



Full length article

Development, validation, and potential applications of the hepatitis C virus injection-risk knowledge scale (HCV-IRKS) among young opioid users in New York City

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ABSTRACT

Background: Hepatitis C virus (HCV) incidence has increased dramatically in the United States in recent years and is associated with the opioid epidemic due to high HCV transmission risk among people who inject drugs (PWID). HCV transmission knowledge is difficult to ascertain given the lack of psychometrically-tested measures. We developed and validated an HCV injection-risk knowledge scale.

Methods: Analyses used data from 539 New York City opioid users ages 18–29 recruited via respondent-driven sampling in 2014–16. Blood samples yielded HCV antibody status. Principal components analysis (PCA) of nine knowledge items answered true, false, or don't know identified useful scale items. We evaluated internal consistency with the Cronbach's alpha coefficient and assessed construct validity by comparing knowledge levels with those from a previously validated general HCV knowledge scale and by comparing key sub-group knowledge levels.

Results: PCA identified one component with five items that explained 45% of the total variance and had high internal consistency ($\alpha = 0.91$). All items referred to transmission through drug-injection equipment and practices: sharing cookers, cottons, diluting water, water containers, and cleaning syringes with water. The mean percent correct was 75%, and as expected, was moderately correlated with general HCV knowledge (Spearman's $\rho = 0.55$). As hypothesized, knowledge levels were highest for those previously tested for HCV, those with HCV antibody-positive status, PWID, and those who had received harm reduction information in various settings.

Conclusions: The 5-item, validated HCV Injection-Risk Knowledge Scale (HCV-IRKS) may provide educators, care providers, and researchers with critical information for reducing HCV among PWID.

1. Introduction

Reported cases of acute hepatitis C virus (HCV) infection in the United States increased 3.5 fold from 2010 to 2016 (Centers for Disease Control and Prevention (CDC, 2016). Amplifying this public health crisis is that few people have symptoms with acute infection, and only a minority of recent infections are diagnosed and reported (Centers for Disease Control and Prevention (CDC, 2016). Prevalence is therefore challenging to ascertain, but an estimated 3.5 million people in the United States were living with chronic HCV infection in 2015 (Edlin et al., 2015), and more than 41,000 estimated new cases occurred in 2016 (Centers for Disease Control and Prevention (CDC, 2016).

HCV contributes to a variety of serious complications if untreated such as liver cirrhosis and hepatocellular carcinoma (Westbrook and

Dusheiko, 2014). In the United States, the average annual HCV mortality rate increased 6.2% from 2003 to 2013, and HCV accounts for more deaths than 60 other notifiable infectious diseases combined (Ly et al., 2016). Chronic HCV costs the United States over \$10 billion annually. (Stepanova and Younossi, 2017). While as many as 90% of HCV infections could be cured with current direct-acting antiviral medication regimens (AASLD, 2018), widespread treatment will require increased awareness of risk factors and testing and care for high-risk populations.

Injection drug use (IDU) is the leading cause of HCV incidence in the United States (Williams et al., 2011). HCV, the most common blood-borne infection, can be transmitted among people who inject drugs (PWID) through the sharing of syringes and other injection equipment (Pouget et al., 2012; Hagan et al., 2001; De et al., 2008). Recent

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increases in HCV infections are associated with the opioid misuse epidemic among young adult injectors (Zibbell et al., 2018, 2015; Suryaprasad et al., 2014; Lankenau et al., 2015). Early studies indicated that most new HCV infections occur among young, white persons who inject drugs and live in non-urban areas of the United States (Onofrey et al., 2011; Zibbell et al., 2015), though trends in the states studied suggest an overall nationwide increase in HCV incidence (Zibbell et al., 2018; Suryaprasad et al., 2014). Underscoring the gravity of the co-epidemics of IDU and HCV among youth is that approximately 20–30% of PWID become infected within 2 years of initiating injection and 50% within 5 years (Hagan et al., 2008). In fact, the HCV epidemic among PWID is a global phenomenon: systematic reviews reported that approximately 10 million PWID worldwide are HCV antibody-positive (Nelson et al., 2011), and HCV prevalence among PWID is estimated to be 52% (Degenhardt et al., 2017).

Researchers have attempted to measure HCV knowledge in various populations, including PWID (Grau et al., 2016; Dunn et al., 2013; Bryant, 2014; Zeremski et al., 2014; Marshall et al., 2015; Carey et al., 2005; O'Brien et al., 2008; Stein et al., 2007; Heimer et al., 2002; Stein et al., 2001; Evans et al., 2005); however, few HCV knowledge measures have been developed specifically for PWID, and none of our knowledge has been thoroughly psychometrically evaluated among PWID. While general HCV knowledge is important, injection-specific risk factors are typically not emphasized or covered in detail in existing measures, therefore these measures' usefulness for targeting populations most in need of education and testing remains unknown. Furthermore, though knowledge scales are intended to measure objective, factual information, without validation, we cannot be sure that the individual items and overall content are measuring well what they are intended to measure. The Brief HCV Knowledge Scale, which was found to have good validity and reliability (Balfour et al., 2009), was developed with HCV and/or HIV patients, healthcare workers, and community college students in Canada, but did not include PWID specifically. Only two of 19 total items pertain to injection risk. One item asks respondents to answer true, false, or don't know to the statement, "Studies show that more than 60% of people who inject street drugs with used needles are infected with hepatitis C"; updates to surveillance data and expectations that the general population are familiar with precise statistics from the scientific literature make this question problematic. The second item, "Using 'new' (i.e., never used before) needles, syringes, and equipment reduces the risk of being infected with hepatitis C" could be clarified and strengthened by specifying the types of equipment (cottons, cookers, water containers, etc.) that have been found to be associated with risk of HCV transmission. Balfour et al.'s scale was published in 2009, and while it remains the gold standard, several additional items would benefit from revision to reflect the current state of the HCV literature.

