Review

Quantifying hepatitis C transmission risk using a new weighted scoring system for the Blood-Borne Virus Transmission Risk Assessment Questionnaire (BBV-TRAQ): Applications for community-based HCV surveillance, education and prevention

Mark A Stoové¹, Craig L Fry*² and Nicholas Lintzeris³

Address: ¹Research Fellow, Centre for Epidemiology and Population Health Research, Macfarlane Burnet Institute for Medical Research and Public Health, 85 Commercial Road, Melbourne, Victoria 3004, Australia, ²Senior Research Fellow, Department of Health Science, Faculty of Medicine, Nursing and Health Sciences, Monash University, PO Box 527, Frankston, Victoria, 3199, Australia and ³Senior Staff Specialist, Drug Health Services, Sydney South West Area Health Service, Page Building 5, Missenden Road, Camperdown, NSW 2050, Australia

Email: Mark A Stoové - stoove@burnet.edu.au; Craig L Fry* - craig.fry@med.monash.edu.au; Nicholas Lintzeris - nicholas.lintzeris@sswa.hs.nsw.gov.au

* Corresponding author

Abstract

Background: The hepatitis C virus (HCV) is a major cause of drug-related morbidity and mortality, with incidence data implicating a wide range of HCV transmission risk practices. The Blood-Borne Virus Transmission Risk Assessment Questionnaire (BBV-TRAQ) is a content valid instrument that comprehensively assesses HCV risk practices. This study examines the properties of a new weighted BBV-TRAQ designed to quantify HCV transmission risk among injecting drug users (IDU).

Methods: Analyses of cross-sectional surveys of Australian IDU (N = 450) were used to generate normative data and explore the properties of a weighted BBV-TRAQ. Items weights were assigned according to expert key informant ratings of HCV risk practices performed during the development stages of the BBV-TRAQ. A range of item weights was tested and psychometric properties explored. A weighting scheme was recommended based on the plausibility of normative subscale data in relation to research evidence and the ability of BBV-TRAQ scores to discriminate between HCV positive and negative participants.

Results: While retaining the psychometric properties of the unweighted scale and demonstrating good internal reliability. By taking into account the relative transmission risk of a broad range of putative HCV practices, the weighted BBV-TRAQ produced promising predictive validity results among IDU based on self-report HCV status, particularly among young and less experienced injectors.

Conclusion: Brief, easy to administer and score, and inexpensive to apply, the utility of the BBV-TRAQ for community based education and prevention is enhanced by the application of item weights, potentially offering a valid surrogate measure for HCV infection among IDU.
Background
As a leading notifiable disease and a major cause of drug related morbidity and mortality, it is well recognised that the hepatitis C virus (HCV) poses a significant public health challenge. In addition to quality of life impairment at all disease stages [1,2], most individuals exposed to HCV become chronically infected (and infectious), with 10–20% developing cirrhosis or hepatocellular carcinoma [3].

In many countries the majority of HCV prevalence cases are comprised of current or former injecting drug users (IDU; [4-6]). Incidence data implicates a wider range of HCV transmission risk practices (e.g., environmental contamination) and injecting paraphernalia (e.g., spoon, filter, water, swab) other than the sharing of used syringes [7,8].

Such findings, in the context of continuing high prevalence of injecting risk behaviour [6,9-11] and HCV infection [12-14], suggest that controlling the spread of HCV is dependent on preventing transmission within the IDU population [8]. Although social and structural determinants of drug use and ‘risk’ are important to this end [15], HCV transmission is unlikely to be reduced without significant changes in the specific behaviours believed responsible for the spread of the virus [16]. Reductions in the prevalence of risk behaviours is therefore a necessary component of prevention responses and require an expansion of existing strategies through improved education and support for IDU [17].

One of the challenges in HCV surveillance and prevention rests with evaluating the efficacy of the broad range of interventions designed to reduce the prevalence of high-risk practices and, ultimately, rates of HCV seroconversion. To monitor HCV incidence, evaluate intervention efficacy or clarify the significance of putative/theoretical risk practices canvassed in the BBV-TRAQ is an advantage, each of these practices ultimately contribute equally to BBV-TRAQ scores, despite evidence suggesting they carry markedly different relative risks of transmitting a blood-borne virus (BBV).

This limitation makes it difficult for the current format BBV-TRAQ to offer a genuine and practical indication of the risk of contracting a BBV. This paper reports on the application of a weighting scheme for BBV-TRAQ items to take account of the relative risks associated with different risk practices. The analyses undertaken in this paper focus on HCV by providing initial normative data of HCV transmission risk among a sample of IDU, and explores the properties of the weighted scale to approximate overall HCV transmission risk in this group. IDU constitute the main HCV sero-prevalent and sero-incident risk group in many countries and constitute the population from which the BBV-TRAQ was originally developed. Thus this popu...
lation was a logical choice from which to begin the iterative process of scale refinement described in this paper.

**Methods**

**Design**

Cross-sectional survey data of IDU was used to examine the properties of the weighted BBV-TRAQ. This data was collected between September 1999 and March 2000 as part of the Australian Blood-Borne Virus Risk and Injecting Drug Use Study (ABRIDUS; [37]). The aim of ABRIDUS was to measure the extent of specific HCV risk practices among IDU and explore the contextual determinants of these practices. The survey contained three sections: demographic information including history of drug use and self-report HIV, HCV, and HBV status; the BBV-TRAQ; and a semi-structured component investigating participants' usual injecting context in relation to injecting risk practices. The BBV-TRAQ was self-completed by participants in the presence of a research assistant, with other survey sections administered by research assistants. Ethics approval for ABRIDUS was granted by Curtin University Ethics Committee, University of NSW Ethics Committee and the Victorian Department of Human Services Ethics Committee. Full details of the methods used in ABRIDUS are described elsewhere [37].

**Participants and sampling**

Participants were recruited in Melbourne (n = 150), Sydney (n = 150), and Perth (n = 150) and selected on the basis of having injected drugs at least monthly for the past six months. A targeted sampling strategy was used, whereby sample stratification was used to ensure that adequate numbers of females, IDU aged less than 25 years, and drug treatment naive participants were recruited (at least one third of each). Participants were recruited through Needle and Syringe Programs, drug and alcohol services, youth services, drug user groups, and snowball methods in each capital city.

