



Pierce, M., Bird, S. M., Hickman, M., Marsden, J., Dunn, G., Seddon, T., & Millar, T. (2018). Effect of initiating drug treatment on the risk of drug-related poisoning death and acquisitive crime among offending heroin users. *International Journal of Drug Policy*, 51, 42-51.  
<https://doi.org/10.1016/j.drugpo.2017.09.017>

Publisher's PDF, also known as Version of record

License (if available):  
CC BY

Link to published version (if available):  
[10.1016/j.drugpo.2017.09.017](https://doi.org/10.1016/j.drugpo.2017.09.017)

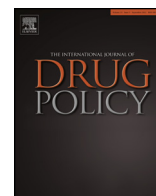
[Link to publication record on the Bristol Research Portal](#)  
PDF-document

This is the final published version of the article (version of record). It first appeared online via Elsevier at <https://www.sciencedirect.com/science/article/pii/S0955395917302955> . Please refer to any applicable terms of use of the publisher.

## University of Bristol – Bristol Research Portal

### General rights

This document is made available in accordance with publisher policies. Please cite only the published version using the reference above. Full terms of use are available:  
<http://www.bristol.ac.uk/red/research-policy/pure/user-guides/brp-terms/>



## Research paper

## Effect of initiating drug treatment on the risk of drug-related poisoning death and acquisitive crime among offending heroin users



Matthias Pierce<sup>a,\*</sup>, Sheila M. Bird<sup>b</sup>, Matthew Hickman<sup>c</sup>, John Marsden<sup>d</sup>, Graham Dunn<sup>a</sup>, Toby Seddon<sup>e</sup>, Tim Millar<sup>a</sup>

<sup>a</sup> School of Health Sciences, Faculty of Biology, Medicine and Health, University of Manchester, UK

<sup>b</sup> MRC Biostatistics Unit at University of Cambridge School of Clinical Medicine, Cambridge, UK

<sup>c</sup> School of Social and Community Medicine, University of Bristol, UK

<sup>d</sup> Addictions Department, Institute of Psychiatry, Psychology and Neuroscience, King's College London, UK

<sup>e</sup> School of Law, University of Manchester, UK

## ARTICLE INFO

## Article history:

Received 7 June 2017

Received in revised form 17 August 2017

Accepted 26 September 2017

Available online xxx

## Keywords:

Heroin users

Treatment

Offending

Acquisitive offending

Drug-related poisoning death

Observational study

## ABSTRACT

**Background:** A recent Cochrane review of randomised trials identified a lack of evidence for interventions provided to drug-using offenders. We use routine data to address whether contact with treatment services reduces heroin users' likelihood of a future acquisitive offence or drug-related poisoning (DRP) death.

**Methods:** Heroin-users were identified from probation assessments and linked to drug-treatment, mortality and offending records. The study cohort was selected to ensure that the subject was not: in prison, in treatment or had recently left treatment. Subjects were classed as initiators if they attended a triage appointment within two weeks of their assessment; non-initiators otherwise. Initiator and non-initiators were compared over a maximum of one year, with respect to their risk of recorded acquisitive offence or DRP-death. Balance was sought using propensity score matching and missing data were accounted for using multiple imputation.

**Results:** Nine percent of assessments identified for analysis were classed as initiators. Accounting for observed confounding and missing data, there was a reduction in DRPs associated with initiator assessments, however there was uncertainty around this estimate such that a null-effect could not be ruled out (HR: 0.42, 95% CI 0.17–1.04). There was no evidence of a decrease in the recidivism risk, in fact the analysis showed a small increase (HR: 1.10, 95% CI 1.02–1.18).

**Conclusion:** For heroin-using offenders, initial contact with treatment services does not appear to reduce the likelihood of a future acquisitive offence.

© 2017 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

## Introduction

Endemic heroin use is associated with significant public health and social problems (UN Office On Drugs and Crime, 2010): in particular, high rates of mortality (Degenhardt et al., 2013; Pierce, Bird, Hickman, & Millar, 2015) and acquisitive offending (Bennett, Holloway, & Farrington, 2008; Pierce, Hayhurst et al., 2015). In the UK, structured addiction treatment is commissioned with the aim of reducing users' dependence on illicit drugs and minimizing the harms associated with these drugs, including premature death and offending (Home Office, 2010). The front-line intervention offered

for heroin dependence is opioid substitution therapy (OST) with methadone or buprenorphine (National Treatment Agency for Substance Misuse, 2006). Psychological support is also available but recommended only as an adjunct to OST (National Treatment Agency for Substance Misuse, 2006). In the UK, the treatment pathway for patients with heroin dependence is determined during a triage appointment with a drugs key-worker (National Treatment Agency for Substance Misuse, 2006).

In medical and social research, randomised controlled trials (RCT's) are considered optimal for assessing the effectiveness of an intervention (Campbell, Stanley, & Gage, 1966). However, RCTs and meta-analysis of interventions provided for heroin users have been underpowered to detect changes in mortality or offending and usually focus on intermediate outcomes such as reduced illicit opioid use and treatment retention (Amato et al., 2013; Amato, Minozzi, Davoli, & Vecchi, 2011a; Amato, Minozzi, Davoli, & Vecchi,

\* Corresponding author at: Centre for Biostatistics, Faculty of Biology, Medicine and Health, University of Manchester, 1st Floor, Jean McFarlane Building, Oxford Road, M13 9PL, UK.

E-mail address: [matthias.pierce@manchester.ac.uk](mailto:matthias.pierce@manchester.ac.uk) (M. Pierce).

2011b; Mattick, Breen, Kimber, & Davoli, 2009; Mattick, Breen, Kimber, & Davoli, 2014). For example, a recent meta-analysis of RCTs for OST offered for heroin-using offenders was unable to detect an effect on future arrests (1 study, 62 subjects, RR: 0.60, 95% CI: 0.32–1.14) or incarceration (3 studies, 472 subjects, RR: 0.77, 95% CI: 0.36–1.64) (Perry et al., 2015).