In light of the opioid misuse epidemic and IDU as the primary risk factor for HCV, we have responded to an urgent need for an easy-to-use measure of injection-risk-related HCV knowledge. Theories of behavior change inform us that knowledge is necessary but not always sufficient to effect behavior change; therefore, knowledge and behavior are not always highly correlated. A knowledge scale that is psychometrically valid for use with PWID may provide educators, interventionists, and health care workers with information that could be used to target important gaps in knowledge and ultimately minimize HCV transmission among drug-using populations via subsequent intervention and allow researchers to compare knowledge and risk and across populations. The purpose of this study is to use a rich source of data from a young, opioid-using population to develop and validate a measure to assess HCV knowledge about drug injection-related risk that can be administered alone or in conjunction with general HCV knowledge scales.

2. Materials and methods

2.1. Study population and design

This analysis used data collected in 2014–16 from 539 participants in a study of young people's opioid use patterns and risk behaviors. Participants were recruited via Respondent-Driven Sampling (RDS), a form of chain-referral sampling designed to connect with difficult-to-reach populations that utilizes participants' network connections to drive recruitment.

Participants lived in one of the five New York City boroughs, were aged 18–29, used prescription opioids non-medically and/or heroin in the past 30 days, spoke English, and provided written informed consent. Eligibility was assessed with a multi-modal screening protocol; we used a combination of self-report, point-of-care urine drug screening for opiates, oxycodone and methadone, a visual quiz to identify pictures of commonly used PO pills, and, for participants who inject drugs, visual inspection for injection marks. Potential participants who appeared to be 25 or older were asked to show identification to confirm age. Eligible participants were paid US\$60.00 for completing the interview and an additional incentive for each eligible peer they referred to the study.

Participants completed a computer-assisted, interviewer-assisted structured assessment lasting 90–120 minutes that included socio-demographic and behavioral questions; drug use, HCV, HIV, and mental health histories; and 12 HCV knowledge questions developed by the investigators in addition to the 19-item Balfour Brief HCV Knowledge Scale (Balfour et al., 2009). Participants provided blood for an OraQuick Advance Rapid HCV Antibody Test (manufactured by OraSure Technologies, Inc., Bethlehem, PA). The Institutional Review Board of National Development and Research Institutes (NDRI) approved the study. Additional detail on recruitment methods and sample description has been published elsewhere (Guarino et al., 2018; Mateu-Gelabert et al., 2015).

We used the software package FACTOR (<http://psico.fcep.urv.es/utilitats/factor/>) to conduct Principal Components Analysis (PCA) given its ability to compute polychoric correlations (required for our categorical knowledge items) and SAS 9.4 (SAS Institute, Cary, North Carolina, USA) for univariable and bivariable analyses. We evaluated statistical significance at the $p < 0.05$ level.

2.2. Scale development

2.2.1. Content validity

The interview instrument for the main study included 12 items about knowledge of HCV which were generated through an extensive literature review and consultation with subject matter experts. Item content areas included transmission, physiological and health sequelae, treatment, and prevention with a focus on drug injection practices. Items were phrased as either accurate or inaccurate statements. Participants answered each true, false, or don't know.

2.2.2. Item analysis

We examined univariable distributions of 12 items for "ceiling and floor effects" (Clark and Watson, 1995) in order to exclude any item answered correctly or incorrectly by more than 90% of the sample.

2.2.3. Construct validity

To identify underlying constructs, we used a parallel analysis PCA as the extraction method in the absence of *a priori* theoretical knowledge of the number of constructs or of shared variance among items. We considered the "don't know" category to be potentially informative and distinct from incorrect; therefore, we conducted the data reduction analysis on a matrix of polychoric correlations suitable for the 3-level response choices. (Uebersax, 2006). Eigenvalues (components > 1.0 to be retained) and component loadings (items > 0.500 on one component and < 0.300 on any other component(s)) informed the selection of

the final solution.

We further assessed construct validity by calculating the Spearman's rho correlation coefficient between the percentages of correct responses among the solution yielded by PCA and the validated 19-item Brief HCV Knowledge Scale (Balfour), a general HCV knowledge scale also included in the assessment. "Don't know" responses were coded as incorrect for this purpose as in the Balfour, et al. validation study. We also conducted paired-sample t-tests to compare mean percentage correct for the newly-developed scale under the hypothesis that the level of HCV knowledge would be higher among persons with a history of drug injection, HCV testing, positive diagnosis, and education, and those concerned about getting HCV, relative to the referent groups without such history/concern.

2.2.4. Reliability

We evaluated internal consistency of the final scale with the Cronbach's alpha coefficient. Because the main study was cross-sectional and participants answered the items at one point in time, we were not able to evaluate test-retest reliability.