**Weighting of BBV-TRAQ items**

Item weights were assigned according to expert key informant ratings of HCV risk practices performed during the development stages of the BBV-TRAQ to help establish the construct validity of the scale [34]. Key informants were asked to rate items according to their relative risk of transmitting HCV on a scale between 0 (no risk) and 10 (highest risk). Median item ratings were then categorised into five groups used to assign item weights according to relative HCV transmission risk (see Table 1).

There are evident challenges in attempting to apply empirical weights to scale items when there is a paucity of empirical data describing the relative risk associated with the specific practices described in those items. For example, sharing a needle and syringe over sharing other injecting equipment? To embark on a process of instrument refinement, an essential but habitually neglected process of improving a scale’s representation of a construct [38], we examined the application of three weighting schemes applied to items within each of the five risk categories shown in Table 1. Log one (weights ranging from one to five for each risk category respectively); log two (weights of one, two, four, eight and 16 for each risk category respectively); and log five (weights of one, five, 25, 125 and 625 for each risk category respectively).

**Analysis**

Detailed descriptions of the original BBV-TRAQ scoring system are reported elsewhere [34,39]. Only participants that answered all BBV-TRAQ questions were included. In this study, weights were applied to scores for each BBV-TRAQ item and then summed according to the factor structure derived from the original BBV-TRAQ development. Final weighted scores were obtained for injecting, other skin penetration, and sex subscales, and for the total scale [35]. Univariate descriptive statistics were generated for unweighted and weighted subscale and total scores.

Internal reliability was calculated for subscale and total scores using standardised item alpha. This internal consistency coefficient is preferred when individual items have different variances, with Cronbach’s alpha being adversely affected by heterogeneity of item variances [40], and is appropriate here as individual items within subscales are weighted differently (thus producing marked differences in item variances). One-way ANOVA assessed differences in BBV-TRAQ scores according to the self-reported HCV status of IDUs (“HCV positive”, “negative”, “never tested”, “don’t know”). In an attempt to limit temporal biases of recent engagement in risk behaviours with HCV status, this between groups analysis was repeated across study sub-samples (i.e., time since first injected and age) to examine the stability of results among more recent initiates or less experienced injectors. Between groups analyses were also conducted on unweighted and weighted scores to explore the sensitivity of results to different weighting structures. Data were analysed using the SPSS Statistical Software Package Release 11.5.0.

**Results**

**Sample profile**

Of the 450 IDU surveyed in ABRIDUS, 419 (93%) completed all BBV-TRAQ items Melbourne (n = 142), Sydney (n = 133), and Perth (n = 144). Demographic and drug use characteristics of these participants are presented in Table 2. The sample was predominantly male and unemployed, most were heroin injectors, injected daily or more often, and had first injected drugs more than three years earlier. Nearly half (45%) the sample reported previously
Table 1: BBV-TRAQ item categorisations and median key informant ratings

| Item | Description | Median Rating |
|------|-------------|---------------|
| **Category 5 (highest risk; median KE ratings 9–10)** | | |
| a5 | In the last month, how many times have you injected a drug which has been filtered through another person’s filter | 9 |
| a7 | In the last month, how many times have you injected a drug prepared with water that had been used by another person | 9 |
| a8 | In the last month, how many times have you injected a drug which had come into contact with another person’s used needle and syringe | 9 |
| a13a | In the last month how many times have you injected with another person’s used needle and syringe | 10 |
| a13b | On those occasions, how often did you rinse it with a combination of full-strength bleach and water (2 × 2) before you used it | 10 |
| a14 | In the last month how many times have you injected with a needle and syringe after another person has already injected some of its contents. | 10 |
| a19 | In the last month, how many times have you received an accidental needle-stick from another person’s used needle and syringe | 9 |
| a20a | In the last month, how many times have you reused a needle and syringe taken out of a shared sharps container | 10 |
| a20b | On those occasions, how often did you rinse it with a combination of full-strength bleach before you re-used it | 10 |
| a6a | In the last month, how many times have you injected a drug that was prepared in another person’s used spoon or mixing container | 7 |
| a6b | On those occasions how often did you clean the spoon or mixing container before using it | 7 |
| a9a | In the last month, how many times have you injected a drug prepared immediately after assisting another person with their injection (injecting them, holding their arm, handling used fits, wipe blood away etc) | 8 |
| a9b | On those occasions, how often did you wash your hands before preparing your mix | 8 |
| a10a | In the last month, how many times have you injected a drug that was prepared by another person who had already injected or assisted someone else to inject | 7 |
| a10b | On those occasions, how often did the person wash your hands before preparing your mix | 7 |
| a11a | In the last month, how many times have you been injected by another person who had already injected or assisted in someone else’s injection | Not rated |
| a11b | On those occasions, how often did the person injecting you wash your hands before injecting you | 7 |
| a12a | In the last month, how many times have you been injected with a needle and syringe which had been handled or touched by another person who had already injected | 7 |
| a12b | On those occasions, how often did they wash their hands prior to handling the needle and syringe that you used | 7 |
| a15a | In the last month, how many times have you touched your own injection site soon after ‘assisting’ another person with their injection | 8 |
| a15b | On those occasions, how often did you wash your hands before touching your injection site | 8 |
| a16a | In the last month, how many times has another person touched your injection site | 8 |
| a16b | On those occasions, how often did their hands touch your injection site | 8 |
| a17 | In the last month, how many times have you wiped your own injection site with an object (swab, tissue, hanky) which had been used by another person | 8 |
| c4 | In the last month, how many times have you used another person’s used razor | 7 |