Cohorts identified from routinely collected data can provide the necessary power to investigate rarer outcomes (Bird, 2008). Many studies of addiction treatment aim to quantify the effect of being treated by contrasting periods in and out of treatment. However, this will be a biased comparison if there are non-random reasons for why patients leave treatment which are related to the outcome under consideration. To account for this confounding bias, confounding variables should be measured over follow-up; however, such information is rarely available or incomplete. This problem can be avoided by analysing subjects according to initial treatment status – something closer to the intention to treat principle routinely used in randomised controlled trials. Treatment and control subjects can then be balanced prior to follow-up, using propensity score methods.

This study used a large, observational, record-linkage dataset from England, to analyse the effect of initiating drug-treatment on subsequent offending and mortality. We focus on the effect of initiating treatment, ignoring the fact that many who begin treatment may drop-out early. Therefore, our study aims to quantify the impact of a policy where everybody with heroin dependence attends a triage appointment. The study is designed to best emulate what would have occurred during an RCT – an approach that has been recommended in pioneering work from other areas of clinical research (Danaei, Rodriguez, Cantero, Logan, & Hernan, 2013; Hernan et al., 2008; Toh & Manson, 2013).

We use this design to investigate two hypotheses: for heroin users identified in the criminal justice system, does initiating contact with treatment services reduce the risk of: (a) a future drug-related poisoning death and (b) a recorded acquisitive offence.

## Methods

A cohort of heroin users was identified from probation (offender management) assessments, using inclusion and exclusion criteria. Following an eligible probation assessment, if subjects were recorded in treatment data as attending a triage appointment within two weeks they were classed as an *initiator*; otherwise they were classed as a *non-initiator*. Outcome events were defined as a drug-related poisoning (DRP) death or a day when the subject committed a recorded acquisitive offence over a maximum of one-year. Time-to-outcome was compared between initiators and non-initiators, irrespective of future treatment status. Balance between initiators and non-initiators was sought by matching on propensity scores calculated using an extensive set of baseline covariates available from probation assessment and historical offending records.

## Datasets

Data were extracted from the Drug Data Warehouse – a collection of case-linked national datasets on substance users in England, covering the period 1st April 2005 to 31st March 2009 (Millar et al., 2012).

The analysis cohort was identified from probation assessments recorded on the Offender Assessment System (OASys) database. OASys contains information from a structured interview between offender and probation officer with the aim of assessing an offender's recidivism risk and to identify particular needs (National Probation Services, 2003). This assessment can form part of a pre-

sentence report, to aid the judge's sentencing decision, or can be used to help probation services manage offenders post-sentence, for example after release from prison on licence (i.e. serving the remainder of a sentence in the community, under regular supervision by probation services).

Treatment data were obtained from the National Drug Treatment Monitoring System (NDTMS). NDTMS collects data on contact between substance-use disorder patients and structured treatment delivered by National Health Service and third-sector providers, which together account for almost all such provision in England. When a substance-use disorder patient initially contacts treatment services they undergo a triage appointment with a key-worker. The aim of this appointment is to assess the patient's needs and determine the most appropriate treatment. After this appointment, clients may be offered treatment within the assessing treatment agency, or onward referral to another service.

Details of sanctioned offending were determined through Police National Computer (PNC) records, for all offences that occurred since the age of ten, and resulted in a conviction, caution, warning or reprimand. A death occurring over follow-up was established from national mortality records.

Linkage was done based on a minimal identifier (initials, date of birth and gender). Additionally, criminal-justice system databases included an individually unique CJS identifier. Due to data release requirements, instances where more than one CJS identifier linked to a single minimal identifier were removed because this provided evidence that multiple subjects shared the latter details. This affected 33.6% of assessments in OASys and these were dropped from the analysis. Identifiers were fully anonymised prior to their release to the study team.

## Inclusion/exclusion criteria

Probation records were included in the analysis cohort provided the interviewed subject: was assessed between April 1 2005 and March 1 2009; reported weekly or more frequent use of heroin (by any route of administration); was aged 18–64 years. After resulted in 117,044 assessments (see Fig. 1).

A priori criteria were established so that, in turn, probation records were excluded from the study if:

- (i) The assessment was for a pre-sentence report which was associated with a subsequent prison sentence ( $n = 22,097$ )

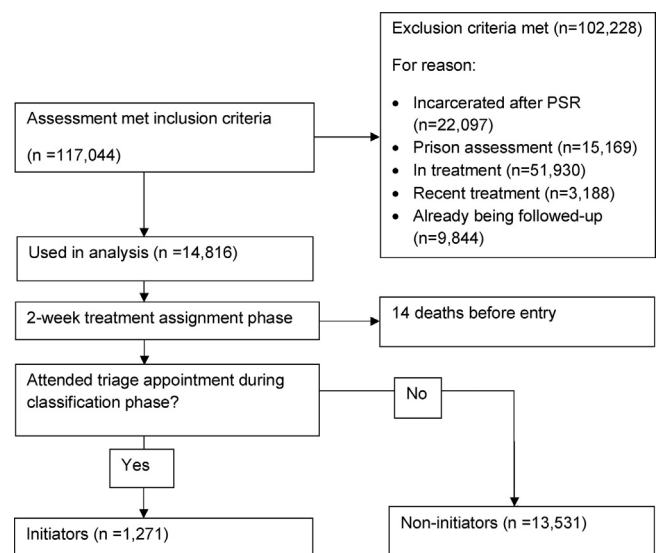


Fig. 1. Flow-chart of selection of probation assessments into the analysis cohort.

- (ii) The assessment was post-sentence but carried out in prison (n = 15,169)
- (iii) The subject was already in treatment at the time of their probation assessment (n = 51,930)
- (iv) The subject had left treatment in the four weeks prior to their probation assessment (n = 3188)
- (v) The subject was already in the study at the time of assessment via a previous assessment (n = 9844)

The rationale for these exclusion criteria were: (i and ii) time incarcerated will be associated with lower DRPs, due to restricted access to drugs, and (naturally) offending risk and our data did not include date of prison release; (iii) the focus of the analysis is on the effect of initiating treatment, not on the effect of having been in treatment for some time; (iv) the four weeks following treatment cessation are known to confer elevated overdose risk (Pierce, Bird, et al., 2016) and so this cut-off was chosen as a wash-out period, prior to subsequent treatment; (v) was to ensure that no person could be entered into the analysis if they were already under observation.

