JOURNAL OF SUBSTANCE USE
https://doi.org/10.1080/14659891.2023.2202767

Taylor & Francis
Taylor & Francis Group

REVIEW

Determinants of emergency department use and hospitalization among people who inject drugs: A systematic review and meta-analysis

Bahram Armoon[a,b], Marie-Josée Fleury[a,b], Mark D. Griffiths[c], Azadeh Bayani[d], Rasool Mohammadi[e,f], and Elaheh Ahounbar[g,h]

[a]Douglas Hospital Research Centre, Montreal, Quebec, Canada; [b]Department of Psychiatry, McGill University, Montreal, Quebec, Canada; [c]International Gaming Research Unit, Psychology Department, Nottingham Trent University, Nottingham, UK; [d]Student Research Committee, School of Allied Medical Sciences, Shahid Beheshti University of Medical Sciences, Tehran, Iran; [e]Social Determinants of Health Research Center, School of Public Health and Nutrition, Lorestan University of Medical Sciences, Khorramabad, Iran; [f]Department of Biostatistics and Epidemiology, School of Public Health and Nutrition, Lorestan University of Medical Sciences, Khorramabad, Iran; [g]Orygen, The National Center of Excellence in Youth Mental Health, University of Melbourne, Parkville, Australia; [h]Center for Youth Mental Health, Faculty of Medicine, Dentistry and Health Sciences, University of Melbourne, Parkville, Australia

ABSTRACT

Background: The present study aimed to identify sociodemographic characteristics, risky behaviors, type of drug use, and service use variables associated with emergency department (ED) use and hospitalization among people who inject drugs (PWID).

Methods: Studies in English published from January 1, 1995, to December 15, 2021, were searched for on *PubMed, Scopus, Cochrane*, and *Web of Science* to identify primary studies on ED use and hospitalization among PWID.

Results: After a detailed assessment of 17,348 outputs, a total of 19 studies met the eligibility criteria for inclusion in the analysis. Greater risks of ED use and hospitalization among PWID were associated with (i) a history of homelessness, (ii) HIV-positive status, and (iii) injecting drugs more than four times per day. Individuals were more likely to use the ED if they (i) had a history of physical abuse, (ii) were using cocaine and methamphetamine, and (iii) had used primary care services. Women and individuals with chronic physical illnesses were more likely to be hospitalized.

Conclusions: The present study is the first to integrate determinants related to ED use and hospitalization based on sociodemographic characteristics, risky behaviors, type of drug, and service use determinants among PWID. To reduce ED use and hospitalization among PWID, the paper also recommends various strategies could be implemented.

ARTICLE HISTORY
Received 12 April 2022
Accepted 6 April 2023

KEYWORDS
Emergency department use; hospitalization; people who inject drugs; psychoactive substances; primary care services

This is the accepted version of this following article: **Determinants of emergency department use and hospitalization among people who inject drugs: A systematic review and meta-analysis**. Journal of Substance Use 2023. https://doi.org/10.1080/14659891.2023.2202767. Online ahead of print.

Determinants of emergency department use and hospitalization among people who inject drugs: A systematic review and meta-analysis

Bahram Armoon PhD [1,2], Marie-Josée Fleury PhD [1,2], Mark D. Griffiths PhD[3], Azadeh Bayani MSc[4], Rasool Mohammadi PhD [5,6], Elaheh Ahounbar MSc[7,8]

[1]Douglas Hospital Research Centre, Montreal, Quebec, Canada

[2]Department of Psychiatry, McGill University, Montreal, Quebec, Canada

[3]International Gaming Research Unit, Psychology Department, Nottingham Trent University, Nottingham, UK

[4]Student Research Committee, School of Allied Medical Sciences, Shahid Beheshti University of Medical Sciences, Tehran, Iran

[5] Social Determinants of Health Research Center, School of Public Health and Nutrition, Lorestan University of Medical Sciences, Khorramabad, Iran

[6]Department of Biostatistics and Epidemiology, School of Public Health and Nutrition, Lorestan University of Medical Sciences, Khorramabad, Iran

[7]Orygen, The National Center of Excellence in Youth Mental Health, University of Melbourne, Parkville, VIC, Australia

[8]Center for Youth Mental Health, Faculty of Medicine, Dentistry and Health Sciences, University of Melbourne, Parkville, Australia

Correspondence:

Dr. Rasool Mohammadi

[5] Social Determinants of Health Research Center, School of Public Health and Nutrition, Lorestan University of Medical Sciences, Khorramabad, Iran

[6]Department of Biostatistics and Epidemiology, School of Public Health and Nutrition, Lorestan University of Medical Sciences, Khorramabad, Iran

Email: rasool.mehr2002@gmail.com

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests:

The authors declare that there are no conflicts of interest.

Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Author contributions: BA. Conceived the study BA. collected all data. RM, and BA analyzed and interpreted the data. BA, EA and AB. drafted the manuscript. BA, MDG and MJF contributed to the revised paper and were responsible for all final editing. All authors commented on the drafts of the manuscript and approved the final copy of the paper for submission.

Acknowledgments:

Not applicable.

Determinants of emergency department use and hospitalization among people who inject drugs: A systematic review and meta-analysis

Abstract

Background: The present study aimed to identify sociodemographic characteristics, risky behaviors, type of drug use, and service use variables associated with emergency department (ED) use and hospitalization among people who inject drugs (PWID).

Methods: Studies in English published from January 1, 1995 to December 15, 2021 were searched for on *PubMed, Scopus, Cochrane,* and *Web of Science* to identify primary studies on ED use and hospitalization among PWID.

Results: After a detailed assessment of 17,348 studies, a total of 19 studies met the eligibility criteria for inclusion in the analysis. Greater risks of ED use and hospitalization among PWID were associated with (i) history of homelessness, (ii) HIV-positive status, and (iii) injecting drugs more than four times per day. Individuals were more likely to use the ED if they (i) had a history of physical abuse, (ii) were using cocaine and methamphetamine, and (iii) had used primary care services. Women and individuals having chronic physical illnesses were more likely to be hospitalized.

Conclusions: The present study is the first to integrate determinants related to ED use and hospitalization based on sociodemographic characteristics, risky behaviors, type of drug, and service use determinants among PWID. To reduce ED use and hospitalization among PWID, the paper also recommends various strategies could be implemented.

Keywords: emergency department use; hospitalization; people who inject drugs; psychoactive substances; primary care services

Introduction

People who inject drugs (PWID) are more likely to frequently use hospital emergency departments (EDs) and be hospitalized (i.e., receive acute care) than those who do not inject drugs (Nambiar, Stoové, & Dietze, 2017; Palepu et al., 2001). A Canadian study reported 64% of PWID had ED use in the previous 12 months, and 35% of them had at least two ED visits during that period (Fairbairn et al., 2012). Moreover, hospitalization rates have been reported to range from 35% to 40% among PWID (Palepu et al., 2001; Takahashi et al., 2007). PWID are affected by depressive and psychotic disorders (Michel et al., 2022; Reddon et al., 2018) and/or physical diseases such as HIV infection or hepatitis C, which may result in greater ED use and/or hospitalization (Kendall et al., 2017; Lloyd-Smith et al., 2010).

ED use and hospitalization are the most costly health services (Galarraga et al., 2016; Mejia de Grubb et al., 2020). They are also key indicators of adverse outcomes (Armoon, Grenier, et al., 2021; Fleury et al., 2019), and may be the sign of poor access or insufficient quality of outpatient care (Sørup et al., 2013). PWD need harm reduction interventions, including access to needle and syringe programs (Noroozi et al., 2018; Noroozi et al., 2019) and safe injecting facilities (Kerr et al., 2007). However, PWID often do not take benefit of such services, and many of them do not receive helpful support such as long-term primary care services (Chitwood et al., 2001).

To the best of the present authors' knowledge, no systematic review and meta-analysis has previously investigated determinants of ED use and hospitalization among PWID. Identifying determinants of ED use and hospitalization among PWID can help inform healthcare decision-makers regarding unmet health needs for this vulnerable population, and help in the development of strategies to reduce acute care use. Additionally, since drug use appears to be increasing in many countries (Brunt et al., 2021; Seitz et al., 2019), comprehensive knowledge of acute care use of

PWID is essential to meet their needs and help in the consolidation of effective drug policy. The present study aimed to identify sociodemographic characteristics, risky behaviors (such as HIV-positive status, injecting drugs more than four times per day), type of drug use, and service use variables associated with ED use and hospitalization among PWID.

Methods

Search strategy and study selection

Two independent researchers individually reviewed the literature from January 1, 1995 to December 15, 2021 using *PubMed, Scopus, Web of Science*, and *Cochrane* databases. A librarian confirmed the search strategy, and it was modified for using in different databases including Boolean operators (AND/OR) and initial keywords *"(emergency medical services), (emergency service, hospital), (hospitalization), (injection drug), (people who inject drugs), (substance abuse, intravenous)"*. References of the included studies were also searched by hand for further relevant studies (see **Supplementary File 1**).

Inclusion and exclusion criteria

All studies had to meet inclusion criteria based on "Population, exposures, comparison, outcome, and study design" (PECOs) criteria. In "population" only PWID was included; for "exposures", associations with sociodemographic characteristics, risky behaviors, type of drug use, and service use variables regarding PWID on ED use and hospitalization were assessed; the "comparison" group was PWID not reporting ED use and hospitalization; the "outcomes" were ED use and hospitalization among PWID; finally, the "study design" integrated cross-sectional, cohort or case-control studies. For outcome, the previous six or twelve months of ED use or hospitalization (yes or no) among PWID was considered. To be included in the present study, at

least two studies with the same acute care measure needed to be found, which is a minimal standard of meta-analyses study inclusion (Ryan, 2016). Studies were excluded if they were (i) qualitative, (ii) not written in English, (iii) did not include primary data, (iv) abstracts, books, theses, or conference proceedings, systematic reviews, and meta-analyses. Studies with high heterogeneity or outcome variations from the considered groups were also excluded.

Data extraction procedure

Two of the authors (BA and AB) independently reviewed and evaluated the selected papers, based on a standardized data collection checklist. The two researchers independently selected the studies in a four-phase monitoring procedure. Initially, the duplicated titles/abstracts (89% agreement) meeting the Newcastle-Ottawa Scale criteria (explained below), were removed. Next, the papers' titles/abstracts were screened for full-text review based on the inclusion criteria of the study (96% agreement). Any disagreements between the authors were resolved by a third author (EA). Following this, the full texts of selected papers were reviewed. Finally, the required data were extracted from the selected papers. Data extraction and management were performed in *Microsoft Excel* software.