**Category 4 (median KE ratings 7–8)**

| Item | Description | Median Rating |
|------|-------------|---------------|
| a6a | In the last month, how many times have you injected a drug that was prepared in another person’s used spoon or mixing container | 7 |
| a6b | On those occasions how often did you clean the spoon or mixing container before using it | 7 |
| a9a | In the last month, how many times have you injected a drug prepared immediately after assisting another person with their injection (injecting them, holding their arm, handling used fits, wipe blood away etc) | 8 |
| a9b | On those occasions, how often did you wash your hands before preparing your mix | 8 |
| a10a | In the last month, how many times have you injected a drug that was prepared by another person who had already injected or assisted someone else to inject | 7 |
| a10b | On those occasions, how often did the person wash your hands before preparing your mix | 7 |
| a11a | In the last month, how many times have you been injected by another person who had already injected or assisted in someone else’s injection | Not rated |
| a11b | On those occasions, how often did the person injecting you wash your hands before injecting you | 7 |
| a12a | In the last month, how many times have you been injected with a needle and syringe which had been handled or touched by another person who had already injected | 7 |
| a12b | On those occasions, how often did they wash their hands prior to handling the needle and syringe that you used | 7 |
| a15a | In the last month, how many times have you touched your own injection site soon after ‘assisting’ another person with their injection | 8 |
| a15b | On those occasions, how often did you wash your hands before touching your injection site | 8 |
| a16a | In the last month, how many times has another person touched your injection site | 8 |
| a16b | On those occasions, how often did their hands touch your injection site | 8 |
| a17 | In the last month, how many times have you wiped your own injection site with an object (swab, tissue, hanky) which had been used by another person | 8 |
| c4 | In the last month, how many times have you used another person’s used razor | 7 |

**Category 3 (median KE ratings 5–6)**

| Item | Description | Median Rating |
|------|-------------|---------------|
| a18 | In the last month, how many times have you used a tourniquet which had been used by another person | 6 |
| b2 | In the last month, how many times have you engaged in unprotected vaginal sex with another person during menstruation | 5 |
| c1 | In the last month, how many times have you come in contact with another person’s blood (fights, slash-ups, accidents, blood nose etc) | 5 |

**Category 2 (median KE ratings 3–4)**

| Item | Description | Median Rating |
|------|-------------|---------------|
| a2 | In the last month, how many times have you sucked or licked left-over drugs from spoon, mixing container used by another person | 3 |
| a3 | In the last month, how many times have you sucked or licked a filter used by another person | 3 |
| a4 | In the last month, how many times have you sucked or licked a plunger after using it in a mix used by another person | 2.5 |
| b3 | In the last month, how many times have you engaged in unprotected vaginal sex with another person without lubrication | 3 |
| b4 | In the last month, how many times have you engaged in unprotected anal sex with another person | 4 |
| c5 | In the last month, how many times have you used another person’s toothbrush | 4 |
testing positive for hepatitis C, 14% reported previously testing positive for hepatitis B, and reported HIV prevalence was very low (2%). There were no systematic differences in the characteristics of those that completed all BBV-TRAQ items and those that did not.

Table 3 presents sample descriptive statistics comparing original and weighted BBV-TRAQ scores. Both the weighted and unweighted scales produced positively skewed data with modes for total and subscale scores of zero (participants reporting no risk behaviours).

Reliability of the weighted BBV-TRAQ
Standardised item alphas were consistent across weighting schemes, showing good internal reliability for the total BBV-TRAQ (α = .89) injecting (α = .87) and sex (α = .89) sub-scales. A lower alpha coefficient was obtained for the other skin penetration (α = .49) subscale.

Validity of the weighted BBV-TRAQ
Key expert rankings of items used in the original BBV-TRAQ established the construct validity of the scale [35]. Total and subscale weighted and unweighted BBV-TRAQ scores were compared between groups of participants.
according to their self-reported HCV status to explore potential predictive validity properties of the scale (see Table 4). Injecting subscale scores for log two and log five weights and total scores for log five weights were able to discriminate between HCV positive and negative IDU in the expected direction. Effects (as determined by specific F scores) increased with increasing item weights. Across all weighting schemes sex and other skin penetration scores were not significantly different across self-report HCV groups.

Characteristics of the IDU sample (i.e., mean age, mean years since first injected; see Table 2) are indicative of a sample of well-established IDU who may have modified

Table 3: Descriptive statistics for original and weighted BBV-TRAQ scores

| Score              | Mean | Median | Standard Error | Standard Deviation | Minimum (number of cases) | Maximum |
|--------------------|------|--------|----------------|-------------------|---------------------------|---------|
| Original BBV-TRAQ Scores |      |        |                |                   |                           |         |
| Total Score        | 26   | 19     | 1.13           | 25.66             | 0 (31)                    | 135     |
| Injecting          | 15   | 9      | 0.79           | 16.13             | 0 (75)                    | 87      |
| Sex                | 8    | 2      | 0.47           | 9.62              | 0 (177)                   | 40      |
| Other Skin Penetration | 3    | 2      | 0.18           | 3.60              | 0 (155)                   | 20      |
| Log 1 Weighted BBV-TRAQ Scores |      |        |                |                   |                           |         |
| Total Score        | 77   | 52     | 3.63           | 74.21             | 0                         | 405     |
| Injecting          | 59   | 36     | 3.12           | 63.84             | 0                         | 332     |
| Sex                | 10   | 3      | 0.63           | 12.83             | 0                         | 60      |
| Other Skin Penetration | 8    | 5      | 0.48           | 9.84              | 0                         | 55      |
| Log 2 Weighted BBV-TRAQ Scores |      |        |                |                   |                           |         |
| Total Score        | 160  | 105    | 8.08           | 165.31            | 0                         | 805     |
| Injecting          | 138  | 82     | 7.50           | 153.41            | 0                         | 770     |
| Sex                | 10   | 3      | 0.66           | 13.51             | 0                         | 65      |
| Other Skin Penetration | 12   | 6      | 0.75           | 15.39             | 0                         | 80      |
| Log 5 Weighted BBV-TRAQ Scores |      |        |                |                   |                           |         |
| Total Score        | 3,899| 2,387  | 222.17         | 4,547.68          | 0                         | 26,095  |
| Injecting          | 3,745| 2,325  | 217.71         | 4,456.33          | 0                         | 25,970  |
| Sex                | 21   | 3      | 1.79           | 36.72             | 0                         | 200     |
| Other Skin Penetration | 133  | 25     | 14.44          | 295.61            | 0                         | 2,500   |