#### Exposure definition

We designated a two-week *classification phase* that followed an eligible probation assessment. During this period, if the subject attended a triage appointment for opioid misuse treatment, as recorded in NDTMS data, they were classified as an *initiator* and the remainder who did not have any treatment contact were defined as a *non-initiator*. This two week cut-off was chosen by members of the research team, prior to analysis, as it was considered that a shorter period missed too many initiators, and a longer period would mean that the variables collected at the assessment would no longer be relevant.

Fourteen deaths occurred during the classification phase and these were excluded from analysis. Follow-up began after this period and ended on the earliest date of: the outcome under consideration, the end of data collection (31st March 2009), death from any cause, or one year after baseline assessment. The resulting analysis dataset consisted of 14,802 assessments (13,204 individuals).

#### Outcome definitions

An acquisitive-offence event was defined using the offence date, recorded in the PNC, for sanctioned offences with an offence code identifying the crime categories: theft, fraud and forgery, burglary, robbery, drug supply (including intent to supply) and prostitution. The PNC does not differentiate between drug-supply for material gain and 'social supply', whereby drugs are shared between individuals. Inclusion of drug-supply in the definition of 'acquisitive offences' is intended to increase its sensitivity, at the cost of some specificity. A fatal drug-related poisoning (DRP) was defined according to the UK harmonised definition (Office for National Statistics, 2016) using the ICD-10 code (World Health Organization, 2010) for the underlying cause of death.

#### Propensity scores

Propensity scores give the probability of a subject being an *initiator*, conditional on a set of baseline covariates. If the model used to predict propensity scores is correctly specified, then the covariates will be evenly distributed between subjects with the same propensity score. It follows that if all possible confounders are used to predict the propensity score – that is all factors are identified which can influence both self-classification and outcome – then the contrast between initiator and non-initiators with the

same propensity score will be unconfounded (Rosenbaum & Rubin, 1985).

Propensity scores were calculated using a logistic regression model which included variables available in the OASys system or calculated from historical PNC records. For ease of presentation, these covariates were grouped into eight types: demographic; relating to the assessment; relating to the current offence; drug use; alcohol use; employment and housing; mental and physical wellbeing; and offending history. All identified covariates were used to calculate the propensity scores. A description of each covariate is available in Appendix A in Supplementary material.

#### Propensity score matching and assessing balance

Once propensity scores were calculated, the variable matching approach recommended in Rassen et al. (2012) was adopted, with up to five *non-initiators* selected for each *initiator*. The matching algorithm is described in detail in Appendix B in Supplementary material. The calliper distance was set as 20% of the standard deviation of the logit of the propensity scores (Austin, 2011a).

Balance for each covariate, both prior to and post matching, was assessed using its standardised distance between *initiator* and *non-initiators*. This was calculated for each *initiator* assessment's worst match (i.e. the match with the greatest propensity score distance) to get a conservative measure of balance. The resulting model was considered poorly balanced if the standardised difference between pairs was >10% of the standard deviation (Austin, 2011b).

#### Analysis model

Proportional hazard models were fitted, contrasting the time to event (acquisitive crime or DRP) between *initiators* and *non-initiators*. Subjects entered the risk set after the classification phase (i.e. two week's post-assessment). Multiple assessments belonging to the same individual were accounted for by adjusting the standard errors using the Huber-White sandwich estimator.

The same propensity score matched groups were used for the analyses of both outcomes. The matched sample was analysed by stratifying the Cox model on each matched group. *Non-initiators* were given weights equal to the inverse of the number of *non-initiators* in that matched group. For example, within a group with a matching ratio of 1:4 each *non-initiator* would be given  $\frac{1}{4}$  weights and the *initiator* was given a weight of one. The Schoenfeld residuals were examined for departures from proportional hazards.

#### Missing data

Thirty percent (4480/14,802) of assessments in the analysis dataset had missing data for at least one of the baseline covariates used to calculate the propensity score. Initially those with missing data were excluded from the matched analysis. To account for potential selection bias in this approach, those with missing information were incorporated into the analysis using multiple imputation (ICE command, Stata 13) (Royston & White, 2011). Missing data distributions were calculated using all variables in Appendix A in Supplementary material, plus indicators for being an *initiator* and whether the subject had a death or an offence over follow-up. Ten imputed datasets were constructed and a propensity score model was fitted to each. The multiple imputation propensity score was taken as the mean of these and the matching process was repeated (Hill, 2004).

#### Sensitivity analysis

A planned sensitivity analysis was conducted to test the robustness of the results to one element of the study design: the

definition of an *initiator*. This was performed by changing the length of the classification phase from two weeks to one week and then four weeks.

## Results

There were 14,802 assessments identified for analysis and 12,948 person years of follow-up (Table 1). Nine percent of assessments (1271) were classed as *initiators*.

Prior to matching, the standardised difference between *initiators* and *non-initiators* was small for many covariates (Table 2). For example, *initiators* had a similar proportion of women and a similar mean age to *non-initiators*. There were differences with respect to the purpose of the baseline assessment: *initiators* were more likely to have been assessed as the result of a pre-sentence report, rather than a sentence review or start of their release on licence. *Initiators* were also more likely to be daily users of heroin and less likely to have declared alcohol use as a significant problem.

Overall there was good overlap of propensity scores between *initiators* and *non-initiators*, implying that there was good availability of potential matches (Fig. 2). Following multiple imputation, to account for missing data, 95% of *initiators* (1201) and 37% of *non-initiators* (5047) were included in the analysis dataset.

After matching, all standardised differences were within the pre-specified 10% threshold, indicating that the propensity score matching approach was successful in achieving covariate balance between *initiators* and *non-initiators* (Table 2). Therefore, further models which included interactions and higher order terms were judged unnecessary.