3. Results

3.1. Sample description

Table 1 presents participants' sociodemographic and drug use and HCV characteristics. RDS-adjusted estimates (not shown) for the study's target population of young adult opioid users in NYC suggest that the sample has good representativeness (Guarino et al., 2018). The sample was 68% male, 69% white, 29% Hispanic, with a mean age of 24 years. There was socioeconomic diversity as shown by 19% who reported an annual household income of over \$100,000 during childhood and 38% who had some college education; however, more than half had experienced lifetime homelessness.

The majority (82%) had used heroin and prescription opioids (POs) while 17% were exclusive PO users. Prevalence of illicit drug injection was very high: 66% had injected drugs, and of those, 86% injected in the past 30 days. One-fifth (19.6%) tested positive for HCV antibodies on the OraQuick test (regardless of previous history of testing and results), and of the 69% who had been tested previously, nearly the same proportion – 20.3% – self-reported an HCV-positive result. Two-thirds of those who said they did not have HCV expressed being very or somewhat concerned about getting HCV while one-third reported they were not concerned at all. One-third of the total sample discussed HCV with drug-using friends very often, often or sometimes while two-thirds rarely or never did so. Most of the sample had some exposure to HCV education in the past: 70% from a doctor or drug treatment program and 46% through services such as syringe exchanges or harm reduction programs.

3.2. Item analysis

Three of twelve HCV knowledge items were answered correctly by the vast majority of respondents (HCV transmission through breathing air (91%) and drug injection (93%) and used syringes (94%) as risk factors) and were excluded from subsequent analyses. Nine items had satisfactory range and distribution of responses (Table 2), with mean percentages correct ranging from 44 to 87%. The percentage of don't know responses ranged from 7 to 39%, indicating that the final scale should allow for this response category rather than limit people to guessing or skipping questions when unsure.

3.3. Construct validity

PCA of nine items indicated a 1-component solution that accounted for 44.5% of the total variance and had an eigenvalue of 4.01. Table 2 shows component loadings, which for five of the items were high,

Table 1
Sociodemographic, drug use, and hepatitis C virus (HCV) characteristics of young opioid users in New York City, 2014-16, N = 539.

	Sample prevalence Number (Percent)
Sociodemographics	
Age (years)	Mean = 24.0 (SD = 3.1)
Sex	
Male	356 (67.7)
Female	170 (31.5)
Transgender	4 (0.8)
Race	
White	371 (68.8)
Black	42 (7.8)
Asian/Pacific Islander	7 (1.3)
American Indian or Alaska Native	9 (1.7)
Multiracial	43 (8.0)
Missing*	67 (12.4)
Hispanic/Latino	154 (28.7)
Household income growing up (annual)	
< = \$50,000	227 (42.1)
\$50,001-100,000	176 (32.7)
> \$100,000	102 (18.9)
Don't know or missing	34 (6.3)
Education	
Did not complete high school	107 (19.9)
High school graduate or GED	224 (41.6)
Some college	181 (33.6)
College graduate or higher	26 (4.8)
Ever homeless	309 (57.4)
Drug use	
Lifetime opioid use characteristics	
Heroin only	6 (1.1)
Prescription opioids only	89 (16.5)
Heroin and prescription opioids	444 (82.4)
Lifetime drug injection	353 (65.5)
Past 30 day injection (among ever injectors)	305 (84.4)
HCV	
Hepatitis C antibody-positive result on OraQuick test	105 (19.6)
Ever previously tested for HCV	369 (68.6)
Positive result on last HCV test (among n = 369 previously tested)	75 (20.3)
Concerned about getting HCV (among n = 456 who self-reported negative result on last test)	
Very/somewhat (vs. not at all)	304 (66.7)
Talked about HCV with drug-using friends	
Very often/often/sometimes (vs. rarely/never)	187 (35.0)
Ever learned about HCV from primary doctor or in drug treatment	378 (70.1)
Ever learned about HCV from syringe exchange, harm reduction, other service provider	247 (45.8)
Percent correct on Brief HCV Knowledge Scale	Mean = 68.0 (SD = 19.3)

*Missing values due to race being reported as Hispanic/Latino.

ranging from 0.616 to 0.876. Another item (about liver damage and death) had an adequately high loading (0.606), but it represented a compound idea and therefore was not a suitable scale item and was excluded. Further, 87% answered it correctly, which approaches the ceiling effect criterion. The following three items had loadings < 0.500 and were excluded from the final scale: the definition of hepatitis as inflammation of the liver (0.336) and blood as a bodily fluid capable of transmitting HCV (0.023) had very low loadings. The existence of a vaccine to prevent HCV infection had a moderately low loading (0.472) warranting its exclusion. This decision was reinforced by the fact that a similar item exists in Balfour et al.'s Brief Hepatitis Knowledge scale (Balfour et al., 2009), and we desired parsimony in our scale. The final scale, hereafter referred to as HCV-IRKS, consisted of five items referring to transmission of HCV through drug-injection equipment and practices: sharing cookers, cottons, diluting water, water containers, and cleaning syringes with water.

Spearman's rho, $r = 0.55$ ($p < 0.0001$) indicated a moderately high correlation of the percentage of correct responses on the HCV-IRKS

Table 2
Descriptive statistics for Hepatitis C virus knowledge items included in Principal Components Analysis (PCA).