Table 4: Comparisons between self-report HCV status groups for unweighted and weighted BBV-TRAQ total and injecting subscales scores

| Weights | BBV-TRAQ Score | F   | p-value | mean difference (HCV positive & negative) | 95% CI of the difference |
|---------|----------------|-----|---------|------------------------------------------|--------------------------|
| None    | Injecting subscale | 2.46 | .141    | 3                                        | -1 – 7                   |
|         | Total           | 0.76 | .997    | 2                                        | -4 – 8                   |
| Log one | Injecting subscale | 3.04 | .080    | 15                                       | -4 – 31                  |
|         | Total           | 1.98 | .250    | 14                                       | -1 – 32                  |
| Log two | Injecting subscale | 3.63 | .038    | 40                                       | 2 – 79                   |
|         | Total           | 2.97 | .078    | 39                                       | -3 – 80                  |
| Log five| Injecting subscale | 4.12 | .017    | 1,293                                    | 176 – 2,411              |
|         | Total           | 3.86 | .023    | 1,273                                    | 132 – 2,414              |

* Comparisons were made between all HCV groups (i.e., inclusive of ‘never tested/not sure’ group). To simplify tables only results relevant to the focus of this paper have been presented (i.e., ‘HCV positive’ and ‘HCV negative’). No differences were detected between the ‘never tested/not sure’ and other groups.
their risk practices over time. As such, it is potentially problematic to ask such older and more experienced IDU about their recent risk behaviours to explore potential predictive validity properties of the BBV-TRAQ. In order to account for and moderate the potential effects of a lengthy injecting career on the relationship between recent risk practices and HCV status, between groups analyses were repeated among more recent initiates to injecting (≤ 3 years; n = 96) and younger participants (≤ 25 years; n = 186). When compared to results from the whole sample (Table 4), both unweighted and weighted BBV-TRAQ injecting and total scores more clearly differentiated HCV positive versus negative IDU among younger aged participants and those that had initiated injecting recently. Consistent with results from the whole sample, the general trend was for increasing effects with increasing item weights (Table 5).

**Discussion**

By retrospectively examining original scale development and subsequent cross-sectional data, we have devised a new risk behaviour weighting system that further refines the BBV-TRAQ instrument and enhances the utility of the scale for HCV surveillance and prevention evaluation purposes. The approach reported here is consistent with classical scale development methods [38,41,42]. Both normative subscale scores and between group (HCV status) differences can be used to recommend the choice of a BBV-TRAQ weighting scheme to measure HCV transmission risk among IDU. First, we can examine the contribution of subscales to total BBV-TRAQ scores in light of the plausible contributions injecting, sex and other skin penetration behaviours have to overall risk of HCV infection. The descriptive statistics presented in Table 3 show average subscale scores for the weighted and unweighted BBV-TRAQ. In terms of rank order contribution, both unweighted and log one-weighted scores can be discounted on the basis of emphasising sexual risk practices over other skin penetration practices, contrary to current opinion [22,25].

Examining the magnitude of subscale contributions, the sample data presented here shows that the log five-weighted scale is the most plausible method of modelling a relative risk profile using the BBV-TRAQ. It is well established that injecting risk behaviours (e.g. re-use of used needles and syringes) represent the greatest contribution to HCV incidence among IDU. In addition, recent research suggests ‘extremely low or even null’ risk of sexual transmission of HCV [30,31]. A log five weighting scheme that proposes injecting behaviours contributing in excess of 95% of overall HCV risk among IDU and sexual behaviours contributing less than one percent therefore offers a credible overall risk profile.

Estimating the role of other skin penetration practices on HCV transmission is less clear, with studies showing large variation in odds ratios attributable to tattooing [26], and the confounding factors of IDU and unprofessional tattooing, particularly in prison [23,25]. However, given the low or no risk of HCV sexual transmission, the blood-to-blood nature of HCV transmission and available epidemiological data, the log five weighting scheme offers a more plausible method of modelling a relative risk profile that is consistent with current opinion.

**Table 5: Comparisons** between self-report HCV status groups and weighted and unweighted BBV-TRAQ total and injecting subscales scores among sub-samples of IDU

| Sub-sample | Weight | BBV-TRAQ Score | F   | p-value | mean difference (HCV positive & negative) | 95% CI of the difference |
|------------|--------|----------------|-----|---------|------------------------------------------|--------------------------|
| Initiated injecting ≤ 3 years | None | Injecting subscale | 3.93 | .033 | 10.76 | 0.63 – 20.88 |
| | | Total | 2.65 | .076 | 14.5 | -1.05 – 30.05 |
| | Log 1 | Injecting subscale | 4.48 | .016 | 46.35 | 6.66 – 86.04 |
| | | Total | 4.19 | .018 | 54.35 | 7.12 – 101.58 |
| | Log 2 | Injecting subscale | 5.49 | .005 | 120.02 | 28.99 – 211.04 |
| | | Total | 5.41 | .006 | 130.32 | 31.25 – 229.39 |
| | Log 5 | Injecting subscale | 7.11 | .001 | 3.696 | 1.278 – 6.113 |
| | | Total | 7.19 | .001 | 3.752 | 1.298 – 6.205 |
| Aged ≤ 25 years | None | Injecting subscale | 12.50 | <.001 | 12.97 | 6.69 – 19.24 |
| | | Total | 8.97 | <.001 | 17.15 | 7.36 – 26.93 |
| | Log 1 | Injecting subscale | 13.66 | <.001 | 53.88 | 28.95 – 78.82 |
| | | Total | 12.08 | <.001 | 61.28 | 31.15 – 91.41 |
| | Log 2 | Injecting subscale | 14.46 | <.001 | 134.11 | 73.86 – 194.36 |
| | | Total | 13.70 | <.001 | 143.11 | 77.05 – 209.16 |
| | Log 5 | Injecting subscale | 14.16 | <.001 | 3.915 | 2.132 – 5.698 |
| | | Total | 13.69 | <.001 | 3.939 | 2.114 – 5.764 |

* Comparisons were made between all HCV groups (i.e., inclusive of ‘never tested/not sure’ group). To simplify tables only results relevant to the focus of this paper have been presented (i.e., ‘HCV positive’ and ‘HCV negative’). No differences were detected between the ‘never tested/not sure’ and other groups.
ological evidence, the larger relative risk contribution of other skin penetration versus sexual risk practices for the log five weighted scale again appears more realistic.

Second, examining differences in scores between self-report HCV positive and negative participants also lends credence to the log five-weighted scale. The log-five weighted total and injecting sub-scale scores were able to discriminate between HCV positive and negative IDU across the entire sample and among sub-groups of younger and less experienced users. Although requiring prospective sero-incident data to reliably establish predictive validity among IDU, the cross-sectional data reported here show log five weighted BBV-TRAQ scores able to differentiate levels of risk between HCV positive and negative participants in the expected direction. These results show that the application of item weights further refines the BBV-TRAQ instrument by presenting a more precise measure of individual risk of contracting HCV across a broad range of risk behaviours.