Quality assessment of the studies

The Newcastle-Ottawa Scale (NOS); (Stang, 2010) was used to examine the quality of the reviewed studies. There are three domains of selection, comparability, and exposure/outcome in the NOS comprising 3, 1, and 1 items for cross-sectional studies and 4, 1, and 3 items for cohort studies. The studies were also categorized as unsatisfactory, satisfactory, good, or very good. The agreement levels of poor, slight, fair, moderate, substantial, and almost perfect were considered by the values 0, 01–0.02, 0.021–0.04, 0.041–0.06, 0.061–0.08, and 0.081–1.00, respectively (Landis

et al., 1977). In total, seven studies were rated as high quality, eight studies were rated as good quality, and four were rated as satisfactory quality. (**Supplementary File 2**).

Data synthesis and statistical analysis

Systematic review and meta-analysis were performed by generating pooled odds ratios (ORs) and 95% confidence intervals (CIs) for determining variables associated with ED use and hospitalization among PWID. The OR was computed by a 2x2 table, and an OR of <1 demonstrated a negative correlation between ED use and hospitalization and the target characteristic. An OR of >1 (i.e., the statistical threshold for examining the correlation between ED use and hospitalization and expositive variables) reflects positive correlation between ED use and hospitalization and independent variables. To evaluate the correlation between studies, the Q test at $p<0.05$ and I^2 statistics (with a cutoff point of ≥50%) were used as the most optimal choices. A 95%CI was considered for I^2. However, the negative scores were considered at zero. To achieve the pooled estimation, the random-effects model was used, considering different sampling methods implemented in the studies. Egger's publication bias test was used to identify any existing publication bias (Egger et al., 1997). Subsequently, the obtained data were illustrated in forest plots. The *R version 3.5.1* with the *"meta"* package was applied to perform the meta-analysis of the collected data (Viechtbauer, 2010).

Results

Study characteristics

After a detailed assessment of 17,348 studies, a total of 19 studies were included in the present study for inclusion in the analysis (Binswanger et al., 2008; Fairbairn et al., 2012; Hope et al., 2015; Islam et al., 2013; Kerr et al., 2005; Knowlton et al., 2001; Lloyd-Smith et al., 2012; Lloyd-Smith et al., 2010; Marshall et al., 2012; McDonald et al., 2011; Nambiar et al., 2018;

Nambiar, Stoové, & Dietze, 2017; Nambiar, Stoové, Hickman, et al., 2017; Olubamwo et al., 2018; Palepu et al., 2003; Palepu et al., 1999; Palepu et al., 2001; Stein et al., 2003; Takahashi et al., 2007) (**Figure 1**). A total of 275 studies were excluded because they did not use a quantitative methodology and/or did not consider parametric measurements such as coefficients and odd ratios of relative to ED use and/or hospitalization (37%), 127 studies did not consider ED use or hospitalization for their outcome variables, or did not have a dichotomous variable (i.e., acute care use: yes, or no) (17%). Finally, 333 studies did not meet the qualifications based on the minimum quality appraisal (45%).

Figure 1 near here

Study characteristics

Canada had the highest number of studies (n=8, comprising 6,212 participants) followed by the United States (n=4, comprising 1,051 participants) and Australia (n=4, comprising 7,201 participants). All studies were conducted within high-income countries. Mean study size at baseline was 3,142 PWID, with 147 being the lowest sample size (Takahashi et al., 2007), and 41,062 being the largest sample size (McDonald et al., 2011), respectively. Response rates varied between studies from 74% to 100%, respectively. PWID were more likely to be male in the studies (67.83%), varying from 60% to 75%, and on average were 34.82 years old. Almost all of the studies were cohort (89%), and 58% of studies were published between 2010 and 2021. Three studies assessed both ED use and hospitalization as the outcomes, using administrative databases or self-reported surveys. Nine studies assessed ED use only, and seven studies assessed hospitalization only as the outcome, using administrative databases, self-report surveys or both administrative databases and surveys. Main types of drug use disorders reported in studies were polydrug use (n=6 studies), heroin and cocaine use (n=5 studies), and methamphetamine use (n=2

studies). This suggests that their main drug of choice is not necessarily the one that they had injected. Six studies did not report specific types of drug use disorders relating to PWID globally. Among the 19 studies included in the meta-analysis, 10 reported sociodemographic characteristics, 14 reported risky behaviors, seven reported type of drug use, and eight reported service use variables (**Table 1**).

Table 1 near here

Pooled prevalence rate of ED use and hospitalization among PWID

The pooled prevalence rate of ED use and hospitalization among PWID were 49% (95% CI, 40%-59%) (**Figure 2**) and 27% (95% CI, 16%-38%) (**Figure 3**) respectively.

Figures 2 and 3 near here

Sociodemographic characteristics, risky behaviors, type of drug use and service use variables associated with ED use and hospitalization among PWID

In four ED use studies (Fairbairn et al., 2012; Palepu et al., 2003; Palepu et al., 1999; Palepu et al., 2001) and three hospitalization studies (Olubamwo et al., 2018; Palepu et al., 1999; Takahashi et al., 2007), those who had a history of homelessness were reported to use ED or to be hospitalized 1.52 and 1.63 times more than non-homeless individuals, respectively (OR=1.52, 95%CI=1.29-1.78) (OR=1.63, 95%CI=1.34-1.97). In two studies (Fairbairn et al., 2012; Kerr et al., 2005), those who had a history of physical abuse were 1.38 times more likely to report ED use (OR=1.38, 95%CI=1.12-1.69). In three studies (McDonald et al., 2011; Palepu et al., 1999; Palepu et al., 2001), PWID who were women were 1.54 times more likely to have been hospitalized (OR=1.54, 95%CI=1.34-1.78). In five ED use studies (Kerr et al., 2005; Knowlton et al., 2001;

Lloyd-Smith et al., 2012; Palepu et al., 1999; Palepu et al., 2001) and three hospitalization studies (Lloyd-Smith et al., 2010; Palepu et al., 1999; Palepu et al., 2001), those who had HIV infection were reported to use ED or to be hospitalized 1.66 and 2.37 times more than who did not have HIV infection, respectively (OR = 1.66, 95%CI = 1.42-1.95) (OR = 2.37, 95%CI = 1.07-5.26). In two ED use studies (Palepu et al., 2001; Stein et al., 2003) and two hospitalization studies (Olubamwo et al., 2018; Stein et al., 2003), those who injected drugs more than four times per day were reported to use EDs or to be hospitalized 1.29 and 1.39 times more than who did not respectively (OR=1.29, 95%CI=1.05-1.57) (OR=1.39, 95%CI=1.15-1.69). In two studies (Binswanger et al., 2008; Stein et al., 2003), those who had chronic physical illnesses were 1.55 times more likely to be hospitalized compared to those who did not (OR = 1.55, 95%CI = 1.23, 1.96). In three ED use studies (Kerr et al., 2005; Marshall et al., 2012; Nambiar, Stoové, & Dietze, 2017) and three studies related to ED use (Palepu et al., 1999; Palepu et al., 2001; Stein et al., 2003), PWID who used methamphetamine were 2.10 times more likely to have ED use (OR=2.10, 95%CI=1.39-3.16), and PWID who used cocaine were 1.48 times more likely to have ED use, respectively (OR=1.48, 95%CI=1.23-1.79). Finally, in four ED use studies (Fairbairn et al., 2012; Kerr et al., 2005; Nambiar, Stoové, Hickman, et al., 2017; Palepu et al., 1999), those who reported using primary care services were 1.87 times more likely to have ED use than those who did not (OR=1.87, 95%CI=1.49-2.35) (**Figures 4 and 5**).

Figures 4 and 5 near here

Publication bias

To identify the probable publication bias, Egger's test (Egger et al., 1997) and the graph were performed. According to Eggers test, a significant publication bias among studies was noted

(coefficient = 3.43, p<0.001). Therefore, metatrim analysis was performed in order to remove the effect of publication bias on the pooled OR. The meta-trim analysis showed that the pooled OR was 0.15 (95%CI: 0.11–0.19) in the random effect model.

Discussion

Findings from the meta-analysis indicated that among people who inject drugs (PWID), the pooled rate for ED use was 49% and the pooled rate for hospitalization was 27%. No pooled prevalence for acute care has previously been reported in relation to PWID. Some of the reasons for this may be because PWID have high rates of injection frequency that may increase the risk of HIV infection, soft-tissue infections, and pneumonia, as well as being engaged with a risky behavior that has a high association with various suicidal behaviors (e.g., suicide ideations, suicide attempts (Armoon, Fleury, et al., 2022; Armoon, Higgs, et al., 2021; Moradi-Joo et al., 2019; Rezaei et al., 2020), all of which would increase the chances of needing acute care. PWID with history of homelessness and HIV-positive status were the most at risk of being both ED users and being hospitalized. Using methamphetamine and cocaine as well as using primary care services also increased the risk of ED use only, while being women who injected drugs increased the risk of hospitalization only.

Having a history of homelessness was the only sociodemographic determinant associated with both ED use and hospitalization. More specifically, homelessness elevated the risk of ED use and hospitalization by 1.52 and 1.63, respectively. Studies have indicated that 40% (Palepu et al., 2003) to 69% (Fairbairn et al., 2012) of PWID who are homelessness have used EDs, and that 24% (Takahashi et al., 2007) to 66% (Palepu et al., 1999) have been hospitalized. The association between homelessness and acute care services was found previously in studies conducted with PWID (McGeary et al., 2000; Nambiar et al., 2018). According to the literature, individuals having

a history of homelessness are more likely to have severe infections (Takahashi et al., 2007), acute illnesses (Rickards et al., 2010), mental disorders (Latimer et al., 2017), substance-related disorders (Magwood et al., 2020), injuries (Mackelprang et al., 2014), and suicidal behaviors (Gentil et al., 2021).

The association between ED use and a history of physical abuse has also been found in previously studies (Kerr et al., 2003; Tyndall et al., 2002). According to the literature, individuals who have a history of physical abuse, have higher risks of injection drug initiation, which may lead to ED use (Prangnell et al., 2020). Previous studies have reported that between 21% (McDonald et al., 2011) and 43% (Palepu et al., 2001) of women who inject drugs are likely to be hospitalized. According to the literature (Shapiro et al., 1999; Solomon et al., 1998), compared to men, women are more likely to be hospitalized and to show adverse outcomes associated with substance-related disorders (Beaudoin et al., 2015; John et al., 2017; Trillo et al., 2012), which may also explain their higher risk of hospitalization in the present study.