### Drug-related poisoning risk initiators vs. non-initiators

There were 84 DRPs over follow-up, resulting in a mortality rate of 6.5 DRPs per 1000 person years (95% CI: 5.2–8.0). The rate of DRPs for *initiators* was less than half that for *non-initiators* (Table 3). In the unmatched proportional hazard analysis, there was insufficient evidence to conclude a reduction in DRP following *initiator*-assessments ( $p=0.12$ ). In the matched analyses there was modest evidence of a reduction in DRP deaths ( $p=0.06$ ).

### Acquisitive offending risk initiators vs. non-initiators

The overall rate of recorded acquisitive offences was 0.91 per person year (95% CI: 0.86–0.96). The risk of an acquisitive offence was 22% higher following *initiator* assessments than following *non-*

*initiator* assessments (Table 4). In the matched analysis, the difference narrowed to 8%, and then 10% after multiple imputation.

### Sensitivity analyses

Changing the length of the classification phase from two weeks to one week or four weeks did not substantially change the estimates with respect to DRPs or acquisitive offences, although the  $p$ -values for the DRP analysis got larger (Appendix C in Supplementary material).

## Discussion

There was a modestly significant reduction in DRP deaths associated with *being an initiator* that is consistent with the hypothesis that initial treatment contact is effective in reducing DRP deaths. However, the current study, in isolation, cannot establish this due to a lack of statistical power, as indicated by the wide confidence intervals. In contrast, the study found that, after adjusting for observed confounding, *initiators* had a ten percent higher offending rate, with lower 95% confidence interval close to neutrality. This result is at odds with the hypothesis that treatment contact is effective at reducing offending for offending-heroin users.

The study was designed to emulate elements of a controlled trial: using eligibility criteria; balancing groups at baseline; and analysing groups as treatment was initially planned, regardless of future treatment status. A large proportion of assessments were excluded from the analysis, mostly because, at the time of their assessment, the subject was already in treatment or they were incarcerated. These exclusion criteria were purposefully established, prior to analysis, to focus the study on the question: for heroin users identified from community probation, what is the effect of initiating contact with drug treatment services on future DRP mortality/acquisitive offending? Adopting eligibility criteria matches what occurs in randomised trials and has been recommended for wider use in observational research (Danaei et al., 2013; Hernan et al., 2008).

Diagnostics showed that propensity score matching provided a cohort where the *initiator* and *non-initiator* assessments were balanced on observed covariates. However, we cannot rule out residual confounding because either: (i) there are further unobserved variables which explain group differences and are also related to outcome; or (ii) the covariates were poorly measured so that they failed sufficiently to capture the true difference.

**Table 1**

Summary of key statistics, initiators and non-initiators.

| Statistic   | Initiators |                | Non-initiators |                |
|---|------------|----------------|----------------|----------------|
|   | N          | % <sup>*</sup> | N              | % <sup>*</sup> |
| Number of people  | 1,255      |                | 11,949         |                |
| Person years  | 1,104      |                | 11,844         |                |
| Assessments   | 1,271      |                | 13,531         |                |
| Assessments with missing data for any variable                            | 304        | 24             | 4,176          | 31             |
| Assessments in 1:5 <sup>**</sup> matched sample                           | 908        | 71             | 3,790          | 28             |
| Person years  | 780        |                | 3,247          |                |
| Assessments in 1:5 <sup>**</sup> matched sample after multiple imputation | 1,201      | 94             | 5,047          | 37             |
| Person years  | 1,044      |                | 4,408          |                |

<sup>\*</sup> Percentage of all assessments.

<sup>\*\*</sup> As the algorithm used to calculate the matched groups allowed *initiator* to have up-to (not exactly) five matches within the pre-specified calliper bounds the final ratio was not 1:5 (actual ratio 1:4.3).

**Table 2**

Comparison between initiators and non-initiators on baseline covariates, classified within 8 groups, prior to and post propensity score matching.