Item	Number (percent) of responses			PCA loading	Role in final solution
	Correct	Incorrect	Don't know		
You can catch hepatitis C by breathing air in a room if someone in the room has hepatitis C (F)	486 (90.5)	11 (2.1)	40 (7.5)	NA	Omitted from PCA due to ceiling effect
Using a syringe used by someone else can put injectors at risk of becoming infected with hepatitis C (T)	505 (94.0)	9 (1.7)	23 (4.3)	NA	Omitted from PCA due to ceiling effect
Injecting drugs is a risk factor for hepatitis C infection (T)	495 (92.5)	11 (2.1)	29 (5.4)	NA	Omitted from PCA due to ceiling effect
Which of these bodily fluids can transmit hepatitis C? BLOOD (T)*	394 (73.2)	106 (19.7)	38 (7.1)	0.023	Omitted due to low loading
The word hepatitis means inflammation of the liver (T)	237 (44.3)	88 (16.5)	210 (39.3)	0.336	Omitted due to low loading
There is a vaccine that can prevent people from getting infected with hepatitis C (F)	243 (45.3)	154 (28.7)	140 (26.1)	0.472	Omitted due to moderate loading and overlap with Balfour scale
Hepatitis C can cause serious liver damage and even death (T)	468 (87.3)	11 (2.1)	57 (10.6)	0.606	Omitted because it represents 2 distinct ideas; approaches 90% ceiling effect
Sharing drug diluting water when injecting can put injectors at risk of becoming infected with hepatitis C (T)	372 (70.0)	55 (10.0)	107 (20.0)	0.876	Retained in final scale
Sharing cottons when injecting can put injectors at risk of becoming infected with hepatitis C (T)	410 (76.5)	32 (6.0)	94 (17.5)	0.866	Retained in final scale
Sharing water containers when injecting can put injectors at risk of becoming infected with hepatitis C (T)	356 (66.3)	66 (12.3)	115 (21.4)	0.843	Retained in final scale
Sharing cookers when injecting can put injectors at risk of becoming infected with hepatitis C (T)	400 (74.6)	44 (8.2)	94 (17.5)	0.834	Retained in final scale
Cleaning syringes with water kills hepatitis C (F)	461 (86.2)	18 (3.4)	56 (10.5)	0.616	Retained in final scale

Correct answers: T: true; F: false.

NA: not applicable.

*Item asked about multiple bodily fluids; only blood was included in PCA.

Bolded items comprise final HCV Injection-Risk Knowledge Scale (HCV-IRKS).

(74.8%, SD = 33.5) and Balfour et al.'s Brief HCV Knowledge Scale (68.0%, SD = 19.3). Table 3 presents t-test results comparing sub-groups by mean percentage correct on the HCV-IRKS, all of which except for one were statistically significant and in the hypothesized direction: HCV antibody-positive result from study test 89% (vs. 72% for HCV-negative), previously tested for HCV 83% (vs. 57% untested); HCV antibody-positive result from previous test 91% (vs. 81% for HCV-negative); lifetime injectors 87% (vs. 51% non-injectors); high concern about getting HCV 76% (vs. 67% low concern); frequent discussion about HCV with drug-using friends 87% (vs. 69% infrequent discussion); received HCV education from doctor or treatment program 78% (vs. 67% no education); and received HCV education from service agency 84% (vs. 67% no education). Past 30 days injectors (89%) were not significantly different from lifetime injectors who had not injected in the past 30 days (83%).

3.4. Internal consistency

The Cronbach's alpha was high (0.91), indicating excellent internal consistency among these items (DeVellis, 2016). The percent of correct responses across the five items ranged from 66 to 86%, indicating ability of the items to discriminate different levels of knowledge. Don't know responses ranged from 11 to 21%, again indicating the value of a third response choice that may help to identify opportunities for clarification of challenging information.

4. Discussion

Starting with numerous items about various aspects of HCV asked of a young, opioid-using population, we identified a single, 5-item scale with very good construct validity and internal reliability. Items pertain to knowledge about the possibility of HCV transmission through shared drug injection equipment (cookers, cottons, and water containers), sharing drug-diluting water, and cleaning syringes with water. The HCV-IRKS can be easily incorporated into research protocols. It can be used by health care and social service providers, and possibly by PWID themselves, as a quick screening tool that allows for immediate one-on-one education and intervention. Also, data collected with HCV-IRKS from groups of PWID could inform educational materials and prevention strategies and allow organizations that serve PWID to monitor knowledge levels over time and tailor programs to participants' needs.

To our knowledge, there is a paucity of validated HCV knowledge scales, and none focused on PWID; therefore, we believe this work makes valuable practical and research contributions. The HCV-IRKS and Balfour et al.'s Brief HCV Knowledge Scale were designed for related but somewhat different purposes (general vs. drug injection-related HCV knowledge) and validated with very different populations. As hypothesized, they had a moderately high correlation that represents very good construct validity of the HCV-IRKS and evidence of its added value to measuring HCV knowledge. Further, our sample's mean percent correct of 68% on the Brief HCV Knowledge Scale is somewhat lower than for community health workers (80%), HCV patients (77%), and HCV and HIV co-infected patients (76%) in the Balfour validation study (Balfour et al., 2009), populations we hypothesize would have had greater exposure to HCV education. Alternatively, our sample had a higher mean percent correct than HIV patients (54%) and college students (43%) in the Balfour study, populations that we might expect to have less concern about HCV and less exposure to HCV harm reduction messaging than our opioid-using New York City population.