The risk of ED use and hospitalization was especially elevated among PWID who have HIV positive status, being 1.66 and 2.37 higher, respectively. Studies have indicated that 13% (Knowlton et al., 2001) to 54% (Palepu et al., 2001) of those with HIV positive status used EDs, and that 28% (Palepu et al., 1999) to 39% (Palepu et al., 2001) of them are hospitalized. Previous studies have found that drug injection increases the risk of infection by HIV (Ball et al., 2019; Mathers et al., 2008), which might increase the risk of ED use or hospitalization (Archibald et al., 1998).

Studies have reported that 32% (Stein et al., 2003) to 35% (Palepu et al., 2001) of PWID who inject drugs more than four times a day have used EDs, and 32% (Stein et al., 2003) to 47% (Olubamwo et al., 2018) among this group have been hospitalized. Higher injection frequency

increases the risk of overdose (Armoon, Bayani, et al., 2022), which can lead to ED use and hospitalization (Stein et al., 2003). Unsurprisingly, chronic physical illnesses increased the expected odds of hospitalization (by a factor of 1.55). A previous study reported that 58% of PWID with chronic physical illnesses had been hospitalized (Binswanger et al., 2008). PWID had an elevated risk of contributing to or causing concurrent medical conditions (e.g., diabetes, high blood pressure, cardiovascular diseases and infective endocarditis) (Binswanger et al., 2008; Rudasill et al., 2019; Stein et al., 2003), which helps explain hospitalization.

The main type of drugs associated with ED use was methamphetamine use. PWID who used methamphetamine were 2.10 more likely to use EDs. Studies have reported 11% (Nambiar, Stoové, & Dietze, 2017) to 30% (Marshall et al., 2012) of PWID who use methamphetamine reported ED use. The association between ED use and methamphetamine has been reported in previous studies (Hendrickson et al., 2008; Marshall et al., 2012), and can be explained by the serious adverse consequences of methamphetamine on health and psychological functioning, which justify ED use (Sommers et al., 2006). ED use might also be explained by the lack of access to other outpatient forms of treatment modalities, or the absence of suitable outpatient treatment programs for PWID who use methamphetamine (Hendrickson et al., 2008). PWID who use cocaine have been reported to have 1.48 times elevated risk of ED use. Studies have also reported that 20% (Palepu et al., 1999) to 47% (Palepu et al., 2001) of those who use cocaine are likely to report ED use. Spanish studies have previously reported a significant relationship between the odds of ED use and cocaine use (Miró et al., 2019; Sanvisens et al., 2021), with one of them reporting a 18% re-admission rate among ED users due to cocaine use (Sanvisens et al., 2021). This confirms an association between cocaine use and severe complications (Butler et al., 2017; Degenhardt et al., 2011). Cocaine users have also been reported as having a higher risk of non-

fatal and fatal overdose compared to those who do not use cocaine (Armoon, Mohammadi, et al., 2021; Armoon, SoleimanvandiAzar, et al., 2022). Moreover, cocaine use in recreational context may lead to accidents or aggressive behaviors that increase risk of ED use (Fulde et al., 2015).

Primary care services were the only service use determinant of ED use. PWID using primary care services had elevated risk of ED use by 1.87 compared to those who did not. Studies have reported that between 57% (Nambiar, Stoové, & Dietze, 2017) and 85% (Palepu et al., 1999) of primary care service users are ED users. This association may be explained by the frequent medical problems reported among many PWID, usually resulting in them using primary care services first. However, many of their acute problems (e.g., overdose) may not be adequately managed in primary care, which consequently leads to referral to EDs or hospitalization. Some risky behaviors among PWID, such as non-fatal overdose and needle sharing, might also require primary healthcare interventions after ED use (Kerr et al., 2005).

Methodological considerations related to results

In the present systematic review and meta-analysis, a number of methodological concerns are worth noting. First, different instruments were used in the studies to assess PWID such as the *International Classification of Diseases* (ninth and tenth revision) in administrative database studies, and the Addiction Severity Index in survey studies. Therefore, it may be difficult to directly compare different types of PWID. Second, variables not reported in more than two studies were not included in the meta-analysis, such as employment status, non-fatal overdose, duration of injection, cannabis use disorders, and use of mental health services. Third, the present study integrated findings from a limited number of selected papers. Considering sociodemographic characteristics, only six studies examined a history of homelessness being associated with ED use and/or hospitalization, only three studies examined being female being associated with ED use,

and only two studies examined a history of physical abuse being associated with ED use. Therefore, interpretation of the results should be exercised with caution. Considering risky behaviors associated with ED use or hospitalization, only six studies examined HIV positive status being associated with ED use and/or hospitalization, only four studies examined injecting drugs more than four times per day being associated with ED use and/or hospitalization, and only two studies examined chronic physical illnesses being associated with hospitalization. There was high heterogeneity among HIV positive status. Therefore, the associations may not be strong. Regarding risky behaviors, the number of studies were especially low, again raising the need to be cautious when interpreting the study's findings.

Considering types of drug use, four studies reported cocaine use disorder, and three studies reported methamphetamine use disorder being associated with ED use, in which high heterogeneity existed among cocaine use disorder. Therefore, this heterogeneity needs to be taken into account when considering the association between use of psychoactive substances and ED use.

Considering service use variables, only four studies were included associated with ED use. Therefore, further studies are needed to confirm the findings here. Finally, in some cases, there was high heterogeneity between studies. This meant several subgroup analyses were applied to decrease the effect of heterogeneity. However, not all sources of heterogeneity could be considered, because with more subgroup analyses, the number of studies in each subgroup decreases. In consequence, a larger number of studies are needed to establish more reliable results.

Conclusions

The present study is the first to integrate determinants related to ED use and hospitalization based on sociodemographic characteristics, risky behaviors, type of drug, and service use determinants among PWID. The finding showed that the most important predictors of ED use or hospitalization were being HIV positives status, methamphetamine users, and having an history of homelessness. A novel finding was that the use of primary care services significantly increased the risk of ED use. Therefore, better collaboration between acute and primary care services is recommended for PWID having HIV positive status or chronic physical illnesses in view to reduce their frequency of ED use. ED liaison nurses in acute care should facilitate referral to addiction treatment centers, especially for patients using cocaine and methamphetamine. ED use and hospitalization of PWID might also be reduced by developing outpatient programs with harm reduction strategies (e.g., safer injecting advice and greater accessibility to sterile needles). Finally, outreach strategies are recommended for PWID having an history of homelessness for improving their overall accessibility to outpatient health care services.

Abbreviations

CI: Confidence intervals

ED: Emergency department

NOS: Newcastle-Ottawa Scale

OR: Odds ratio

PICOs: Population, intervention, comparison, outcome, study design

PRISMA: Protocols of systematic reviews and meta-analyses

PWID: People who inject drugs

References

Archibald, C. P., Ofner, M., Strathdee, S. A., Patrick, D. M., Sutherland, D., Rekart, M. L., Schechter, M. T., & O'Shaughnessy, M. V. (1998). Factors associated with frequent needle exchange program attendance in injection drug users in Vancouver, Canada. *Journal of Acquired Immune Deficiency Syndromes, 17*(2), 160-166. doi: 10.1097/00042560-199802010-00010

Armoon, B., Bayani, A., Griffiths, M. D., Bayat, A.-H., Mohammadi, R., Fattah Moghaddam, L., & Ahounbar, E. (2022). Prevalence and high-risk behaviors associated with non-fatal overdose among people who use illicit opioids: A systematic review and meta-analysis. *Journal of Substance Use, 27*(6), 569-584. doi: 10.1080/14659891.2021.1978112

Armoon, B., Fleury, M.-J., Bayani, A., Mohammadi, R., Ahounbar, E., & Griffiths, M. D. (2022). Suicidal behaviors among intravenous drug users: A meta-analysis. *Journal of Substance Use*, 1-11. doi: 10.1080/14659891.2022.2120435

Armoon, B., Grenier, G., Cao, Z., Huỳnh, C., & Fleury, M.-J. (2021). Frequencies of emergency department use and hospitalization comparing patients with different types of substance or polysubstance-related disorders. *Substance Abuse Treatment, Prevention, and Policy, 16*(1), 89. doi: 10.1186/s13011-021-00421-7

Armoon, B., Higgs, P., & Mohammadi, R. (2021). Mental health status, health service utilization, drug use behaviors associated with non-fatal overdose among people who use illicit drugs: A meta-analysis. *Journal of Substance Use*, 1-12. doi: 10.1080/14659891.2021.2019331

Armoon, B., Mohammadi, R., Fattah Moghaddam, L., & Gonabadi-Nezhad, L. (2021). Type of drug use and risky determinants associated with fatal overdose among people who use drugs: A meta-analysis. *Journal of Substance Use*, 1-11. doi: 10.1080/14659891.2021.2019329

Armoon, B., SoleimanvandiAzar, N., Rostami, M., Higgs, P., Bayani, A., Bayat, A.-H., Mohammadi, R., Ahounbar, E., & Fattah Moghaddam, L. (2022). Drug type and risk behaviors associated with non-fatal overdose among people who use drugs: A systematic review and meta-analysis. *Journal of Addictive Diseases, 40*(1), 114-125. doi: 10.1080/10550887.2021.1950262

Ball, L. J., Puka, K., Speechley, M., Wong, R., Hallam, B., Wiener, J. C., Koivu, S., & Silverman, M. S. (2019). Sharing of injection drug preparation equipment is associated with HIV infection: A cross-sectional study. *Journal of Acquired Immune Deficiency Syndromes, 81*(4), e99-e103. doi: 10.1097/qai.0000000000002062

Beaudoin, F. L., Baird, J., Liu, T., & Merchant, R. C. (2015). Sex differences in substance use among adult emergency department patients: Prevalence, severity, and need for intervention. *Academic Emergency Medicine, 22*(11), 1307-1315. doi: 10.1111/acem.12810

Binswanger, I. A., Takahashi, T. A., Bradley, K., Dellit, T. H., Benton, K. L., & Merrill, J. O. (2008). Drug users seeking emergency care for soft tissue infection at high risk for subsequent hospitalization and death. *Journal of Studies on Alcohol and Drugs, 69*(6), 924-932. doi: 10.15288/jsad.2008.69.924

Brunt, T. M., Lefrançois, E., Gunnar, T., Arponen, A., Seyler, T., Goudriaan, A. E., McAuley, A., McKeown, D. A., Detrez, V., Csorba, J., Deimel, D., Auwärter, V., Kempf, J., Karolak, S., & Nefau, T. (2021). Substances detected in used syringes of injecting drug users across 7 cities in Europe in 2017 and 2018: The European Syringe Collection and Analysis Project Enterprise