| Variable   | Initiators N = 1271 |       | Non-initiators N = 13,531 |       | Standardised difference (%) |         |
|--|---------------------|-------|---------------------------|-------|-----------------------------|---------|
|  | N/mean              | %/±SD | N/mean                    | %/±SD | All                         | Matched |
| <b>Group 1: demographic variables</b>  |                     |       |                           |       |                             |         |
| Gender   |                     |       |                           |       |                             |         |
| Male   | 955                 | 75    | 10,422                    | 77    | -4.4                        | -2.1    |
| Female   | 316                 | 25    | 3109                      | 23    |                             |         |
| Mean age   | 31.1                | ±7.0  | 31.7                      | ±7.3  | -8.1                        | -3.4    |
| Ethnicity  |                     |       |                           |       |                             |         |
| White  | 1084                | 85    | 11,246                    | 83    | 4.6                         | -0.8    |
| Non-white  | 106                 | 8     | 1284                      | 9     |                             |         |
| Missing  | 81                  | 6     | 1001                      | 7     |                             |         |
| Region   |                     |       |                           |       |                             |         |
| Eastern  | 87                  | 7     | 1119                      | 8     | -5.4                        | 0.0     |
| East Midlands  | 185                 | 15    | 1465                      | 11    | 11.2                        | -3.2    |
| London   | 85                  | 7     | 1246                      | 9     | -9.3                        | 2.8     |
| North East   | 70                  | 6     | 677                       | 5     | 2.3                         | 5.1     |
| North West   | 264                 | 21    | 2676                      | 20    | 2.5                         | -1.9    |
| South East   | 154                 | 12    | 1728                      | 13    | -2.0                        | 1.4     |
| South West   | 84                  | 7     | 1031                      | 8     | -3.9                        | -0.5    |
| West Midlands  | 166                 | 13    | 1699                      | 13    | 1.5                         | 1.0     |
| Yorkshire & Humber   | 176                 | 14    | 1890                      | 14    | -0.3                        | -1.8    |
| <b>Group 2: relating to the assessment</b>                                   |                     |       |                           |       |                             |         |
| Purpose of assessment  |                     |       |                           |       |                             |         |
| Pre-sentence report  | 456                 | 36    | 2695                      | 20    | 36.2                        | -1.1    |
| Start community sent   | 366                 | 29    | 3736                      | 28    | 2.6                         | 4.8     |
| Sentence review  | 119                 | 9     | 2264                      | 17    | -22.0                       | 0.0     |
| Start licence  | 135                 | 11    | 2361                      | 17    | -19.8                       | -1.5    |
| End sentence   | 195                 | 15    | 2475                      | 18    | -7.9                        | -3.3    |
| Sentence tied to the assessment  |                     |       |                           |       |                             |         |
| Community  | 596                 | 47    | 5225                      | 39    | 15.4                        | -2.0    |
| Custody  | 89                  | 7     | 1556                      | 12    | -17.7                       | -1.3    |
| Suspended  | 159                 | 13    | 1448                      | 11    | 4.7                         | -4.1    |
| Other  | 198                 | 16    | 1993                      | 15    | 1.0                         | 3.0     |
| Community punishment   | 111                 | 9     | 1641                      | 12    | -13.1                       | 6.0     |
| Missing  | 118                 | 9     | 1668                      | 12    |                             |         |
| Mean assessment no.  | 1.11                | ±0.33 | 1.13                      | ±0.36 | -5.0                        | -3.9    |
| Assessment financial year  |                     |       |                           |       |                             |         |
| 2005–2006  | 355                 | 28    | 4213                      | 31    | -7.0                        | 4.3     |
| 2006–2007  | 287                 | 23    | 3073                      | 23    | -0.3                        | -0.5    |
| 2007–2008  | 308                 | 24    | 3065                      | 23    | 3.7                         | -1.3    |
| 2008–2009  | 321                 | 25    | 3180                      | 24    | 4.1                         | -2.5    |
| <b>Group 3: Offending which led to assessment</b>                            |                     |       |                           |       |                             |         |
| Offence which resulted in the probation assessment                           |                     |       |                           |       |                             |         |
| Violence/sexual  | 103                 | 8     | 1273                      | 9     | -4.7                        | 0.0     |
| Serious acquisitive  | 210                 | 17    | 2445                      | 18    | -4.2                        | -1.5    |
| Non-serious acq.   | 618                 | 49    | 5991                      | 44    | 8.6                         | -1.1    |
| Drugs offences   | 155                 | 12    | 1747                      | 13    | -2.3                        | 1.0     |
| Other  | 176                 | 14    | 1945                      | 14    | -1.6                        | 2.2     |
| Missing  | 9                   | 1     | 130                       | 1     |                             |         |
| Are current offence(s) an escalation in seriousness from previous offending? |                     |       |                           |       |                             |         |
| Yes  | 234                 | 18    | 2823                      | 21    | -6.5                        | 0.0     |
| No   | 1007                | 79    | 10,342                    | 76    |                             |         |
| Missing  | 30                  | 2     | 366                       | 3     |                             |         |
| Are current offence(s) an established pattern of similar offending?          |                     |       |                           |       |                             |         |
| Yes  | 1044                | 82    | 10,840                    | 80    | 4.9                         | -0.9    |
| No   | 217                 | 17    | 2560                      | 19    |                             |         |
| Missing  | 10                  | 1     | 131                       | 1     |                             |         |
| <b>Group 4: Drug use/problems</b>  |                     |       |                           |       |                             |         |
| Was there evidence of motivation due to addictions/perceived needs?          |                     |       |                           |       |                             |         |
| Yes  | 887                 | 70    | 9055                      | 67    | 5.0                         | -4.2    |
| No   | 363                 | 29    | 4136                      | 31    |                             |         |
| Missing  | 21                  | 2     | 340                       | 3     |                             |         |
| Did drugs act as a disinhibitor?   |                     |       |                           |       |                             |         |
| Yes  | 862                 | 68    | 8774                      | 65    | 5.8                         | -6.5    |
| No   | 395                 | 31    | 4553                      | 34    |                             |         |
| Missing  | 14                  | 1     | 204                       | 2     |                             |         |
| Daily use of heroin?   |                     |       |                           |       |                             |         |
| Yes  | 1009                | 79    | 9720                      | 72    | 17.7                        | 1.9     |
| No   | 262                 | 21    | 3811                      | 28    |                             |         |
| Currently injects heroin   |                     |       |                           |       |                             |         |
| Yes  | 516                 | 41    | 4896                      | 36    | 9.1                         | -5.1    |
| No   | 755                 | 59    | 8635                      | 64    |                             |         |
| Previously (but not currently) injected heroin                               |                     |       |                           |       |                             |         |



Table 2 (Continued)