**Study strengths and weaknesses in relation to other studies**

Other studies investigating injecting risk practices associated with HCV status have reported mixed results. Some have reported no differences in rates of sharing between HCV positive and negative IDU [43,44], suggesting that the targeting of individual risk behaviours may have little utility. Others [10,45-47] have demonstrated differences in self-reported injecting risk behaviours according to the HCV status of IDU.

One possible explanation for the discrepancies in results is the format of risk behaviour questions asked of IDU. Those reporting no differences have reported ‘catch-all’ responses about the sharing of 'needles and syringes' and the sharing of 'other equipment' with dichotomised yes/no response categories. Assuming participants were asked about their risk behaviours in the same way their responses were reported and analysed, such measurement may under-estimate the sharing of injecting equipment. Indeed, others have found the reported prevalence of injecting risk practices increases markedly when more detailed questions about the sharing of specific injecting equipment are asked [21,48].

Graded response options, as used in the BBV-TRAQ, may help to limit recall bias and aid in the collection of more accurate injecting risk practice data [19]. This may be particularly valid among highly socialised injectors where ‘accidental or unnoticed sharing of equipment’ might contribute to HCV transmission risk [49-52]. It is also possible that multiple domain graded-response instruments such as the BBV-TRAQ might be more likely to trigger the memory of participants' risky injecting behaviours, reduce recall bias, and subsequently enhance the likelihood of detecting associations between injecting behaviours and HCV status. In some studies, graded frequency scales have been employed with success in multiple questions about the sharing of individual items used in the preparation and injecting process [10,45-47].

**Implications for clinicians and policymakers**

One of the key advantages of having a standardised HCV risk practice assessment instrument with a weighted scoring system is that it can be applied widely as a measure of the likelihood of HCV infection. Further validation using prospective sero-incident data could see such a scale used as a reliable screening tool and as a surrogate indicator of seroconversion, particularly among IDU, providing a low cost alternative to serology testing.

For example, the BBV-TRAQ could potentially be adopted as an outcome measure to evaluate community-based HCV prevention activities, particularly those that target high-risk behaviours identified in the BBV-TRAQ, and inform the development of future education and prevention initiatives in specific settings. Because the scale is brief, easy to administer and score, and inexpensive to apply [34,35], adopting the BBV-TRAQ as an outcome measure overcomes some of the impediments inherent in evaluating the efficacy of interventions to reduce HCV transmission. This can be particularly valuable in circumstances where resources, time, and the capacity to recruit and follow large numbers of prevention trial participants is limited, as can often be the case in community-based or non-government organisation prevention settings.

In addition, the instrument offers opportunities for empirically scaled standardised population surveillance of HCV risk behaviour that go beyond recording dichotomised responses indicating if someone had recently engaged in a risk practice or not. By covering the full range of injecting and putative HCV risk practices in combination with protective practices, the BBV-TRAQ also offers education opportunities to IDU by highlighting risk behaviours and opportunities for risk reduction. Our experience using the instrument in standard descriptive epidemiological studies [37] and recent brief intervention research [53] indicates that the scale has some impact for people completing it by accentuating both risk and risk reduction behaviours. Using BBV-TRAQ normative data, respondents could be categorised into BBV risk categories with prevention education tailored accordingly, and could also be provided with qualitative feedback that highlights particular risk behaviours that contributed most to their overall BBV-TRAQ score.

Needless to say the ability for individuals to adopt risk reduction behaviours is affected by numerous social and...
gies by describing why people adopt or maintain practices that place them at risk of HCV infection are best explored using ethnographic and qualitative methods [15], the BBV-TRAQ would ideally sit alongside such methodologies by describing what practices people actually engage in and the frequency with which they occur.

**Strengths and weaknesses of the study**

A number of methodological limitations need to be considered when interpreting these results. The most salient limitation is the reliance upon self-reports to characterise the HCV status of IDU. Researchers assessing self-report HCV and HBV status among IDU have reported variable validity [57,58], however, there is evidence that questionnaire self-administration (the BBV-TRAQ is a self-administered instrument) increases the reliability of self-report of behaviours relating to sensitive topics [59]. A recent study reported that 72% of HCV positive IDU and 46% of HCV negative IDU were not aware of their HCV status [60]. This study was, however, conducted across five US cities and found that use of drug treatment or needle and syringe programs was associated with increased awareness of HCV status. Given the more comprehensive nature of Australia’s long-established needle and syringe program network and a well recognised harm reduction framework with regards to injecting drugs, one might expect that knowledge of HCV status among Australian IDU would be higher than those reported in the US. In addition, the rates of HCV infection in our sample (45%) are similar to other comparable Australian samples in which serological data were collected (e.g., 50%; [6]). However, it is the case that some anti-HCV positive IDU may have cleared the virus, whereas others may have mistakenly identified themselves as HCV positive or negative. The latter misclassification is the most salient here, because associations between BBV-TRAQ scores and HCV may in fact reflect an underlying association with awareness of HCV status. Previous research among Australian IDU showed an association between HCV testing and greater knowledge about BBV transmission and safe injecting [61]. Although such results would suggest that participants in this study that were tested for HCV more often or more recently might more reliably report their HCV status, we cannot assume that this reliability would be more biased towards self-report HCV positives or negatives. However, if we assume similar HCV knowledge characteristics in this sample as those reported by Treloar et al [61] and also take account of the HCV status awareness reported above in the US [60], then it is possible that self-report HCV negatives may be more likely to report safer injecting practices on the BBV-TRAQ.

A second limitation is the cross-sectional data collection and the temporal differences between reporting risk behaviours and infection. To definitively test the suitability of scale weights among IDU (and reliably establish predictive validity), the BBV-TRAQ would need to be examined within the context of prospective sero-incident studies. In most cases, however, changes in risk behaviour profiles are theoretically likely to favour reductions in risk over time as IDU are exposed to more harm reduction messages and more contacts with service providers [60,62]. Combined with cumulatively more opportunities for viral transmission over time, such temporal changes would be more likely to diminish the ability of recent risk behaviours to predict lifetime exposure to HCV. Indeed, the analyses conducted on study sub-samples of younger and less experienced injectors shows an enhanced effect for the weighted BBV-TRAQ to distinguish between self-report HCV positive and negative participants (see Table 5). Although not a substitution for a prospective sero-incident study, examining HCV prevalence among recent initiates to injecting drugs has previously been used to help with indirect estimates of HCV incidence [63].