The HCV-IRKS has immediate application for assessing knowledge of HCV injection risk among opioid users. This is an urgent need given the alarming increase of HCV associated with non-medical opioid use across the United States (Zibbell et al., 2018, 2015; Suryaprasad et al., 2014; Lankenau et al., 2015) and very low awareness of HCV status among general and PWID populations (Smith et al., 2012, Denniston et al., 2012; Hagan et al., 2006). Whereas previous attempts to assess

Table 3
Comparisons of mean percent correct on the 5-item Hepatitis C Virus Injection-risk Knowledge Scale (HCV-IRKS).

	Number	Mean percent correct	Degrees of freedom	t test statistic	p-value
Hepatitis C antibody positive result on OraQuick test	104	89.2	239	−6.33	< 0.0001
Hepatitis C antibody negative result on OraQuick test	425	71.7			
Previously tested for HCV	366	83.2	257	−8.30	< 0.0001
Not previously tested for HCV	166	56.5			
Positive result on previous HCV test (self-report)	75	90.7	166	−3.25	0.001
Negative result on previous HCV test (self-report)	274	80.9			
Lifetime drug injection	343	87.2	284	−12.3	< 0.0001
No lifetime drug injection	187	51.4			
Past 30 day injection (among ever injectors)	301	87.8	346	−1.13	0.2586
No past 30 day injection (among ever injectors)	44	83.4			
Very/somewhat concerned about getting HCV	300	75.5	448	−2.47	0.0138
Not at all concerned about getting HCV	150	67.1			
Very often/often/sometimes talked about HCV with drug-using friends	183	86.9	499	−6.91	< 0.0001
Rarely/never talked about HCV with drug-using friends	345	68.8			
Learned about HCV from primary doctor or in drug treatment	375	78.2	252	−3.40	0.0008
Never learned about HCV from primary doctor or in drug treatment	157	66.8			
Learned about HCV from syringe exchange, harm reduction, other service provider	245	84.4	527	−6.41	< 0.0001
Never learned about HCV from syringe exchange, harm reduction, other service provider	278	66.7			

HCV knowledge have focused on general and biomedical information, the HCV-IRKS has an important role in directly improving HCV prevention among PWID, the group at highest risk of new infections. Given that HCV is highly infectious and stable (Doerrbecker et al., 2012, 2011), it is crucial that drug-using populations have not just a general knowledge of HCV transmission but are fully aware of the potential for transmission through various injection-related materials and practices. The spread of this practical knowledge could be a critical first step in curbing the increasing incidence of HCV among PWID. Nonetheless, since percentage correct on the Brief HCV Knowledge Scale was slightly lower (68%) than on the HCV-IRKS (75%), this opioid-using population is also in need of education on vaccines, treatments, sexual and perinatal risk, and other aspects of HCV addressed in Balfour's et al. scale (2009).

It is worth noting that our empirical analysis informed the exclusion of the item “Using a syringe used by someone else can put injectors at risk of becoming infected with Hepatitis C” because 94% of our sample answered it correctly. Given that syringe sharing is a key risk for the spread of HCV, we recommend considering the inclusion of this or a similar item in future work, particularly with populations with less access to harm reduction programming due to their geographic location or legal, political or stigma-related issues. The high ceiling effect for this item in this sample is likely related to the high coverage of harm reduction efforts in NYC. Our sample of NYC residents who used opioids in the past 30 days, 65.5% of whom had injected drugs, may represent a population with increased exposure to harm reduction services, health care, and drug treatment programs, and thus, more opportunities to gain HCV knowledge. They may also represent a relatively high socioeconomic stratum with increased access to various services and educational opportunities relative to other parts of the United States and other countries. Nonetheless, these findings indicate that despite near-universal understanding of HCV risk related to sharing syringes and high overall HCV knowledge, HCV prevalence is 20% in the sample and harm reduction tools are evidently not accessible to all.

Another analysis that included data from this NYC sample as well as from PWID in Russia and Columbia demonstrated the willingness of PWID to spread knowledge to prevent the spread of infections (Mateu-Gelabert et al., 2018). Other research has shown information exchange among PWID to be common, though accuracy is a concern (Ellard, 2007; Treloar and Abelson, 2005). A widespread effort to increase HCV knowledge among PWID in regions where drug injection is expanding could lead to more effective prevention efforts as PWID essentially

serve in the unofficial role of harm reductionists as they share knowledge with members of their drug-using networks. However, much educational work remains, as this analysis indicates the need for improved HCV knowledge among young opioid users in NYC. The percent correct for the individual items ranged from 66% to 86%, indicating some lack of awareness of the risks associated with sharing secondary injection equipment despite high risk and HCV prevalence of 20%, which is likely to rise given this young sample is aged only 18–29. Safer injection practices must be emphasized in prevention efforts which should be focused on young PWID since time since the first few years of a person's injection career is an extremely high-risk period for exposure to HCV (Hagan).