| Variable  | Initiators N = 1271 |       | Non-initiators N = 13,531 |       | Standardised difference (%) |         |
|---|---------------------|-------|---------------------------|-------|-----------------------------|---------|
|   | N/mean              | %/±SD | N/mean                    | %/±SD | All                         | Matched |
| Yes   | 279                 | 22    | 3076                      | 23    | -1.9                        | -0.3    |
| No  | 992                 | 78    | 10,455                    | 77    |                             |         |
| Other opiates or (non-prescribed) methadone   |                     |       |                           |       |                             |         |
| Yes   | 136                 | 11    | 1543                      | 11    | -2.2                        | 0.0     |
| No  | 1135                | 89    | 11,988                    | 89    |                             |         |
| Crack use   |                     |       |                           |       |                             |         |
| No  | 765                 | 60    | 7627                      | 56    | 7.8                         | 7.9     |
| Occasionally  | 133                 | 10    | 1286                      | 10    | 3.2                         | -4.1    |
| Frequently  | 373                 | 29    | 4618                      | 34    | -10.3                       | -5.8    |
| Previously used crack   |                     |       |                           |       |                             |         |
| Yes   | 350                 | 28    | 3338                      | 25    | 6.5                         | 2.0     |
| No  | 921                 | 72    | 10,193                    | 75    |                             |         |
| Cocaine/amphetamine use   |                     |       |                           |       |                             |         |
| Yes   | 71                  | 6     | 851                       | 6     | -3.0                        | -3.4    |
| No  | 1200                | 94    | 12,680                    | 94    |                             |         |
| Benzodiazepine use  |                     |       |                           |       |                             |         |
| No  | 1157                | 91    | 12,425                    | 92    | -2.8                        | 1.9     |
| Occasionally  | 40                  | 3     | 316                       | 2     | 5.0                         | -1.3    |
| Frequently  | 74                  | 6     | 790                       | 6     | -0.1                        | -1.3    |
| Other drug used?  |                     |       |                           |       |                             |         |
| Yes   | 60                  | 5     | 692                       | 5     | -1.8                        | -4.3    |
| No  | 1211                | 95    | 12,839                    | 95    |                             |         |
| A current injector of a drug aside from heroin?   |                     |       |                           |       |                             |         |
| Yes   | 410                 | 32    | 4412                      | 33    | -0.7                        | -3.7    |
| No  | 861                 | 68    | 9119                      | 67    |                             |         |
| Violent behaviour related to drug use?  |                     |       |                           |       |                             |         |
| Yes   | 263                 | 21    | 3129                      | 23    | -6.1                        | -6.3    |
| No  | 998                 | 79    | 10,258                    | 76    |                             |         |
| Missing   | 10                  | 1     | 144                       | 1     |                             |         |
| Motivated to tackle drug misuse?  |                     |       |                           |       |                             |         |
| Yes   | 368                 | 29    | 3431                      | 25    | 8.1                         | 2.7     |
| Somewhat  | 754                 | 59    | 7859                      | 58    | 2.6                         | -1.6    |
| No  | 145                 | 11    | 2201                      | 16    | -14.1                       | -1.3    |
| Missing   | 4                   |       | 40                        |       |                             |         |
| Drug use and obtaining drugs a major activity/occupation?                                   |                     |       |                           |       |                             |         |
| No  | 140                 | 11    | 1721                      | 13    | -5.3                        | 1.1     |
| Somewhat  | 470                 | 37    | 4795                      | 35    | 3.1                         | 1.8     |
| Significantly   | 659                 | 52    | 6978                      | 52    | 0.4                         | -2.4    |
| Missing   | 2                   |       | 37                        |       |                             |         |
| Drug misuse issues linked to risk of serious harm, risks to the individual and other risks? |                     |       |                           |       |                             |         |
| Yes   | 814                 | 64    | 8274                      | 61    | -6.2                        | -5.1    |
| No  | 445                 | 35    | 5144                      | 38    |                             |         |
| Missing   | 12                  | 1     | 113                       | 1     |                             |         |
| Drug misuse issues linked to offending behaviour?   |                     |       |                           |       |                             |         |
| Yes   | 1213                | 95    | 12,829                    | 95    | 3.7                         | -4.7    |
| No  | 49                  | 4     | 623                       | 5     |                             |         |
| Missing   | 9                   | 1     | 79                        | 1     |                             |         |
| Group 5: Alcohol  |                     |       |                           |       |                             |         |
| Did alcohol act as a disinhibitor?  |                     |       |                           |       |                             |         |
| Yes   | 178                 | 14    | 2337                      | 17    | -9.8                        | 0.9     |
| No  | 1046                | 82    | 10,530                    | 78    |                             |         |
| Missing   | 47                  | 4     | 664                       | 5     |                             |         |
| Is current alcohol use a problem?   |                     |       |                           |       |                             |         |
| No  | 966                 | 76    | 9687                      | 72    | 10.1                        | 0.5     |
| Somewhat  | 166                 | 13    | 1829                      | 14    | -1.4                        | -1.6    |
| Significantly   | 128                 | 10    | 1886                      | 14    | -12.0                       | 1.1     |
| Missing   | 11                  | 1     | 129                       | 1     |                             |         |
| Binge drinking or excessive use of alcohol in the last 6 months?                            |                     |       |                           |       |                             |         |
| Yes   | 280                 | 22    | 3415                      | 25    | -7.7                        | 2.4     |
| No  | 980                 | 77    | 9968                      | 74    |                             |         |
| Missing   | 11                  | 1     | 148                       | 1     |                             |         |
| Frequency and level of alcohol in the past  |                     |       |                           |       |                             |         |
| No problems   | 897                 | 71    | 9155                      | 68    | 6.1                         | -1.5    |
| Some problems   | 125                 | 10    | 1536                      | 11    | -5.0                        | 0.0     |
| Significant problems  | 238                 | 19    | 2694                      | 20    | -3.1                        | 1.7     |
| Missing   | 11                  | 1     | 146                       | 1     |                             |         |
| Motivated to tackle alcohol misuse?   |                     |       |                           |       |                             |         |
| No problems   | 1030                | 81    | 10,449                    | 77    | 9.3                         | -3.2    |
| Some problems   | 188                 | 15    | 2260                      | 17    | -5.4                        | 2.2     |
| Significant problems  | 41                  | 3     | 669                       | 5     | -8.8                        | 2.5     |
| Missing   | 12                  | 1     | 153                       | 1     |                             |         |
| Alcohol misuse linked to offending behaviour  |                     |       |                           |       |                             |         |
| Yes   | 326                 | 26    | 3884                      | 29    | -7.3                        | 3.5     |
| No  | 935                 | 74    | 9467                      | 70    |                             |         |

Table 2 (Continued)