Consistent with results from other studies [10,43], injecting and total weighted BBV-TRAQ risk scores in younger less experienced IDU were considerably higher (in the order of three times) than those for the whole sample combined. Results from prospective cohort work in the US with recent initiates to injecting drug use suggest that seroconversion could occur in a quarter of IDU within approximately two years of initiating injecting and in at least half within four years of initiation [10]. In addition, a recent Australian cohort study reported high HCV incidence among new initiates, with mean time to seroconversion of 1.6 years among participants injecting for less than two years [64]. In this context, results showing BBV-TRAQ scores better able to discriminate between HCV positive and negative recent initiates must give greater confidence (even if only as a surrogate measure) in the predictive validity of the weighted BBV-TRAQ. It is likely that recent injecting risk practices among less experienced injectors would be somewhat indicative of their lifetime injecting risk practices, strengthening the connection between self-reported recent behaviours and lifetime exposure to HCV.

Finally, the BBV-TRAQ has largely been developed using IDU cohorts. By testing this weighted instrument with IDU we are not assuming that this group is the only one at risk of HCV infection. IDU are, however, the predominant risk group in many countries [4-6] and therefore constitute the most relevant group from which to begin establishing the reliability and validity of the weighted BBV-TRAQ. As described below, testing the validity of the BBV-TRAQ with other populations is needed. For example, testing the suitability of the instrument for non-injection routes of transmission with people not currently...
injecting but considered at some level of risk according to BBV-TRAQ scores.

**Unanswered questions and future research**

The psychometric development and refinement of a scale is a necessarily iterative process [38]. Of fundamental importance in early scale development stages is the establishment of construct and content validity [65,66], properties that were emphasised and assiduously developed during the initial development stages of the BBV-TRAQ [34,35]. Building on this foundation, this paper presents data on refinements to the BBV-TRAQ that strengthen its representation of the underlying construct of BBV risk assessment – in particular behavioural risk practices for HCV infection among IDU.

There are two important areas of future research warranted to enhance the properties and utility of the scale. First, in order to overcome the temporal limitations of relating lifetime infection with recent risk behaviours and reliably confirm the predictive validity of the scale, the BBV-TRAQ needs to be incorporated into prospective incidence studies of HCV transmission that involve the serial testing over time of baseline HCV-negative IDU. Second, as the properties of the BBV-TRAQ have largely been examined in the Australian IDU context with primary heroin injectors, subsequent studies are needed to explore these properties across different cultural, socio-environmental, disease prevalent and drug market conditions. How scores for the BBV-TRAQ might translate to other populations with different drug markets (e.g., cocaine injecting) or different harm reduction capacities (e.g., more restricted access to clean injecting equipment) is unknown. The utility of the instrument for determining risk of HIV and HBV infection among IDU and other at risk groups also needs to be examined in populations with higher disease prevalence. In this regard, no scale development occurs with all population groups at one time. As such, it is important to publish data on this stage of scale refinement as an iterative step in providing normative data, upon which data collection and analysis of results from different populations can be built.

**Conclusion**

In this study we have refined the BBV-TRAQ to recommend the use of a log five weighted scoring system to quantify HCV transmission risk among IDU. The application of such weights resulted in credible relative risk scores across subscales and provided a clear distinction between HCV positive and negative IDU, particularly among younger and less experienced injectors, for both total and injecting subscale BBV-TRAQ scores. Reliable, valid and easy to administer, the BBV-TRAQ is ideal for use in community settings for research and surveillance purposes, and for the evaluation of BBV education and prevention initiatives.

**Competing interests**

The authors declare that they have no competing interests.

**Authors’ contributions**

MS conceptualised the weighting scheme and the analytical approach to testing the properties of the weighted BBV-TRAQ. MS conducted the analyses presented in this paper, provided content knowledge and made major contributions to the written manuscript. CF was the principal researcher on the original development of the BBV-TRAQ and for the ABRIDUS. CF contributed content knowledge and made major contributions to the written manuscript. NL was a co-researcher on the original development of the BBV-TRAQ, provided content knowledge and clinical expertise to this paper and made contributions to the written manuscript. All authors read and approved the final manuscript.

**Acknowledgements**

The authors would like to acknowledge other members of the research team involved in the original BBV-TRAQ development – Greg Rumbold, Nick Crofts, Aaron Scowe, Hilary Irwin, Jenny Kelsall and Sanja Pahoki. They would also like to acknowledge other members of the research team involved in ABRIDUS – Robyn Dwyer, Susan Carruthers, Amanda Bolleter, Kate Dolan, Alyza Donald, Jude Byrne and Wendy Loxley. We would like to thank Jesus Navarro for his valuable comments on an earlier draft of this paper. ABRIDUS was funded by the National Health & Medical Research Council, Strategic Reserve Fund (HCV Social & Behavioural Research). Development of a weighted scoring system was funded by the Queensland Health Department and we would like to acknowledge Turning Point Alcohol and Drug Centre where some of the recent BBV-TRAQ development work was conducted. All authors are independent from the funding bodies, and the opinions expressed are their own.

**References**

1. Chong CA, Gulamhussein A, Heathcote Ej, Lilly L, Sherman M, Naglie G, Krahn M. Health-state utilities and quality of life in hepatitis C patients.[see comment]. American Journal of Gastroenterology 2003, 98(3):630-638.

2. Foster GR, Goldin RD, Thomas HC: Chronic hepatitis C virus infection causes a significant reduction in quality of life in the absence of cirrhosis.[see comment]. Hepatology 1998, 27(1):209-212.

3. Law MG, Dore GJ, Bath N, Thompson S, Crofts N, Dolan K, Giles W, Gow P, Kaldor J, Loveday S, Powell E, Spencer J, Wodak A: Modeling hepatitis C virus incidence, prevalence and long-term sequelae in Australia, 2001.[see comment]. International Journal of Epidemiology 2003, 32(5):717-724.