(ESCAPE). *International Journal of Drug Policy, 95*, 103130. doi: https://doi.org/10.1016/j.drugpo.2021.103130

Butler, A. J., Rehm, J., & Fischer, B. (2017). Health outcomes associated with crack-cocaine use: Systematic review and meta-analyses. *Drug and Alcohol Dependence, 180*, 401-416. doi: 10.1016/j.drugalcdep.2017.08.036

Chitwood, D. D., Sanchez, J., Comerford, M., & McCoy, C. B. (2001). Primary preventive health care among injection drug users, other sustained drug users, and non-users. *Substance Use & Misuse, 36*(6-7), 807-823. doi: 10.1081/ja-100104092

Degenhardt, L., Singleton, J., Calabria, B., McLaren, J., Kerr, T., Mehta, S., Kirk, G., & Hall, W. D. (2011). Mortality among cocaine users: A systematic review of cohort studies. *Drug and Alcohol Dependence, 113*(2-3), 88-95. doi: 10.1016/j.drugalcdep.2010.07.026

Egger, M., Smith, G. D., Schneider, M., & Minder, C. (1997). Bias in meta-analysis detected by a simple, graphical test. *BMJ, 315*(7109), 629-634. doi: 10.1136/bmj.315.7109.629

Fairbairn, N., Milloy, M.-J., Zhang, R., Lai, C., Grafstein, E., Kerr, T., & Wood, E. (2012). Emergency department utilization among a cohort of HIV-positive injecting drug users in a Canadian setting. *Journal of Emergency Medicine, 43*(2), 236-243. doi: 10.1016/j.jemermed.2011.05.020

Fleury, M.-J., Fortin, M., Rochette, L., Grenier, G., Huỳnh, C., Pelletier, É., & Vasiliadis, H.-M. (2019). Assessing quality indicators related to mental health emergency room utilization. *BMC Emergency Medicine, 19*(1), 8. doi: 10.1186/s12873-019-0223-8

Fulde, G. W. O., & Forster, S. L. (2015). The impact of amphetamine-type stimulants on emergency services. *Current Opinion in Psychiatry, 28*(4), 275-279. doi: 10.1097/yco.0000000000000171

Galarraga, J. E., & Pines, J. M. (2016). Costs of ED episodes of care in the United States. *American Journal of Emergency Medicine, 34*(3), 357-365. doi: 10.1016/j.ajem.2015.06.001

Gentil, L., Grenier, G., & Fleury, M.-J. (2021). Determinants of suicidal ideation and suicide attempt among former and currently homeless individuals. *Social Psychiatry and Psychiatric Epidemiology, 56*(5), 747-757. doi: 10.1007/s00127-020-01952-3

Hendrickson, R. G., Cloutier, R., & McConnell, K. J. (2008). Methamphetamine-related emergency department utilization and cost. *Academic Emergency Medicine, 15*(1), 23-31. doi: 10.1111/j.1553-2712.2007.00006.x

Hope, V., Ncube, F., Parry, J., & Hickman, M. (2015). Healthcare seeking and hospital admissions by people who inject drugs in response to symptoms of injection site infections or injuries in three urban areas of England. *Epidemiology & Infection, 143*(1), 120-131. doi: 10.1017/S0950268814000284

Islam, M. M., Topp, L., Iversen, J., Day, C., Conigrave, K. M., & Maher, L. (2013). Healthcare utilisation and disclosure of injecting drug use among clients of Australia's needle and syringe programs. *Australian and New Zealand Journal of Public Health, 37*(2), 148-154. doi: 10.1111/1753-6405.12032

John, W. S., & Wu, L. T. (2017). Problem alcohol use and healthcare utilization among persons with cannabis use disorder in the United States. *Drug and Alcohol Dependence, 178*, 477-484. doi: 10.1016/j.drugalcdep.2017.05.035

Kendall, C. E., Boucher, L. M., Mark, A. E., Martin, A., Marshall, Z., Boyd, R., Oickle, P., Diliso, N., Pineau, D., & Renaud, B. (2017). A cohort study examining emergency department visits and hospital admissions among people who use drugs in Ottawa, Canada. *Harm Reduction Journal, 14*(1), 16. doi: 10.1186/s12954-017-0143-4

Kerr, T., Kimber, J., DeBeck, K., & Wood, E. (2007). The role of safer injection facilities in the response to HIV/AIDS among injection drug users. *Current HIV/AIDS Reports, 4*(4), 158-164. doi: 10.1007/s11904-007-0023-8

Kerr, T., Wood, E., Grafstein, E., Ishida, T., Shannon, K., Lai, C., Montaner, J., & Tyndall, M. (2005). High rates of primary care and emergency department use among injection drug users in Vancouver. *Journal of Public Health, 27*(1), 62-66. doi: 10.1093/pubmed/fdh189

Kerr, T., Wood, E., Small, D., Palepu, A., & Tyndall, M. W. (2003). Potential use of safer injecting facilities among injection drug users in Vancouver's Downtown Eastside. *Canadian Medical Association Journal, 169*(8), 759-763.

Knowlton, A. R., Hoover, D. R., Chung, S.-e., Celentano, D. D., Vlahov, D., & Latkin, C. A. (2001). Access to medical care and service utilization among injection drug users with HIV/AIDS. *Drug and Alcohol Dependence, 64*(1), 55-62. doi: 10.1016/s0376-8716(00)00228-3

Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics, 33*(1), 159-174.

Latimer, E. A., Rabouin, D., Cao, Z., Ly, A., Powell, G., Aubry, T., Distasio, J., Hwang, S. W., Somers, J. M., & Stergiopoulos, V. (2017). Costs of services for homeless people with mental illness in 5 Canadian cities: A large prospective follow-up study. *Canadian Medical Association Journal Open, 5*(3), E576-E585. doi: 10.9778/cmajo.20170018

Lloyd-Smith, E., Tyndall, M., Zhang, R., Grafstein, E., Sheps, S., Wood, E., Montaner, J., & Kerr, T. (2012). Determinants of cutaneous injection-related infections among injection drug users at an emergency department. *Open Infectious Diseases Journal, 6*, 80176398. doi: 10.2174/1874279301206010005

Lloyd-Smith, E., Wood, E., Zhang, R., Tyndall, M. W., Sheps, S., Montaner, J. S., & Kerr, T. (2010). Determinants of hospitalization for a cutaneous injection-related infection among injection drug users: A cohort study. *BMC Public Health, 10*(1), 1-7. doi: 10.1186/1471-2458-10-327

Mackelprang, J. L., Graves, J. M., & Rivara, F. P. (2014). Homeless in America: injuries treated in US emergency departments, 2007-2011. *International Journal of Injury Control and Safety Promotion, 21*(3), 289-297. doi: 10.1080/17457300.2013.825631

Magwood, O., Salvalaggio, G., Beder, M., Kendall, C., Kpade, V., Daghmach, W., Habonimana, G., Marshall, Z., Snyder, E., O'Shea, T., Lennox, R., Hsu, H., Tugwell, P., & Pottie, K. (2020). The effectiveness of substance use interventions for homeless and vulnerably housed persons: A systematic review of systematic reviews on supervised consumption facilities, managed alcohol programs, and pharmacological agents for opioid use disorder. *PloS One, 15*(1), e0227298. doi: 10.1371/journal.pone.0227298

Marshall, B., Grafstein, E., Buxton, J., Qi, J., Wood, E., Shoveller, J., & Kerr, T. (2012). Frequent methamphetamine injection predicts emergency department utilization among street-involved youth. *Public Health, 126*(1), 47-53. doi: 10.1016/j.puhe.2011.09.011

Mathers, B. M., Degenhardt, L., Phillips, B., Wiessing, L., Hickman, M., Strathdee, S. A., Wodak, A., Panda, S., Tyndall, M., Toufik, A., & Mattick, R. P. (2008). Global epidemiology of injecting drug use and HIV among people who inject drugs: A systematic review. *Lancet, 372*(9651), 1733-1745. doi: 10.1016/s0140-6736(08)61311-2

McDonald, S. A., Hutchinson, S. J., Bird, S. M., Robertson, C., Mills, P. R., Dillon, J. F., & Goldberg, D. J. (2011). Hospitalisation for an alcohol-related cause among injecting drug users in Scotland: Increased risk following diagnosis with hepatitis C infection. *International Journal of Drug Policy, 22*(1), 63-69. doi: 10.1016/j.drugpo.2010.04.003

McGeary, K. A., & French, M. T. (2000). Illicit drug use and emergency room utilization. *Health Services Research, 35*(1 Pt 1), 153-169. doi: https://pubmed.ncbi.nlm.nih.gov/10778828/

Mejia de Grubb, M. C., Salemi, J. L., Gonzalez, S. J., Chima, C. C., Kowalchuk, A. A., & Zoorob, R. J. (2020). Opioid, cocaine, and amphetamine use disorders are associated with higher 30-day inpatient readmission rates in the United States. *Substance Abuse, 41*(3), 365-374. doi: 10.1080/08897077.2019.1635964

Michel, L., Le, S. M., Thi, G. H., Trouiller, P., Thi, H. D., Thi Hai, O. K., Minh, K. P., Vallo, R., Rapoud, D., Quillet, C., Nguyen, T. L., Nguyen, Q. D., NhamThi, T. T., Feelemyer, J., Hai, V. V., Moles, J.-P., Doan, H. Q., Laureillard, D., Des Jarlais, D. C., & Nagot, N. (2022). Assessment of a psychiatric intervention at community level for people who inject drugs in a low-middle income

country: the DRIVE-Mind cohort study in Hai Phong, Viet Nam. *Lancet Regional Health – Western Pacific, 18*, 100337. doi: 10.1016/j.lanwpc.2021.100337

Miró, Ò., Dargan, P. I., Wood, D. M., Dines, A. M., Yates, C., Heyerdahl, F., Hovda, K. E., Giraudon, I., Group, E.-D. P. R., & Galicia, M. (2019). Epidemiology, clinical features and management of patients presenting to European emergency departments with acute cocaine toxicity: Comparison between powder cocaine and crack cocaine cases. *Clinical Toxicology, 57*(8), 718-726. doi: 10.1080/15563650.2019.1613549

Moradi-Joo, M., Ghiasvand, H., Noroozi, M., Armoon, B., Noroozi, A., Karimy, M., Rostami, A., Mirzaee, M. S., & Hemmat, M. (2019). Prevalence of skin and soft tissue infections and its related high-risk behaviors among people who inject drugs: A systematic review and meta-analysis. *Journal of Substance Use, 24*(4), 350-360. doi: 10.1080/14659891.2019.1572805