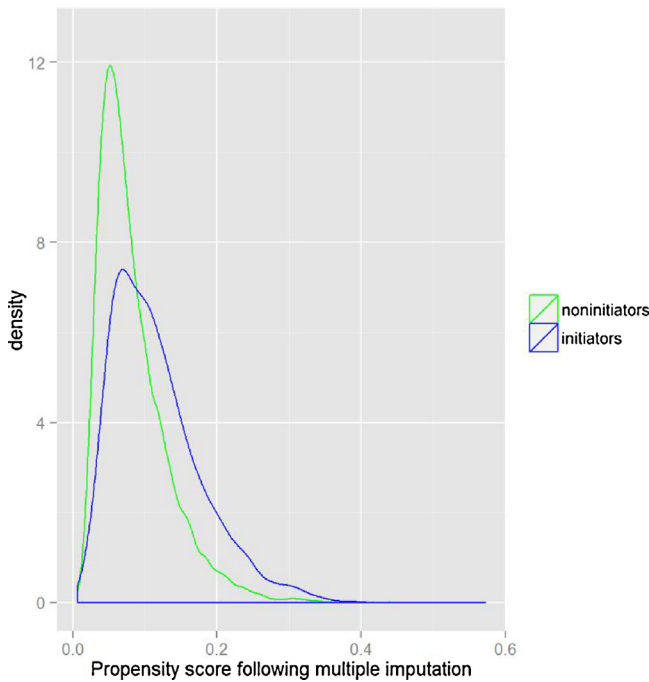
| Variable   | Initiators N = 1271 |       | Non-initiators N = 13,531 |       | Standardised difference (%) |         |
|--|---------------------|-------|---------------------------|-------|-----------------------------|---------|
|  | N/mean              | %/±SD | N/mean                    | %/±SD | All                         | Matched |
| Missing  | 10                  | 1     | 180                       | 1     |                             |         |
| Group 6: Employment/housing  |                     |       |                           |       |                             |         |
| Unstable accommodation   |                     |       |                           |       |                             |         |
| Yes  | 755                 | 59    | 7504                      | 55    | 7.7                         | 0.9     |
| No   | 506                 | 40    | 5882                      | 43    |                             |         |
| Missing  | 10                  | 1     | 145                       | 1     |                             |         |
| Unemployed   |                     |       |                           |       |                             |         |
| Yes  | 1166                | 92    | 12,287                    | 91    | 1.6                         | 0.4     |
| No   | 94                  | 7     | 1052                      | 8     |                             |         |
| Missing  | 11                  | 1     | 192                       | 1     |                             |         |
| In receipt of benefits?  |                     |       |                           |       |                             |         |
| Yes  | 1050                | 83    | 10,891                    | 80    | 4.5                         | -1.2    |
| No   | 198                 | 16    | 2320                      | 17    |                             |         |
| Missing  | 23                  | 2     | 320                       | 2     |                             |         |
| Financial issues linked to offending behaviour                               |                     |       |                           |       |                             |         |
| Yes  | 1018                | 80    | 10,594                    | 78    | 4.2                         | -4.9    |
| No   | 243                 | 19    | 2806                      | 21    |                             |         |
| Missing  | 10                  | 1     | 131                       | 1     |                             |         |
| Group 7: Mental/physical wellbeing   |                     |       |                           |       |                             |         |
| Current psychiatric problems   |                     |       |                           |       |                             |         |
| No problems  | 1083                | 85    | 11,216                    | 83    | 5.9                         | -2.5    |
| Some problems  | 124                 | 10    | 1371                      | 10    | -1.3                        | -0.4    |
| Significant problems   | 63                  | 5     | 909                       | 7     | -7.6                        | 4.5     |
| Missing  | 1                   |       | 35                        |       |                             |         |
| History of psychiatric treatment   |                     |       |                           |       |                             |         |
| Yes  | 111                 | 9     | 1375                      | 10    | -4.9                        | 4.9     |
| No   | 1160                | 91    | 12,156                    | 90    |                             |         |
| Emotional wellbeing linked to offending behaviour                            |                     |       |                           |       |                             |         |
| Yes  | 503                 | 40    | 5537                      | 41    | -2.9                        | -2.9    |
| No   | 754                 | 59    | 7823                      | 58    |                             |         |
| Missing  | 14                  | 1     | 171                       | 1     |                             |         |
| Has physical or mental health conditions which need to be taken into account |                     |       |                           |       |                             |         |
| Yes  | 524                 | 41    | 5777                      | 43    | -3.2                        | -6.0    |
| No   | 727                 | 57    | 7506                      | 55    |                             |         |
| Missing  | 20                  | 2     | 248                       | 2     |                             |         |
| Group 8: Offending history from PNC records                                  |                     |       |                           |       |                             |         |
| Mean years since last recorded offence                                       |                     |       |                           |       |                             |         |
| Mean previous acquisitive crimes   | 0.35                | ±0.69 | 0.45                      | ±0.68 | -15.7                       | -3.3    |
| <4 weeks   | 0.32                | ±0.75 | 0.21                      | ±0.63 | 17.2                        | 4.5     |
| 4wks to 6 months   | 1.21                | ±1.71 | 1.06                      | ±1.68 | 8.9                         | 1.4     |
| 6 months to 1 year   | 0.89                | ±1.59 | 0.90                      | ±1.54 | -0.8                        | -2.1    |
| Over one year  | 20.7                | ±22.0 | 21.6                      | ±21.2 | -3.9                        | -7.8    |
| Previous non-acquisitive crimes  |                     |       |                           |       |                             |         |
| <4 weeks   | 0.14                | ±0.53 | 0.11                      | ±0.49 | 5.4                         | 4.5     |
| 4 weeks to 6 months  | 0.65                | ±1.24 | 0.64                      | ±1.34 | 0.8                         | -0.3    |
| 6 months to 1 year   | 0.52                | ±1.09 | 0.63                      | ±1.33 | -8.8                        | 1.6     |
| Over one year  | 13.8                | ±14.9 | 14.7                      | ±15.3 | -6.0                        | -6.8    |
| Breach offences  |                     |       |                           |       |                             |         |
| <4 weeks   | 0.17                | ±0.49 | 0.18                      | ±0.52 | -2.1                        | 0.0     |
| > 4weeks   | 8.60                | ±8.21 | 8.73                      | ±7.59 | -1.7                        | -1.0    |

Although an extensive set of covariates were available from probation assessments, in addition to historical offending information from police records, bias by unobserved confounding cannot be ruled out. The probation interview is specifically designed to assess future offending likelihood and has previously shown utility in this regard, (Howard, 2011; Howard & Moore, 2009) however they might be less effective at identifying drug treatment need. Given that most covariates came from self-report, disclosure bias may mask true differences between groups. One study of the inter-rater reliability of probation interviews concluded that questions relating to drug use and accommodation had good reliability, whilst those relating to prior alcohol use and risk of serious harm had poor reliability (Morton, 2009). In England and Wales, when the cause of death is deemed to be unnatural then it is subject to a coroner inquest. Coding of the cause of death from

a coroner's report is subject to error, and there may be some familial pressure to code the death as something other than drug-related, resulting in an underreporting of the number of DRPs.