Yet, we must not neglect to target non-injectors and other subgroups of drug users in prevention efforts. The percentage of HCV-IRKS items answered correctly was quite low for some subgroups, particularly those who had not been tested for HCV before the study (57% vs. 83% correct for those who had been previously tested). This highlights the potential dual benefits of expanding HCV testing among opioid injectors: providing knowledge of their HCV status and increasing knowledge of risk of HCV acquisition and transmission. Likewise, the low percentage correct among those who had never injected (52% vs. 83% correct among injectors) is concerning given the possibility of their experimenting with drug injection as route of administration (Mateu-Gelabert et al., 2015). Also informative is that these results suggest that primary care providers, drug treatment programs, and syringe exchange programs are important sources of HCV risk knowledge among at-risk populations, similar to other studies' findings (Jost et al., 2010; Treloar and Abelson, 2005).

This analysis highlights a number of limitations and lessons for future work. The assessment included a question meant to elicit knowledge of bodily fluids that can transmit HCV, and respondents were instructed to choose all that apply among blood, cum and pre-cum, vaginal fluids, and breast milk. Because scientific understanding of HCV transmission is evolving, we decided to exclude all but blood from the PCA since the other response choices might be confusing. Future data collection efforts and validation studies should test a refined version of this question since understanding the role of blood is especially crucial to HCV prevention. Existing and future scales, too, need to be updated with emerging knowledge, especially since vaccine and treatment advances should continue for some time. We omitted an item about transmission due to sharing straws when snorting drugs given the absence of documented cases substantiating this potential pathway, but

emerging evidence needs to be considered in future work. An issue that would have been difficult to predict but could be addressed in future work stems from the fact four of the five items retained in the final scale have very similar wording and are presented as true statements. Rephrasing one or more item(s) to present an inaccurate statement could be useful for minimizing test-taker response bias. Revalidation in different populations and in other languages is also necessary. Finally, this cross-sectional study did not allow us to re-administer the items to participants in order to assess test-retest reliability.

We note several strengths of this work. The HCV-IRKS is very brief, uses common language, and can be self-administered, thereby minimizing respondent burden and response biases. Its brevity may be especially important for substance-using populations. We included a response category for don't know, which can be used to highlight content that may not be straightforward and could benefit from elaboration in educational settings and materials. We used data from a large sample and a dataset that contained numerous additional variables, such as history of drug use and HCV testing and education, which allowed us to conduct multiple tests of construct validity and demonstrate robustness of results as well as to describe this unique sample in rich detail. We also had complete data for another validated HCV knowledge scale, which allowed us to empirically demonstrate construct validity as well as the added value of a novel scale focused on drug injection HCV risk.

Finally, the relevance of HCV-IRKS for measuring knowledge and informing prevention strategies and increasing testing and treatment especially among high-risk PWID is underscored by Liang and Ward's recent article stating, "The opioid epidemic is a stark reminder of the consequences of a societal problem that remained hidden for years, in part because of the stigma associated with drug use and the reluctance to confront it as a public health problem." The concurrent spread of HCV, if not controlled, will similarly have public health and financial repercussions for decades to come." (Liang and Ward, 2018).

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Contributors

All authors are responsible for this reported research. K. Quinn, C. Fong, H. Guarino, and P. Mateu-Gelabert conceptualized the analyses. K. Quinn conducted the analyses and drafted the manuscript. All authors interpreted results, contributed to the manuscript, and reviewed and approved the final manuscript.

Conflict of interest

None.