Nambiar, D., Spelman, T., Stoove, M., & Dietze, P. (2018). Are people who inject drugs frequent users of emergency department services? A cohort study (2008–2013). *Substance Use & Misuse, 53*(3), 457-465. doi: 10.1080/10826084.2017.1341921

Nambiar, D., Stoové, M., & Dietze, P. (2017). Frequent emergency department presentations among people who inject drugs: A record linkage study. *International Journal of Drug Policy, 44*, 115-120. doi: 10.1016/j.drugpo.2017.03.010

Nambiar, D., Stoové, M., Hickman, M., & Dietze, P. (2017). A prospective cohort study of hospital separations among people who inject drugs in Australia: 2008–2013. *BMJ Open, 7*(8), e014854. doi: 10.1136/bmjopen-2016-014854

Noroozi, M., Marshall, B. D., Noroozi, A., Armoon, B., Sharifi, H., Farhoudian, A., Ghiasvand, H., Vameghi, M., Rezaei, O., & Sayadnasiri, M. (2018). Do needle and syringe programs reduce risky behaviours among people who inject drugs in Kermanshah City, Iran? A coarsened exact matching approach. *Drug and Alcohol Review, 37*(Suppl 1), S303-S308. doi: 10.1111/dar.12646

Noroozi, M., Noroozi, A., Sharifi, H., Harouni, G. G., Marshall, B. D., Ghisvand, H., Qorbani, M., & Armoon, B. (2019). Needle and syringe programs and HIV-related risk behaviors among men who inject drugs: A multilevel analysis of two cities in Iran. *International Journal of Behavioral Medicine, 26*(1), 50-58. doi: 10.1007/s12529-018-9758-4

Olubamwo, O. O., Onyeka, I. N., Aregbesola, A., Ronkainen, K., Tiihonen, J., Föhr, J., & Kauhanen, J. (2018). Determinants of hospitalizations for pneumonia among Finnish drug users. *SAGE Open Medicine, 6*, 2050312118784311. doi: 10.1177/2050312118784311

Palepu, A., Horton, N. J., Tibbetts, N., Dukes, K., Meli, S., & Samet, J. H. (2003). Substance abuse treatment and emergency department utilization among a cohort of HIV-infected persons with alcohol problems. *Journal of Substance Abuse Treatment, 25*(1), 37-42. doi: 10.1016/s0740-5472(03)00064-3

Palepu, A., Strathdee, S. A., Hogg, R. S., Anis, A. H., Rae, S., Cornelisse, P. G., Patrick, D. M., O'Shaughnessy, M. V., & Schechter, M. T. (1999). The social determinants of emergency department and hospital use by injection drug users in Canada. *Journal of Urban Health, 76*(4), 409-418. doi: 10.1007/BF02351499

Palepu, A., Tyndall, M. W., Leon, H., Muller, J., O'Shaughnessy, M. V., Schechter, M. T., & Anis, A. H. (2001). Hospital utilization and costs in a cohort of injection drug users. *Canadian Medical Association Journal, 165*(4), 415-420.

Prangnell, A., Imtiaz, S., Karamouzian, M., & Hayashi, K. (2020). Childhood abuse as a risk factor for injection drug use: A systematic review of observational studies. *Drug and Alcohol Review, 39*(1), 71-82. doi: 10.1111/dar.13001

Reddon, H., Pettes, T., Wood, E., Nosova, E., Milloy, M.-J., Kerr, T., & Hayashi, K. (2018). Incidence and predictors of mental health disorder diagnoses among people who inject drugs in a Canadian setting. *Drug and Alcohol Review, 37 Suppl 1*(Suppl 1), S285-S293. doi: 10.1111/dar.12631

Rezaei, O., Ghiasvand, H., Higgs, P., Noroozi, A., Noroozi, M., Rezaei, F., Armoon, B., & Bayani, A. (2020). Factors associated with injecting-related risk behaviors among people who inject drugs: A systematic review and meta-analysis study. *Journal of Addictive Diseases, 38*(4), 420-437. doi: 10.1080/10550887.2020.1781346

Rickards, L. D., McGraw, S. A., Araki, L., Casey, R. J., High, C. W., Hombs, M. E., & Raysor, R. S. (2010). Collaborative initiative to help end chronic homelessness: Introduction. *Journal of Behavioral Health Services & Research, 37*(2), 149-166. doi: 10.1007/s11414-009-9175-1

Rudasill, S. E., Sanaiha, Y., Mardock, A. L., Khoury, H., Xing, H., Antonios, J. W., McKinnell, J. A., & Benharash, P. (2019). Clinical outcomes of infective endocarditis in injection drug users. *Journal of the American College of Cardiology, 73*(5), 559-570. doi: https://doi.org/10.1016/j.jacc.2018.10.082

Ryan, R. (2016). Cochrane Consumers and Communication Group reviews: Meta-analysis. Cochrane handbook for systematic reviews of interventions; Melbourne, Australia: Cochrane Consumers and Communication: http://cccrg.cochrane.org.

Sanvisens, A., Hernández-Rubio, A., Zuluaga, P., Fuster, D., Papaseit, E., Galan, S., Farré, M., & Muga, R. (2021). Long-term outcomes of patients with cocaine use disorder: A 18-years addiction cohort study. *Frontiers in Pharmacology, 12*(111), 625610. doi: 10.3389/fphar.2021.625610

Seitz, N.-N., Lochbühler, K., Atzendorf, J., Rauschert, C., Pfeiffer-Gerschel, T., & Kraus, L. (2019). Trends in substance use and related disorders: Analysis of the epidemiological survey of substance abuse 1995 to 2018. *Deutsches Arzteblatt International, 116*(35-36), 585-591. doi: 10.3238/arztebl.2019.0585

Shapiro, M. F., Morton, S. C., McCaffrey, D. F., Senterfitt, J. W., Fleishman, J. A., Perlman, J. F., Athey, L. A., Keesey, J. W., Goldman, D. P., Berry, S. H., & Bozzette, S. A. (1999). Variations in the care of HIV-infected adults in the United States: Results from the HIV cost and services utilization study. *JAMA, 281*(24), 2305-2315. doi: 10.1001/jama.281.24.2305

Solomon, L., Stein, M., Flynn, C., Schuman, P., Schoenbaum, E., Moore, J., Holmberg, S., & Graham, N. M. (1998). Health services use by urban women with or at risk for HIV-1 infection: The HIV Epidemiology Research Study (HERS). *Journal of Acquired Immune Deficiency Syndromes and Human Retrovirology, 17*(3), 253-261. doi: 10.1097/00042560-199803010-00011

Sommers, I., Baskin, D., & Baskin-Sommers, A. (2006). Methamphetamine use among young adults: Health and social consequences. *Addictive Behaviors, 31*(8), 1469-1476. doi: https://doi.org/10.1016/j.addbeh.2005.10.004

Sørup, C. M., Jacobsen, P., & Forberg, J. L. (2013). Evaluation of emergency department performance - a systematic review on recommended performance and quality-in-care measures. *Scandinavian*

Journal of Trauma, Resuscitation and Emergency Medicine, 21, 62. doi: 10.1186/1757-7241-21-62

Stang, A. (2010). Critical evaluation of the Newcastle-Ottawa scale for the assessment of the quality of nonrandomized studies in meta-analyses. *European Journal of Epidemiology, 25*(9), 603-605. doi: 10.1007/s10654-010-9491-z

Stein, M. D., & Anderson, B. (2003). Injection frequency mediates health service use among persons with a history of drug injection. *Drug and Alcohol Dependence, 70*(2), 159-168. doi: 10.1016/s0376-8716(02)00344-7

Takahashi, T. A., Baernstein, A., Binswanger, I., Bradley, K., & Merrill, J. O. (2007). Predictors of hospitalization for injection drug users seeking care for soft tissue infections. *Journal of General Internal Medicine, 22*(3), 382-388. doi: 10.1007/s11606-006-0079-y

Trillo, A. D., Merchant, R. C., Baird, J. R., Liu, T., & Nirenberg, T. D. (2012). Sex differences in alcohol misuse and estimated blood alcohol concentrations among emergency department patients: Implications for brief interventions. *Academic Emergency Medicine, 19*(8), 924-933. doi: 10.1111/j.1553-2712.2012.01408.x

Tyndall, M. W., Patrick, D., Spittal, P., Li, K., O'Shaughnessy, M. V., & Schechter, M. T. (2002). Risky sexual behaviours among injection drugs users with high HIV prevalence: Implications for STD control. *Sexually Transmitted Infections, 78*(suppl 1), i170-i175.

Viechtbauer, W. (2010). Conducting meta-analyses in R with the metafor package. *Journal of Statistical Software, 36*(3), 1-48. doi: 10.18637/jss.v036.i03

Tables and figure legends:

Table 1: Study characteristics of ED use and hospitalization among PWID

Figure 1: PRISMA flow diagram

Figure 2: The pooled prevalence of emergency department use among people who inject drugs.

Figure 3: The pooled prevalence of hospitalization among people who inject drugs.

Figure 4: Pooled odds ratio of variables associated with emergency department use among people who inject drugs.

Figure 5: Pooled odds ratio of variables associated with hospitalization among people who inject drugs.