4. Alter MJ, Kruszon-Moran D, Nainan OV, McQuillan GM, Gao F, Moyer LA, Kaslow RA, Margolis HS: The prevalence of hepatitis C virus infection in the United States, 1988 through 1994.[see comment]. New England Journal of Medicine 1999, 341(8):556-562.

5. Health Protection Agency: Shooting up: infections among injecting drug users in the United Kingdom 2003. London , Health Protection Agency; 2004.

6. National Centre in HIV Epidemiology and Clinical Research: Australian NSP Survey National Data Report 1999-2003. Sydney , The University of New South Wales; 2004.
7. Crofts N, Atkin CK: Incidence of bloodborne virus infection and risk behaviours in a cohort of injecting drug users in Vic-
mon, Australia 1997, 167(1):17-20.

8. van Beek L, Dwyer R, Dore GJ, Luo K, Kaldor JM: Infection with HIV and hepatitis C virus among injecting drug users in a
prevention setting: retrospective cohort study.[see comment]. British Medical Journal 1998, 317(7516):433-437.

9. Cook PA, McVeigh J, Syed Q, Muntan K, Stimson G, Goldberg D: Prevalence of, and risk factors for, hepatitis B and C in injecting drug users both in and out of drug treatment. Addition 2001, 96(12):1787-1797.

10. Hagan H, Thiede H, Des Jarlais DC: Hepatitis C virus infection among injection drug users: survival analysis of time to sero-
conversion.[see comment]. Epidemiology 2004, 15(5):543-549.

11. Valenciano M, Emmanuelli J, Lert F: Unsafe injecting practices among attendees of syringe exchange programmes in
France.[see comment]. Addiction 2001, 96(4):597-606.

12. Dore GJ, Law M, MacDonald M, Kaldor JM: Epidemiology of hepatitis C virus infection in Australia. Journal of Clinical Virology 2003, 26(2):171-184.

13. Judd A, Hutchinson S, Wadd S, Hickman M, Taylor A, Jones S, Parry JV, Cameron S, Rhodes T, Ahmed S, Bird S, Fox, R, Renton A, Stimson GV, Goldberg D: Prevalence of, and risk factors for, hepatitis C among injection drug users in England and Wales: is harm reduction working? American Journal of Public Health 2001, 91(1):38-42.

14. Hope VD, Judd A, Hickman M, Lamagni T, Hunter G, Stimson GV, Jones S, Donovan L, Parry JV, Gill ON: Prevalence of hepatitis C among injection drug users in England and Wales: is harm reduction working? American Journal of Public Health 2001, 91(1):21-22.

15. Crofts N, Sanna S, Bowden S, Kergor M: Minimising harm from hepatitis C virus needs better strategies. British Medical Journal 2000, 321(7265):7.

16. Darke S Hall, W., Heather, N., Ward, J. & Wodak, A.: The social structural production of HIV risk among injecting drug
users. Soc Sci Med 2000, 51(5):1026-1044.

17. Rhodes T, Singer M, Bourgois P, Friedman SR, Strathdee SA: Stimson GV, Jones S, Donovan L, Parry JV, Gill ON: Prevalence of hepatitis C among injection drug users in England and Wales: is harm reduction working? American Journal of Public Health 2001, 91(1):38-42.

18. Donald L: The tattooing paradox: are studies of hepatitis C virus infection adequate to identify routes of transmission of
hepatitis B and C infection in injecting drug users both in and out of drug treatment. Addition 2001, 96(12):1787-1797.

19. Goodyer I, Verbeek J, Van Ranst M, Robaeys G, Van Damme P, Buntinx F: Molecular epidemiology of hepatitis C among drug users in Flanders, Belgium: association of genotype with clinical parameters and with sex- and drug-related risk behaviours. Eur J Clin Microbiol Infect Dis 2005, 24(6):514-522.

20. Nishioka SA, Gyorkos TW: Tattoos as Risk Factors for Transfu-
nion-Transmitted Diseases. International Journal of Infectious Disease 2001, 5:27-34.

21. Cainelli F, Vento S: Hepatitis C is not a sexually transmissible disease.[comment]. American Journal of Gastroenterology 2002, 97(1):80-81.

22. Masur CD: Re: J. Gross editorial—‘‘Hepatitis C: a sexually transmitted disease?’’ [Comment]. American Journal of Gastroen-
terology 2002, 97(5):1256-1257.

23. Roy KM, Goldberg DJ, Hutchinson S, Cameron SO, Wilson K, Mac-
than L: Hepatitis C virus among self declared non-injecting sexual partners of injecting drug users. Journal of Medical Virology 2004, 74(1):62-66.

24. Alary M, Joly JR, Vincette J, Lavoie R, Turmel B, Remis RS: Lack of evidence of sexual transmission of hepatitis C virus in a pro-
spective cohort study of men who have sex with men. American Journal of Public Health 2005, 95(3):502-505.

25. Vandelli C, Renzo F, Romano L, Tisminetzky S, De Palma M, Stroffolini T, Ventura E, Zanetti A: Lack of evidence of sexual transmission of hepatitis C among monogamous couples: results of a 10-
year prospective cohort study. [comment]. American Journal of Gastroenterology 2004, 99(5):855-859.

26. Brussetto S, Barbone F, Andriani P, Brianti G, Ciccone L, Furlan A, Gnesutta D, Stel S, Zamparo E, Toniutioi P, Ferroni P, Gasparini V: A study on the role of the family and other risk factors in HCV transmission. European Journal of Epidemiology, 1999, 15(2):125-132.

27. Demelia L, Vallebona E, Poma R, Sanna G, Masia G, Coppola RC: HIV transmission working? American Journal of Public Health 2001, 91(1):38-42.

28. Hope VD, Judd A, Hickman M, Lamagni T, Hunter G, Stimson GV, Jones S, Donovan L, Parry JV, Gill ON: Prevalence of hepatitis C among injection drug users in England and Wales: is harm reduction working? American Journal of Public Health 2001, 91(1):21-22.

29. Crofts N, Sanna S, Bowden S, Kerger M: Minimising harm from hepatitis C virus needs better strategies. British Medical Journal 2000, 321(7265):7.

30. Darke S Hall, W., Heather, N., Ward, J. & Wodak, A.: The reliability and validity of a scale to measure HIV risk-taking behaviour among injecting drug users. AIDS 1991, 5:181-185.

