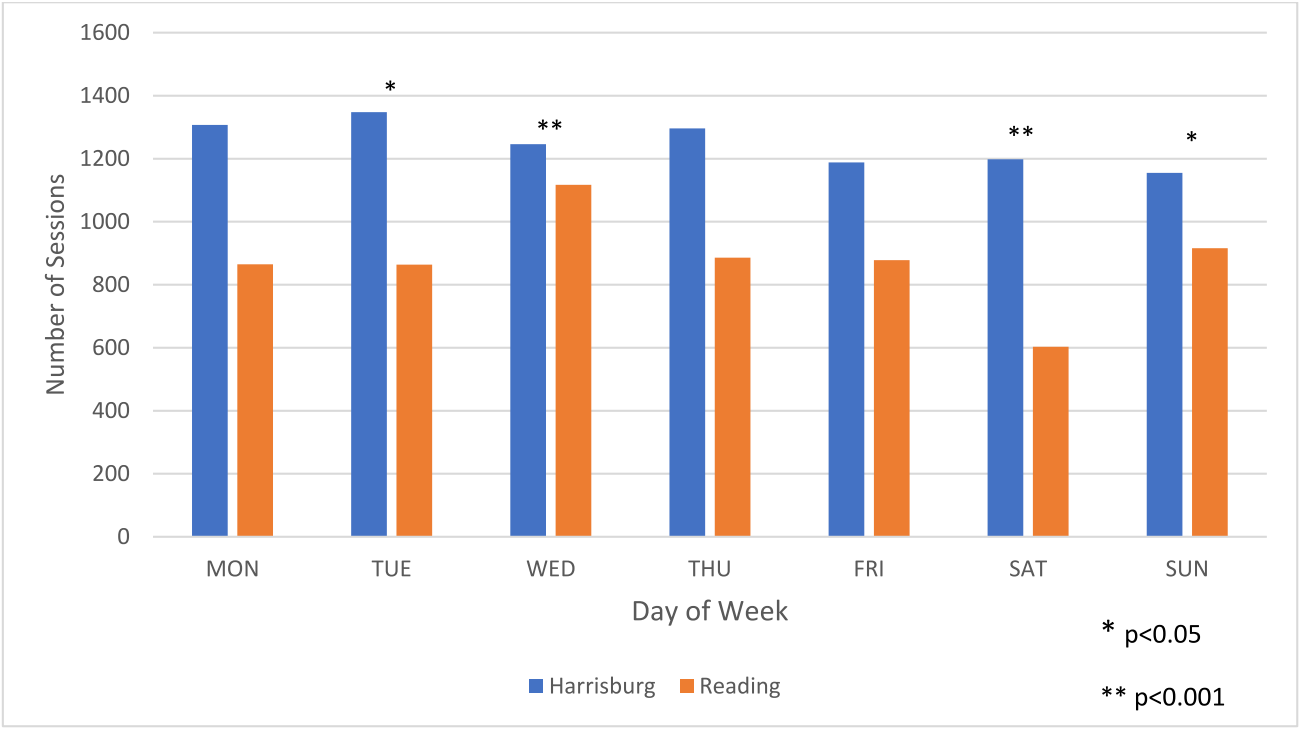

Fig. 2. Number of sVM sessions by day of week over 1 year. sVM = "smart" vending machine. *p* value: test of proportions was used.

related wounds, may have served general first-aid needs.

Utilization of our sVMs was partly limited by budgets and restocking capacity. Limits were placed on popular items to prevent stock depletion, though naloxone remained freely available without registration or limit restriction. Irregular supplies of certain items (e.g., HIV test kits) reduced consistency. Harrisburg's sVM had proportionally higher

usage on Tuesdays and Saturdays compared to Reading, which may have reflected the restocking schedule. Reading's sVM was managed on-site and stocked more regularly, potentially enabling more consistent use. In addition, given the sVMs' higher degree of technical sophistication, their operations were dependent on internet connectivity and the touchscreen being functional. Occasionally, the sVMs required servicing, thereby limiting its availability to the community; this typically occurred 0–2 days per month during the study period. Finally, sVM usage was likely influenced by each machine's location. While outdoor placement raises concerns around weather and potential vandalism, Harrisburg's outdoor courtyard location near a busy ED likely facilitated higher use, including after-hours, compared to indoor Reading sVM, which had more limited access during nighttime. In general, though, both sVMs were utilized after-hours when many services/resources are closed or have limited staffing. Other machines also reported robust after-hours usage (Cama et al., 2014; Otiashvili et al., 2021; Shaw et al., 2025; Stafylis et al., 2018). Given our findings on sVM utilization, future initiatives could consider different locations to expand reach to different populations, e.g., areas outside courthouses or correctional facilities, community centers, parking garages and transportation centers, libraries, and other locations accessible to and trusted by the community members who are most at need. Successful sVM utilization may also hinge upon community involvement and input to address the needs of underserved populations, including economically disadvantaged groups or people of color (Marschke et al., 2025; Russell et al., 2023).

4.3. Limitations

Demographic data were self-reported and may be inaccurate. Furthermore, there was a brief technical error during the study period in which two racial categories were auto-selected. Although clients could uncheck these categories, this may have led to inaccurate reporting; this issue has now been resolved for future reporting. Many clients also chose the default birth year during username generation; current work is ongoing with the sVM vendor to include other options, such as a keypad for clients to input their birth year or having an additional demographic question inquiring about age. While sVMs collected detailed data, they could not capture detailed information on non-registered use or nuanced behaviors, for example, on why individuals may choose to browse for items and services but not register to obtain items. Clients could create multiple usernames to bypass item limits. Qualitative interviews can elucidate further understanding on sVM utilization. Findings are not generalizable due to the small sample of two semi-urban sites in a region with growing HR acceptance. Different settings, such as rural areas, may yield different outcomes.

5. Conclusions

As communities look to implement VMs for HR, they may face a decision between interactive sVMs with additional technological features versus traditional VMs. Our findings show that sVMs, using the approach we applied, may reach more individuals by allowing for an integrated and anonymous client registration, and may dispense more general health and basic needs items, with a comparable number of HR items. These sVMs also enabled clients to browse and navigate community resources and services, alongside built-in data collection—uncommon features in traditional VM models. Differences between traditional versus “smart” VMs emphasize the need for contextual implementation and flexible, community-tailored strategies. Future studies should use mixed methods to explore in more depth the client experience and acceptability of the sVM, assess cost-effectiveness and community-level impacts, when balanced against the cost of implementation, including setup, maintenance, and resource allocation.

CRediT authorship contribution statement

Alice Zhang: Writing – review & editing, Writing – original draft, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Data curation, Conceptualization. **Jennifer Murphy:** Writing – review & editing, Project administration, Methodology, Conceptualization. **Paul M. Griffin:** Writing – review & editing, Resources, Methodology, Formal analysis, Data curation, Conceptualization. **Marcia Goodman-Hinnershitz:** Writing – review & editing, Project administration. **Casey N. Pinto:** Writing – review & editing, Project administration, Methodology, Funding acquisition, Conceptualization. **Sarah M. Ballard:** Writing – review & editing, Project administration, Methodology, Conceptualization. **Patricia Sue Grigson:** Writing – review & editing, Methodology, Funding acquisition, Conceptualization. **Sarah S. Kawasaki:** Writing – review & editing, Methodology, Conceptualization. **Wen-Jan Tuan:** Writing – review & editing, Methodology, Formal analysis, Conceptualization. **Aleksandra E. Zgierska:** Writing – review & editing, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization.

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Declaration of competing interest

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.josat.2026.209991.

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