Supplementary File 1: Search strategy

Supplementary File 2: Risk of bias assessment using Newcastle-Ottawa Scale

Table 1: Study characteristics on emergency department (ED) use and hospitalization among people who inject drugs

ED use and hospitalization studies	Authors and year of publication	Years (y.) of data collections (number)	Sample at baseline	Final sample size and response rates	Country	Study Design	ED use/hospitalization/both	Diagnostic criteria used	Type of drug injection	Duration (months) of outcome measurements	Reason for ED use and hospitalization	Percentage of ED use / hospitalization: ED use	Percentage of ED use / hospitalization: Hospitalization	Socio-demographic determinants: Being man	Being women	Age <30 years	Higher education	Being employed	History of homelessness	History of physical abuse	Risky behaviors: Incarceration	Injecting>4 times/day	Duration of injection	Require assistance inject	Needle sharing	HIV-positive status	HCV-positive status	Soft tissue infection	Chronic physical illnesses	Non-injury-related diagnosis	Type of drug used: Methamphetamine use	Cocaine use	Cannabis use	Service use variables: Primary care services	Methadone maintenance treatment	Mental health services	Hospital referral	Nonurgent visits
ED use studies (n=9)	Fairbairn et al., 2011	2005-to 08 (4 y.)	437	428 98%	Canada	Cohort	ED use **(Yes/no)**	ICD-9[e]	Heroin and cocaine	12	Any reason	64%							✓✓	✓✓														✓✓				
	Marshall et al., 2012	1996 (1 y.)	427	427 100%	Canada	Cohort	ED use **(Yes/no)**	NA	Polydrug	12	Any reason	38%																			✓✓							
	Lloyd-Smith et al., 2012	1997-2001 (5y.)	1083	1068 99%	Canada	Cohort	ED use **(Yes/no)**	ICD-10[f]	Heroin and cocaine	48	Soft tissue infection	27%												✓		✓✓										✓	
	Palepu et al., 2003	2011 (1 y.)	444	350 79%	Canada	Cohort	ED use **(Yes/no)**	CAGE[g]	Polydrug	6	Alcohol use reason	29%							✓✓																			
	Knowlton et al., 2001	2006-2008 (3 y.)	287	287 100%	USA	Cohort	ED use **(Yes/no)**	NA	NA	6	HIV.AIDS infection	33%														✓✓												

	Islam et al., 2013	2013 (1 y.)	2395	2395 100%	Australia	Cross section	ED use **(Yes/no)**	NA	Polydrug	NA	Any reason	78%									✓																				
	Nambiar et al., 2017	2005-2007 (3 y.)	757	757 100%	Australia	Cohort	Frequent ED use **(Yes/no)** [a]	ICD-10 [f]	NA	12	Any reason	64%		✓		✓															✓									✓
	Nambiar et al., 2017	2008-2013 (6 y.)	688	612 89%	Australia	Cohort	Frequent ED use **(Yes/no)** [a]	AUDIT-C [h]	Poly drug	12	Any reason	58%					✓	✓													✓✓		✓	✓✓	✓	✓				
	Kerr et al., 2004	2004-2008 (5 y.)	941	883 94%	Canada	Cohort	Frequent ED use **(Yes/no)** [b]	NA	Methamphetamine	24	Any reason	60%								✓✓						✓✓					✓✓			✓✓						
Hospitalization studies (n=7)	Hope et al., 2015	2001-2002 (2 y.)	855	855 100%	UK	Cross section	Hospitalization **(Yes/no)**	NA	polydrug	12	Soft tissue infections or injuries		9.5%												✓						✓✓								
	Olubamwo et al, 2018	1997-2013 (16 y.)	4817	4817 100%	Finland	Cohort	Hospitalization **(Yes/no)**	ICD-10 [f]	Polydrug	1	pneumonia		31.9						✓✓			✓✓																	
	Binswanger et al., 2008	2004-2008 (5 y.)	211	156 74%	USA	Cohort	Hospitalization **(Yes/no)**	ASI [i]	NA	12	Soft tissue infection		55%																✓	✓✓							✓		
	Takahashi et al., 2006		147	136 92%	USA	Cohort	Hospitalization **(Yes/no)**	ASI [i]	NA	12	Soft tissue infection		40%						✓✓			✓																	
	Lloyd-Smith et al., 2010		1083	901 83%	Canada	Cohort	Hospitalization **(Yes/no)**	ICD-10 [f]	NA	48	Soft tissue infection		9%													✓✓													

	McDonald et al., 2011		41062	41062 100%	UK	Cohort	Hospitalization **(Yes/no)**	ICD-9 **e**	NA	6	Alcohol use reason		8.1%		✓✓												✓											
	Nambiar et al., 2017	1995-2006 (12 y.)	1892	2106 90%	Australia	Cohort	Frequent Hospitalization **(Yes/no)** **c**	ICD-10 **f**	Heroin or methamphetamine	12	Any reason		29%																					✓					
ED use and hospitalization (n=3)	Stein & Anderson, 2003	2001-2002 (2 y.)	472	472 100%	USA	Cohort	ED use and hospitalization **(Yes/no)**	DSM-III **j**	Heroin and cocaine	6	Any reason	34.5%	13.4%								✓✓									✓✓							
	Palepu et al., 1999	2001 (1 y.)	1103	1103 100%	Canada	Cohort	ED use and hospitalization **(Yes/no)**	NA	Heroin and cocaine	6	Any reason	45%	21%		✓✓				✓✓						✓✓					✓✓		✓✓					
	Palepu et al., 2001	1997-1998 (2 y.)	598	598 100%	Canada	Cohort	Frequent ED use and hospitalization **(Yes/no)** **d**	NA	cocaine	36	Any reason	60.2%	56.2%		✓✓				✓✓		✓✓				✓✓					✓✓							

✓: All variables extracted from studies.

✓✓: Variables are retained in the final model after their inclusion in the meta-analysis.

a: Frequent ED use is defined as 3+ visits in a 12-month period.

b: Frequent ED use is defined as 3+ visits in a 2-years period.

c: Frequent hospitalizations is defined as 2+ stays in a 12-month period.

d: Frequent ED use is defined as 3+ visits and frequent hospitalizations as 2+ stays in the 3-year study period.

e: International Classification of Diseases, Ninth Revision

f: International Classification of Diseases, Tenth Revision

g: Screening tool for diagnosis of alcohol use disorders

h: The Alcohol Use Disorders Identification Test-Concise

i: Addiction Severity Index

j: Diagnostic and Statistical Manual of Mental Disorders, Third Edition

Figure 1: PRISMA flow diagram

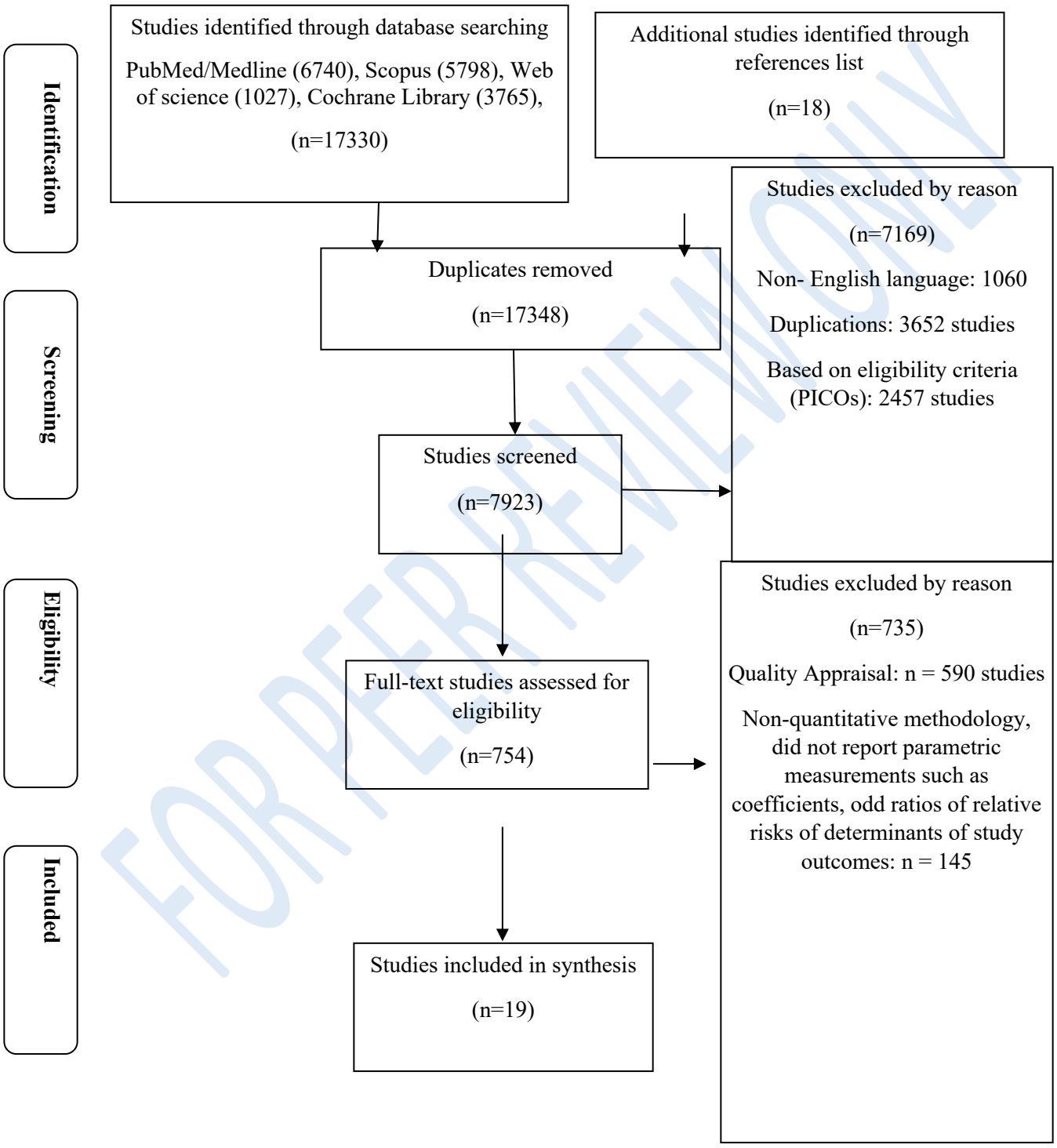


Figure 2: The pooled prevalence of emergency department use among people who inject drugs