31. Stimson GV, Jones S, Chalmers C, Sullivan D: A short question-
naire (IRQ) to assess injecting risk behaviour. Addiction 1998, 93(3):337-347.

32. Adelenk ML Green, A., Dasgupta, N., Tallack, F., Stimson, G. V. & Wells, B.: Reliability and validity of the Opiate Treatment Index among opioid users in the United Kingdom. Drug Alcohol Rev 1996, 15(3):260-261.

33. Hunter GM, Stimson GV, Judd A, Jones S, Hickman M: Measuring injecting risk behaviour in the second decade of harm re-
duction: a survey of injecting drug users in England. Addition 2000, 95(9):1351-1361.

34. Clarke A, Kulasegaram R: Hepatitis C transmission -- where are we now? International Journal of STD & AIDS 2006, 17(2):74-80.

35. Babudieri S, Longo B, Sarmati L, Starnini G, Durand P, Stein E, Evans JL, Busch MP, Tobler LH, Phillips B, Mass AR: Hepatitis C virus seroconversion among young injection drug users: relationships and risks. Journal of Infectious Diseases 2002, 186(11):1558-1564.

36. Villano SA, Vlahov D, Nelson KE, Lyles CM, Cohn S, Thomas DL: Incidence and risk factors for hepatitis C among injection

drug users in Baltimore, Maryland. Journal of Clinical Microbiology 1997, 35(12):3274-3277.

48. Jones S, Hickman M, Judd A, Barwick P, & Sondhi A: Survey of Sharing by Injecting Drug Users. Comparison of London Community Sample with London Treatment Sample. London, The Centre for Research on Drugs and Health Behaviour, Imperial College; 1998.

49. Smyth BP, Barry J, Keenan E: Irish injecting drug users and hepatitis C: the importance of the social context of injecting. International Journal of Epidemiology 2000, 29(1):166-172.

50. Crofts N, Attkins CK, Kaldor JM: The force of numbers: why hepatitis C is spreading among Australian injecting drug users while HIV is not.[see comment]. Medical Journal of Australia 1999, 170(5):220-221.

51. Taylor A, Fleming A, Rutherford A, Goldberg D: Examining the injecting practices of injecting drug users in Scotland. Edinburgh, Substance Misuse Division, Scottish Executive; 2004.

52. Taylor A, Crofts N: Once more unto the breach: controlling hepatitis C in injecting drug users. Addiction 1996, 91(2):181-184.

53. Tucker T, Fry CL, Lintzeris N, Baldwin S, Ritter A, Donath S, Whelan G: Randomised controlled trial of a brief behavioural intervention for reducing hepatitis C virus risk practices among injecting drug users. Addiction 2004, 99(9):1157-1166.

54. Carruthers SJ: Preventing hepatitis C: what do positive injectors do? Drug & Alcohol Review 2005, 24(2):193-198.

55. Maher L: Don't leave us this way: ethnography and injecting drug use in the age of AIDS. International Journal of Drug Policy 2002, 13:311-325.

56. Wright N, Tompkins CN, Jones L: Exploring risk perception and behaviour of homeless injecting drug users diagnosed with hepatitis C. Health & Social Care in the Community 2005, 13(1):75-83.

57. Thornton L, Barry J, Long J, Allwright S, Bradley F, Parry JV: Comparison between self-reported hepatitis B, hepatitis C, and HIV antibody status and oral fluid assay results in Irish prisoners. Communicable Disease & Public Health 2000, 3(4):253-255.

58. Kwiatkowski CF, Corsi KF, Booth RE: The association between knowledge of hepatitis C virus status and risk behaviours in injecting drug users. Addiction 2002, 97:1289-1294.

59. Tourangeau R, Rasinski, K., Jobe, J. B., Smith, T. W. & Pratt, W. F.: Sources of error in a survey on sexual behaviour. Journal of Official Statistics 1997, 13:341-365.

60. Hagan H, Campbell J, Thiede H, Stratdhee S, Ouellet L, Kapadia F, Hudson S, Garfein RS: Self-reported hepatitis C virus antibody status and risk behavior in young injectors. Public Health Reports 2006, 121(6):710-719.

61. Trelloar C, Abelson J: Information exchange among injecting drug users: a role for an expanded peer education workforce. International Journal of Drug Policy 2005, 16:46-53.

62. Becker Buxton M, Vlahov D, Stratdhee SA, Des Jarlais DC, Morse EV, Gayler Q, Kerndt P, Garfein RS: Association between injection practices and duration of injection among recently initiated injection drug users. Drug Alcohol Depend 2004, 75(2):177-183.

63. Ministerial Advisory Committee on AIDS SHHCSC: Hepatitis C Virus Projections Working Group: Estimates and Projections of the Hepatitis C Virus Epidemic in Australia 2006. Sydney, NSW , National Centre in HIV Epidemiology and Clinical Research, University of NSW; 2006.

64. Maher L, Jalaludin B, Chant KG, Jayasuriya R, Sladden T, Kaldor JM: Sargent PL: Incidence and risk factors for hepatitis C seroconversion in injecting drug users in Australia. Addiction 2006, 101(10):1499-1508.

65. Clarke LA, Watson D: Constructing validity: basic issues in objective scale development. Psychological Assessment 1995, 7(3):309-319.

66. Haynes SN, Richard DCS, Kubary ES: Content validity in psychological assessment: a functional approach to concepts and methods. Psychological Assessment 1995, 7:238-247.
Author/s:
Stoové, MA; Fry, CL; Lintzeris, N

Title:
Quantifying hepatitis C transmission risk using a new weighted scoring system for the Blood-Borne Virus Transmission Risk Assessment Questionnaire (BBV-TRAQ): applications for community-based HCV surveillance, education and prevention.

Date:
2008-04-23

Citation:
Stoové, M. A., Fry, C. L. & Lintzeris, N. (2008). Quantifying hepatitis C transmission risk using a new weighted scoring system for the Blood-Borne Virus Transmission Risk Assessment Questionnaire (BBV-TRAQ): applications for community-based HCV surveillance, education and prevention.. Harm Reduct J, 5 (1), pp.12-.
https://doi.org/10.1186/1477-7517-5-12.

Persistent Link:
http://hdl.handle.net/11343/270221

File Description:
Published version

License:
CC BY