References

- American Association for the Study of Liver Diseases (AASLD)/the Infectious Diseases Society of America (IDSA) Recommendations for Testing, Management, and Treating Hepatitis C. HCV Testing and Linkage To Care. Accessed October 2, 2018 at: <http://www.hcvguidelines.org>.
- Balfour, L., Kowal, J., Corace, K.M., Tasca, G.A., Kryszanski, V., Cooper, C.L., Garber, G., 2009. Increasing public awareness about hepatitis C: development and validation of the brief hepatitis C knowledge scale. *Scand. J. Caring Sci.* 23 (4), 801–808.
- Bryant, J., 2014. A study of young people who inject drugs: an opportunity to decrease high risk injecting by improving knowledge about hepatitis C prevention. *Vulnerable Child. Youth Stud.* 9 (2), 104–113.
- Carey, J., Perlman, D.C., Friedmann, P., Kaplan, W.M., Nugent, A., Deutscher, M., Masson, C.L., Des Jarlais, D.C., 2005. Regular article: knowledge of hepatitis among active drug injectors at a syringe exchange program. *J. Subst. Abuse Treat.* 29, 47–53.
- Centers for Disease Control and Prevention (CDC), 2016. *Viral Hepatitis Surveillance – United States*. Accessed on October 2, 2018 at: <https://www.cdc.gov/hepatitis/statistics/2016surveillance/pdfs/2016HepSurveillanceRpt.pdf>.
- Clark, L.A., Watson, D., 1995. Constructing validity: basic issues in objective scale development. *Psychol. Assess.* 7, 309–319.
- Degenhardt, L., Peacock, A., Colledge, S., Leung, J., Grebely, J., Vickerman, P., 2017. Global prevalence of injecting drug use and sociodemographic characteristics and prevalence of HIV, HBV, and HCV in people who inject drugs: a multistage systematic review. *Lancet Glob. Health* 5 (12), e1192–e1207.
- De, P., Roy, E., Boivin, J., Cox, J., Morissette, C., 2008. Risk of hepatitis C virus transmission through drug preparation equipment: a systematic and methodological review. *J. Viral Hepat.* 15 (4), 279–292.
- Denniston, M.M., Kleven, R.M., McQuillan, G.M., Jiles, R.B., 2012. Awareness of infection, knowledge of hepatitis C, and medical follow-up among individuals testing positive for hepatitis C: national Health and Nutrition Examination Survey 2001–2008. *Hepatology* 55, 1652–1661.
- DeVellis, R.F., 2016. *Scale Development: Theory and Applications*, fourth ed. Sage Publications, Inc, Los Angeles.
- Doerrbecker, J., Behrendt, P., Mateu-Gelabert, P., Ciesek, S., Riebesehl, N., Wilhelm, C., Steinmann, J., Pietschmann, T., Steinmann, E., 2012. Transmission of hepatitis C virus among people who inject drugs: viral stability and association with drug preparation equipment. *J. Infect. Dis.* 207 (2), 281–287.
- Doerrbecker, J., Friesland, M., Ciesek, S., Erichsen, T.J., Mateu-Gelabert, P., Steinmann, J., Steinmann, J., Pietschmann, T., 2011. Inactivation and survival of hepatitis C virus on inanimate surfaces. *J. Infect. Dis.* 204 (12), 1830–1838.
- Dunn, K.E., Saulsgiver, K.A., Patrick, M.E., Heil, S.H., Higgins, S.T., Sigmon, S.C., 2013. Characterizing and improving HIV and hepatitis knowledge among primary prescription opioid abusers. *Drug Alcohol Depend.* 133 (2), 625–632.
- Edlin, B.R., Eckhardt, B.J., Shu, M.A., Holmberg, S.D., Swan, T., 2015. Toward a more accurate estimate of the prevalence of hepatitis C in the United States. *Hepatology* 62 (5), 1353–1363.
- Ellard, J., 2007. 'There is no profile it is just everyone': the challenge of targeting hepatitis C education and prevention messages to the diversity of current and future injecting drug users. *Int. J. Drug Policy* 18 (3), 225–234.
- Evans, M., Hokanson, P., Augsburg, J., Sayre, S., Stotts, A., Schmitz, J., 2005. Increasing knowledge of HIV and hepatitis C during substance abuse treatment. *Addict Disord. Treat.* 4, 71–76.
- Grau, L.E., Zhan, W., Heimer, R., 2016. Prevention knowledge, risk behaviours and seroprevalence among nonurban injectors of southwest Connecticut. *Drug Alcohol Rev.* 35 (5), 628–636.
- Guarino, H., Mateu-Gelabert, P., Teubl, J., Goodbody, E., 2018. Young adults' opioid use trajectories: from nonmedical prescription opioid use to heroin, drug injection, drug treatment and overdose. *Addict. Behav.* 86, 118–123.
- Hagan, H., Campbell, J., Thiede, H., Strathdee, S., Ouellet, L., Kapadia, F., Hudson, S., Garfein, R.S., 2006. Self-reported hepatitis C virus antibody status and risk behavior in young injectors. *Public Health Rep.* 121, 710–719.
- Hagan, H., Pouget, E.R., Des Jarlais, D.C., Lelutiu-Weinberger, C., 2008. Meta-regression of hepatitis C virus infection in relation to time since onset of illicit drug injection: the influence of time and place. *Am. J. Epidemiol.* 168, 1099–1109.
- Hagan, H., Thiede, H., Weiss, N.S., Hopkins, S.G., Duchin, J.S., Alexander, E.R., 2001. Sharing of drug preparation equipment as a risk factor for hepatitis C. *Am. J. Public Health* 91, 42–46.
- Heimer, R., Clair, S., Grau, L.E., Bluthenthal, R.N., Marshall, P.A., Singer, M., 2002. Hepatitis-associated knowledge is low and risks are high among HIV-aware injection drug users in three US cities. *Addiction* 97 (10), 1277–1287.
- Jost, J.J., Goldsamt, L.A., Harocopos, A., Kobrak, P., Clatts, M.C., 2010. Hepatitis C knowledge among new injection drug users. *Drug Educ. Prev. Pol.* 17 (6), 821–834.
- Lankenau, S., Kecojevic, A., Silva, K., 2015. Associations between prescription opioid injection and Hepatitis C virus among young injection drug users. *Drug Educ. Prev. Pol.* 22 (1), 35–42.
- Liang, T.J., Ward, J.W., 2018. Hepatitis C in injection-drug users—a hidden danger of the opioid epidemic. *N. Engl. J. Med.* 378 (13), 1169–1171.
- Ly, K.N., Hughes, E.M., Jiles, R.B., Holmberg, S.D., 2016. Rising mortality associated with hepatitis C virus in the United States, 2003–2013. *Clin. Infect. Dis.* 62 (10), 1287–1288.
- Marshall, A.D., Micallef, M., Erratt, A., Telenta, J., Treloar, C., Everingham, H., Jones, S.C., Bath, H., How-Chow, D., Byrne, J., Harvey, P., Dunlop, A., Jauncey, M., Read, P., Collie, T., Dore, G.J., Grebely, J., 2015. Liver disease knowledge and acceptability of non-invasive liver fibrosis assessment among people who inject drugs in the drug and alcohol setting: the LiveLife Study. *Int. J. Drug Pol.* 26 (10), 984–991.
- Mateu-Gelabert, P., Guarino, H., Jessell, L., Teper, A., 2015. Injection and sexual HIV/HCV risk behaviors associated with nonmedical use of prescription opioids among young adults in New York City. *J. Subst. Abuse Treat.* 48 (1), 13–20.
- Mateu-Gelabert, P., Guarino, H., Quinn, K., Meylaks, P., Campos, S., Meylaks, N., Berbesi, D., Toro-Tobon, D., Goodbody, E., Ompad, D., Friedman, S.R., 2018. *Young Drug Users: a Vulnerable Population and an Underutilized Resource in HIV/HCV Prevention*. *Curr HIV/AIDS Rep.* <https://doi.org/10.1007/s11904-018-0406-z>.
- Nelson, P.K., Mathers, B.M., Cowie, B., Hagan, H., Des Jarlais, D., Horyniak, D., Degenhardt, L., 2011. Global epidemiology of hepatitis B and hepatitis C in people who inject drugs: results of systematic reviews. *Lancet* 378, 571–583.
- O'Brien, S., Day, C., Black, E., Dolan, K., 2008. Injecting drug users' understanding of hepatitis C. *Addict. Behav.* 33 (12), 1602–1605.
- Onofrey, S., Church, D., Kludt, P., DeMaria, M.D., Cranston, K., Beckett, G.A., Holmberg,