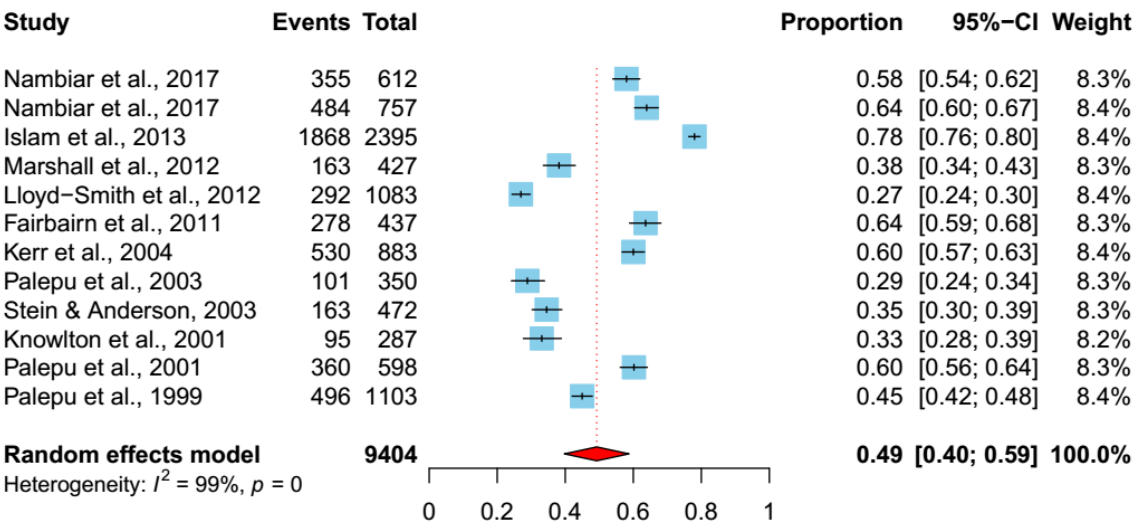


Figure 3: The pooled prevalence of hospitalization among people who inject drugs

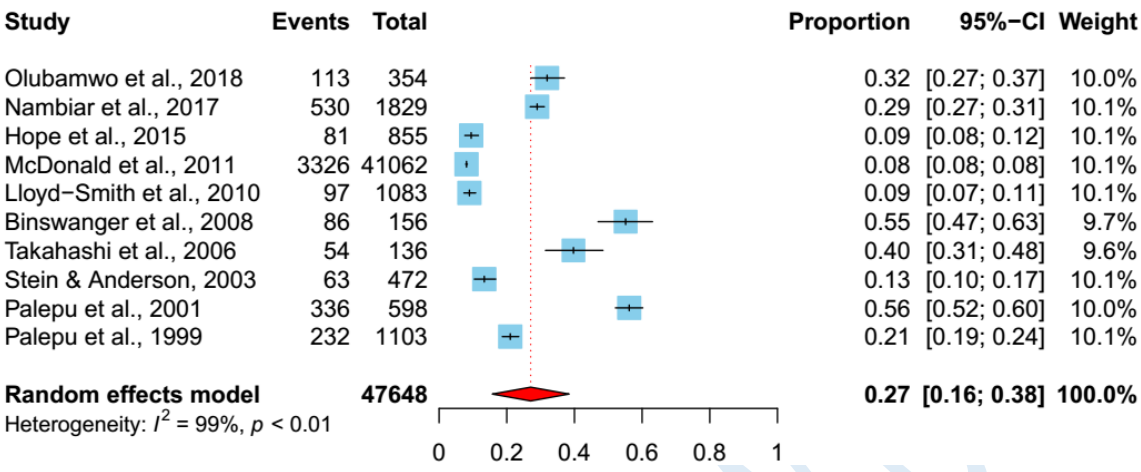


Figure 4: Pooled odds ratio of variables associated with emergency department use among people who inject drugs

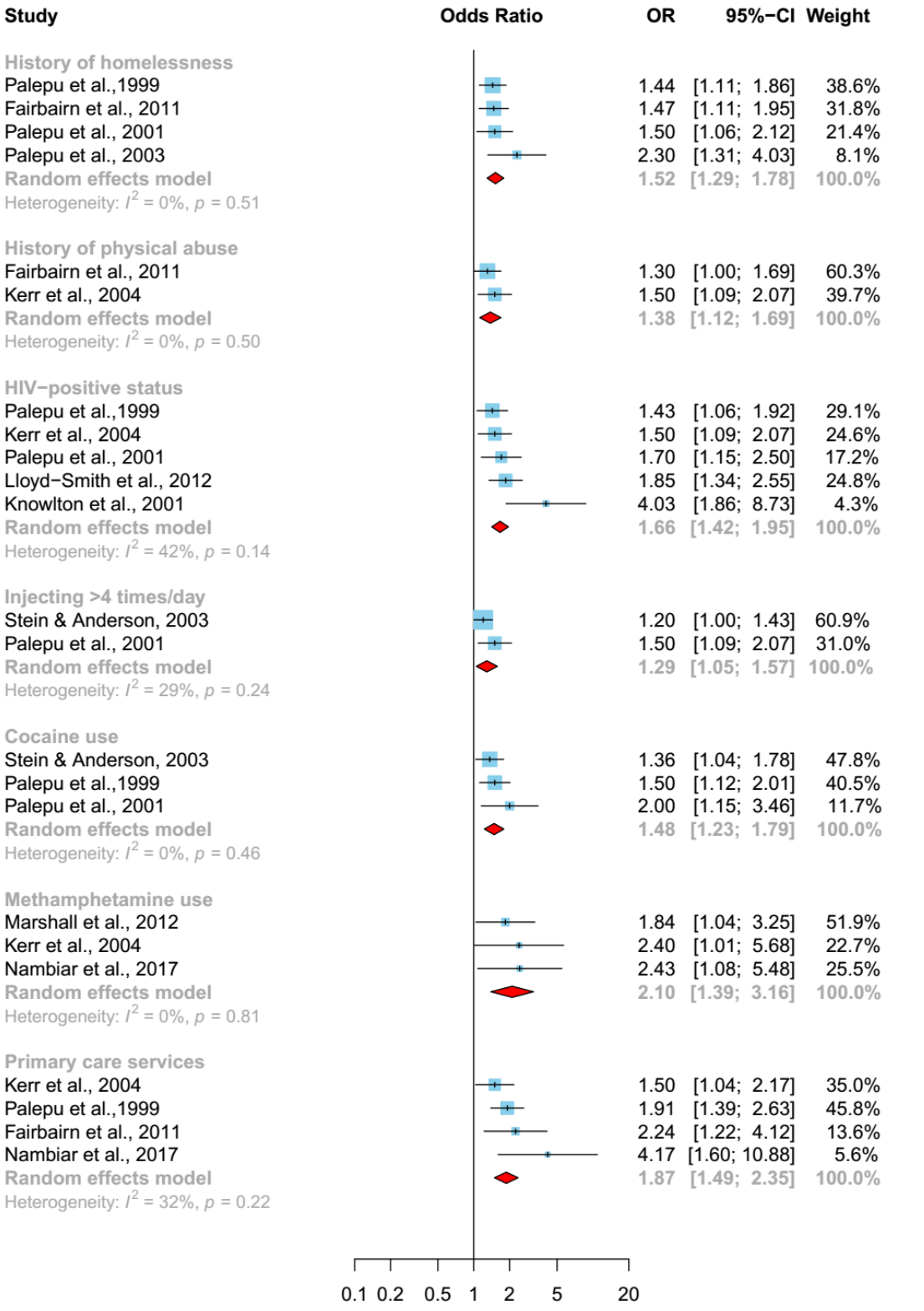
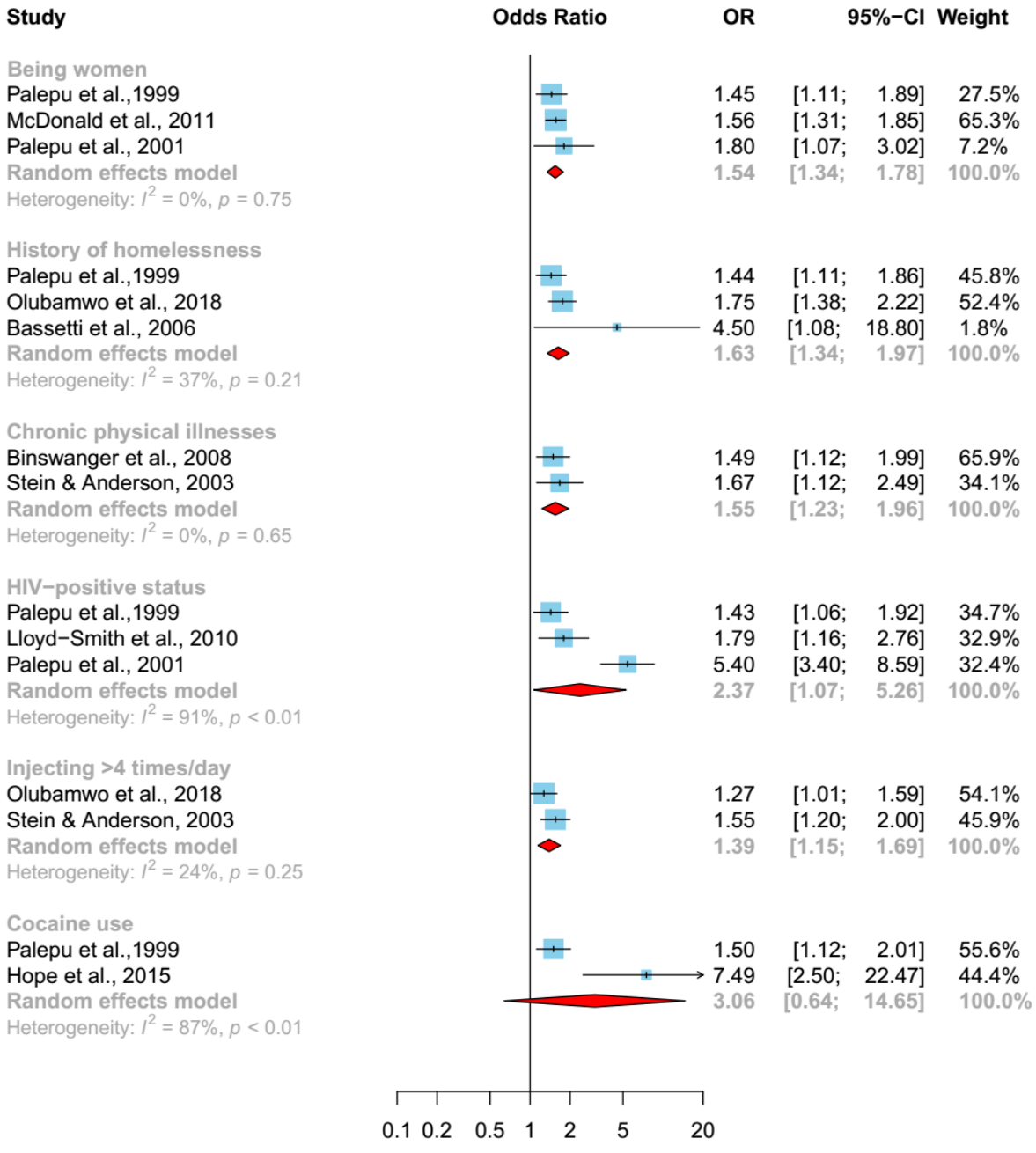


Figure 5: Pooled odds ratio of variables associated with hospitalization among people who inject drugs



Supplementary File 1: Search strategy

Database	Key words
PubMed	#27 (((((((((Ambulatory Care[MeSH Terms]) OR (Inpatients[MeSH Terms])) OR (Health Services Administration[MeSH Terms])) OR (Health Services Accessibility[MeSH Terms])) OR (Emergency Medical Services[MeSH Terms])) OR (Emergency Service, Hospital[MeSH Terms])) OR (("access"[All Fields] OR "accessed"[All Fields] OR "accesses"[All Fields] OR "accessibilities"[All Fields] OR "accessibility"[All Fields] OR "accessible"[All Fields] OR "accessing"[All Fields]) AND "to general practitioner"[Title/Abstract])) OR (General Practitioners[MeSH Terms])) OR (Hospitalization[MeSH Terms])) AND ((((((((((((((((((Injecting drug use[Title/Abstract]) OR (injection drug[Title/Abstract])) OR (injected drug use[Title/Abstract])) OR (inject drug use[Title/Abstract])) OR (People who inject drugs[Title/Abstract])) OR (PWID[Title/Abstract])) OR (Substance-Related Disorders[MeSH Terms])) OR (Substance Abuse, Intravenous[MeSH Terms])) OR (injecting cocaine[Title/Abstract])) OR (injecting cocaine[Title/Abstract])) OR (inject methamphetamine[Title/Abstract])) OR (injecting heroin[Title/Abstract])) OR (Morphine injection[Title/Abstract])) OR (opioid injection[Title/Abstract])) OR (Injecting Heroin[Title/Abstract]))) OR (Morphine injection[Title/Abstract])) OR (opioid injection[Title/Abstract])) OR (Ativan Injection[Title/Abstract])) OR (benzodiazepine injection[Title/Abstract])) #26 (((((((Ambulatory Care[MeSH Terms]) OR (Inpatients[MeSH Terms])) OR (Health Services Administration[MeSH Terms])) OR (Health Services Accessibility[MeSH Terms])) OR (Emergency Medical Services[MeSH Terms])) OR (Emergency Service, Hospital[MeSH Terms])) OR (("access"[All Fields] OR "accessed"[All Fields] OR "accesses"[All Fields] OR "accessibilities"[All Fields] OR "accessibility"[All Fields] OR "accessible"[All Fields] OR "accessing"[All Fields]) AND "to general practitioner"[Title/Abstract])) OR (General Practitioners[MeSH Terms])) OR (Hospitalization[MeSH Terms]) #25 ((((((((((((((((((Injecting drug use[Title/Abstract]) OR (injection drug[Title/Abstract])) OR (injected drug use[Title/Abstract])) OR (inject drug use[Title/Abstract])) OR (People who inject drugs[Title/Abstract])) OR (PWID[Title/Abstract])) OR (Substance-Related Disorders[MeSH Terms])) OR (Substance Abuse, Intravenous[MeSH Terms])) OR (injecting cocaine[Title/Abstract])) OR (injecting cocaine[Title/Abstract])) OR (inject methamphetamine[Title/Abstract])) OR (injecting heroin[Title/Abstract])) OR (Morphine injection[Title/Abstract])) OR (opioid injection[Title/Abstract])) OR (Injecting Heroin[Title/Abstract]))) OR (Morphine injection[Title/Abstract])) OR (opioid injection[Title/Abstract])) OR (Ativan Injection[Title/Abstract])) OR (benzodiazepine injection[Title/Abstract]) #24 Hospitalization[MeSH Terms] #23 General Practitioners[MeSH Terms] #22 Emergency Service, Hospital[MeSH Terms]

	#21 Emergency Medical Services[MeSH Terms] #20 Health Services Accessibility[MeSH Terms] #19 Health Services Administration[MeSH Terms] #18 Inpatients[MeSH Terms] #17 Ambulatory Care[MeSH Terms] #16 benzodiazepine injection[Title/Abstract] #15 Ativan Injection[Title/Abstract] #14 Injecting Heroin[Title/Abstract] #13 opioid injection[Title/Abstract] #12 Morphine injection[Title/Abstract] #11 injecting heroin[Title/Abstract] #10 inject methamphetamine[Title/Abstract] #9 injecting cocaine[Title/Abstract] #8 Substance Abuse, Intravenous[MeSH Terms] #7 Substance-Related Disorders[MeSH Terms] #6 PWID[Title/Abstract] #5 People who inject drugs[Title/Abstract] #4 inject drug use[Title/Abstract] #3 injected drug use[Title/Abstract] #2 injection drug[Title/Abstract] #1 Injecting drug use[Title/Abstract]
Scopus	#1 TITLE-ABS-KEY (injecting AND drug AND use) #2 TITLE-ABS-KEY (injection AND drug) #3 TITLE-ABS-KEY (injected AND drug AND use) #4 TITLE-ABS-KEY (inject AND drug AND use) #5 TITLE-ABS-KEY (people AND who AND inject AND drugs) #6 TITLE-ABS-KEY (pwid) #7 TITLE-ABS-KEY (substance-related AND disorders) #8 TITLE-ABS-KEY (substance AND abuse, AND intravenous) #9 TITLE-ABS-KEY (injecting AND cocaine) #10 TITLE-ABS-KEY (inject AND methamphetamine) #11 TITLE-ABS-KEY (injecting AND heroin) #12 TITLE-ABS-KEY (morphine AND injection) #13 TITLE-ABS-KEY (opioid AND injection) #14 TITLE-ABS-KEY (injecting AND heroin) #15 TITLE-ABS-KEY (ativan AND injection) #16 TITLE-ABS-KEY (benzodiazepine AND injection) #17 TITLE-ABS-KEY (ambulatory AND care) #18 TITLE-ABS-KEY (inpatients) #19 TITLE-ABS-KEY (health AND services AND administration) #20 TITLE-ABS-KEY (health AND services AND accessibility) #21 TITLE-ABS-KEY (emergency AND medical AND services) #22 TITLE-ABS-KEY (emergency AND service, AND hospital) #23 TITLE-ABS-KEY (general AND practitioners) #24 TITLE-ABS-KEY (hospitalization)

	#25 #1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13 OR #14 OR #15 OR #16 #26 #17 OR #18 OR #19 OR #20 OR #21 OR #22 OR #23 OR #24 #27 #25 AND #26S
Web of Knowledge	TS=(Injecting drug use OR injection drug OR injected drug use OR inject drug use OR People who inject drugs OR PWID OR Substance-Related Disorders OR Substance Abuse, Intravenous OR injecting cocaine OR inject methamphetamine OR injecting heroin OR Morphine injection OR opioid injection OR Ativan Injection OR benzodiazepine injection) AND TS=(Ambulatory Care OR Inpatients OR Health Services Administration OR Health Services Accessibility OR Emergency Medical Services OR Emergency Service, Hospital OR General Practitioners OR Hospitalization)
Cochrane	#1 ("injecting drug use"):ti,ab,kw #2 (injection drug):ti,ab,kw #3 (injected drug use):ti,ab,kw #4 (People who inject drugs):ti,ab,kw #5 (PWID):ti,ab,kw #6 MeSH descriptor: [Substance-Related Disorders] explode all trees #7 MeSH descriptor: [Substance Abuse, Intravenous] explode all trees #8 (injecting cocaine):ti,ab,kw #9 (inject methamphetamine):ti,ab,kw #10 (injecting heroin):ti,ab,kw #11 (Morphine injection):ti,ab,kw #12 (opioid injection):ti,ab,kw #13 (Injecting Heroin):ti,ab,kw #14 (Ativan Injection):ti,ab,kw #15 (benzodiazepine injection):ti,ab,kw #16 MeSH descriptor: [Ambulatory Care] explode all trees #17 MeSH descriptor: [Inpatients] explode all trees #18 MeSH descriptor: [Outpatients] explode all trees #19 MeSH descriptor: [Health Services Administration] explode all trees #20 MeSH descriptor: [Health Services Accessibility] explode all trees #21 MeSH descriptor: [Emergency Medical Services] explode all trees #22 MeSH descriptor: [Emergency Service, Hospital] explode all trees #23 MeSH descriptor: [General Practitioners] explode all trees #24 MeSH descriptor: [Hospitalization] in all MeSH products #25 #1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13 OR #14 OR #15 #26 #16 OR #17 OR #18 OR #19 OR #20 OR #21 OR #22 OR #23 OR #24 #27 #25 AND #26

Supplementary File 2: Risk of bias assessment using Newcastle-Ottawa Scale

Study	Selection (***●)	Comparability (*)	Exposure/outcome (*●●)	Method of assessment	Quality Assessment
Fairbairn et al., 2011	**	*	*●●	Newcastle-Ottawa Scale adapted for cohort studies	Good
Nambiar et al., 2017	***●	*	*●	Newcastle-Ottawa Scale adapted for cohort studies	Very Good
Nambiar et al., 2017	*	*	*●	Newcastle-Ottawa Scale adapted for cohort studies	Satisfactory
Kerr et al., 2004	**●	*	*●	Newcastle-Ottawa Scale adapted for cohort studies	Good
Marshall et al., 2012	**●		*●●	Newcastle-Ottawa Scale adapted for cohort studies	Good
Lloyd-Smith et al., 2012	**●●	*	*●	Newcastle-Ottawa Scale adapted for cohort studies	Very Good
Palepu et al., 1999	**●	*	*●	Newcastle-Ottawa Scale adapted for cohort studies	Good
Palepu et al., 2001	**●	*	*●	Newcastle-Ottawa Scale adapted for cohort studies	Good
Palepu et al., 2003	***●	*	*●●	Newcastle-Ottawa Scale adapted for cohort studies	Very Good
Knowlton et al., 2001	***●	*	*●	Newcastle-Ottawa Scale adapted for cohort studies	Very Good
Stein & Anderson, 2003	***		*	Newcastle-Ottawa Scale adapted for cohort studies	Satisfactory
Islam et al., 2013	**	*	*	Newcastle-Ottawa Scale adapted for	Good

				cross-sectional studies	
Hope et al., 2015	***	*	*	Newcastle-Ottawa Scale adapted for cohort studies	Very Good
Binswanger et al., 2008	**•	*	*•	Newcastle-Ottawa Scale adapted for cohort studies	Good
Nambiar et al., 2017	***•	*	*•	Newcastle-Ottawa Scale adapted for cohort studies	Very Good
Olubamwo et al, 2018	***•	*	*	Newcastle-Ottawa Scale adapted for cohort studies	Good
Takahashi et al., 2006	***•	*	*•	Newcastle-Ottawa Scale adapted for cohort studies	Very Good
Lloyd-Smith et al., 2010	**	*	**	Newcastle-Ottawa Scale adapted for cohort studies	Satisfactory
McDonald et al., 2011	**	*	**	Newcastle-Ottawa Scale adapted for cohort studies	Satisfactory

∗: For cross-section studies

•: For cohort studies