- S.D., Ward, J.W., Holtzman, D., 2011. Hepatitis C virus infection among adolescents and young adults: massachusetts, 2002-2009. *Morb. Mortal. Rep. Surveill. Summ.* 60 (17), 537–541.
- Pouget, E.R., Hagan, H., Des Jarlais, D.C., 2012. Meta-analysis of hepatitis C seroconversion in relation to shared syringes and drug preparation equipment. *Addiction* 107 (6), 1057–1065.
- Stein, M.D., Dubyak, P., Herman, D., Anderson, B.J., 2007. Perceived barriers to safe injection practices among drug injectors who remain HCV-negative. *Am. J. Drug Alcohol Abuse* 33 (4), 517–525.
- Stein, M.D., Maksad, J., Clarke, J., 2001. Hepatitis C disease among injection drug users: knowledge, perceived risk and willingness to receive treatment. *Drug Alcohol Depend.* 61 (3), 211–215.
- Stepanova, M., Younossi, Z.M., 2017. Economic burden of hepatitis C infection. *Clin. Liver Dis. (Hoboken)* 21 (3), 579–594.
- Suryaprasad, A.G., White, J.Z., Xu, F., Eichler, B., Hamilton, J., Patel, A., Hamdouina, S.B., Church, D.R., Barton, K., Fisher, C., Macomber, K., Stanley, M., Guilfoyle, S.M., Sweet, K., Liu, S., Iqbal, K., Sharapov, U., Kupronis, B.B., Ward, J.W., Holmberg, S.S., 2014. Emerging epidemic of hepatitis C virus among young non-urban persons who inject drugs in the United States, 2006-2011. *Clin. Infect. Dis.* 59 (10), 1411–1419.
- Treloar, C., Abelson, J., 2005. Information exchange among injecting drug users: a role for an expanded peer education workforce. *Int. J. Drug Pol.* 16, 46–53.
- Uebersax, J.S., 2006. The Tetrachoric and Polychoric Correlation Coefficients. *Statistical Methods for Rater Agreement Web Site*. Accessed on October 2, 2018 at. <http://john-uebersax.com/stat/tetra.htm>.
- Westbrook, R.H., Dusheiko, G., 2014. Natural history of hepatitis C. *J. Hepatol.* 61 (1 Suppl), S58–S68.
- Williams, I.T., Bell, B.P., Kuhnert, W., Alter, M.J., 2011. Incidence and transmission patterns of acute hepatitis C in the United States, 1982-2006. *Arch. Intern. Med.* 171, 242–248.
- Zeremski, M., Dimova, R., Zavala, R., Kritz, S., Lin, M., Smith, D., Zibbell, J.E., Talal, A.H., 2014. Hepatitis C virus-related knowledge and willingness to receive treatment among patients on methadone maintenance. *J. Addict. Med.* 8 (4), 249–257.
- Zibbell, J.E., Asher, A.K., Patel, R.C., Kupronis, B., Iqbal, B., Ward, J.W., Holtzman, D., 2018. Increases in acute hepatitis C virus infection related to a growing opioid epidemic and associated injection drug use, United States, 2004 to 2014. *Am. J. Public Health* 108, 175–181.
- Zibbell, J.E., Iqbal, K., Patel, R.C., Suryaprasad, A., Sanders, K.J., Moore-Moravian, L., Serrecchia, J., Blankenship, S., Ward, J.Q., Holtzman, D., Centers for disease Control and Prevention (CDC), 2015. Increases in hepatitis C virus infection related to injection drug use among persons aged ≤ 30 years - Kentucky, Tennessee, Virginia, and West Virginia, 2006-2012. *Morb. Mortal. Rep. Surveill. Summ.* 64, 453–458.