One reason to believe that residual confounding exists is that there is no compelling theory to support an increase in offending following treatment contact, albeit the small one observed here. There is some confounding evident in the analysis: the estimated increase in offending, associated with being an initiator, changed from twenty to eight percent after propensity-score matching. The amount of unobserved confounding would have to be greater than that observed to change the inference towards a positive effect of treatment contact and given the number and range of variables used to calculate propensity scores, this seems unlikely. It should be noted that a recent UK-based randomised trial (Holland et al., 2014) found a similarly counter-intuitive result: supervised





**Fig. 2.** Distribution of propensity scores, averaged across 10 multiple imputation datasets, for initiator and non-initiator assessments where height indicates density of subjects.

consumption of methadone over three months, compared to one-week supervision, resulted in an increase in offending (OR = 3.37, 95% CI: 1.3–8.9). In conjunction with this, our finding may warrant fresh investigation into the relationship between treatment and offending.

Utilising records from probation assessments allows subjects to be identified prior to entering treatment and provides an extensive set of variables to achieve balance. This approach has previously

been used to assess the effect of alcohol treatment referral on recidivism – a study that found no overall impact of the intervention (McSweeney, 2014). Alternative observational study designs compare treated and untreated periods. The DRP-risk reduction estimated here was consistent with that seen in such studies (Cornish, Macleod, Strang, Vickerman, & Hickman, 2010; Pierce, Bird et al., 2016; Sordo et al., 2017). In contrast to the findings presented here, studies of this type that investigate offending outcomes have tended to show lower rates in treatment than those observed out of treatment (Bukten et al., 2011; Lind, Chen, Weatherburn, & Mattick, 2005).

One difference between these studies and the current one is the different measures of treatment effectiveness. The object of the current analysis is to estimate the effect of *initial contact* with treatment, whilst other observational studies tend to estimate the effect of *receiving* treatment. The effect of initiating treatment is also likely to be more conservative because addiction-treatment tends to be most effective whilst subjects are being treated. To illustrate, in one Australian study of offending among prison leavers, comparing those who were on methadone maintenance at baseline with those who were not resulted in a Hazard ratio of 0.98 (95% CI: 0.88–1.09) and analysing according to being in treatment resulted in an HR of 0.80 (95% CI: 0.71–0.90) (Larney, Toson, Burns, & Dolan, 2012). One difficulty in measuring the effect of receiving treatment is that, because treatment exposure changes over follow-up, time-updated covariates are needed to account for confounding, but in most cases such variables will not be available. Even if sufficient data were collected, when treatment affects the future values of a time-dependent confounder standard estimation methods will still produce biased estimates (Pierce, Dunn, & Millar, 2016). Regardless, the effect of initial treatment contact is of greater interest when assessing the effectiveness of current policy, as is the aim of the present analysis.

Another reason why our study might fail to reveal an effect of treatment on offending is because the cohort is restricted to those who were identified in the criminal justice system, with 63% of *initiators* have been referred to treatment from within the criminal justice system (compared to the national proportion of 26%)

**Table 3**

Results of drug-related poisoning mortality analyses, comparing initiators and non-initiators: unmatched, propensity score matching and propensity score matching following multiple imputation (Number of assessments = 14,802).

| Analysis             | Group          | Deaths | Person years | Rate, per 1000 person year [95% CI] | Hazard ratio [95% CI] | p-value |
|----------------------|----------------|--------|--------------|-------------------------------------|-----------------------|---------|
| Un matched           | Initiators     | 3      | 1104         | 2.7 [0.9, 8.4]                      | 0.40 [0.13, 1.26]     | 0.116   |
|                      | Non-initiators | 81     | 11,844       | 6.8 [5.5, 8.5]                      | Ref                   |         |
| 1:5 matched          | Initiators     | 2      | 780          | 2.6 [0.6, 10.2]                     | 0.30 [0.09, 0.99]     | 0.048   |
|                      | Non-initiators | 25     | 3251         | 7.7 [5.2, 11.4]                     | Ref                   |         |
| 1:5 matched after MI | Initiators     | 3      | 1049         | 2.9 [0.9, 8.9]                      | 0.42 [0.17, 1.04]     | 0.060   |
|                      | Non-initiators | 30     | 4413         | 6.8 [4.8, 8.9]                      | Ref                   |         |

**Table 4**

Results of acquisitive crime analyses, comparing initiators and non-initiators: unmatched, propensity score matching and propensity score matching following multiple imputation (No of assessments = 14,802).

| Analysis             | Group          | Crimes | Person years | Rate, per person year [95% CI] | Hazard ratio [95% CI] | p-value |
|----------------------|----------------|--------|--------------|--------------------------------|-----------------------|---------|
| Unmatched            | Initiator      | 544    | 666          | 0.82 [0.75, 0.89]              | 1.22 [1.11, 1.33]     | <0.001  |
|                      | Non-initiators | 5261   | 7965         | 0.66 [0.64, 0.68]              | Ref                   |         |
| 1:5 matched          | Initiators     | 391    | 464          | 0.84 [0.76, 0.93]              | 1.08 [0.99, 1.17]     | 0.102   |
|                      | Non-initiators | 1579   | 2079         | 0.76 [0.72, 0.80]              | Ref                   |         |
| 1:5 matched after MI | Initiators     | 513    | 636          | 0.81 [0.74, 0.88]              | 1.10 [1.02, 1.18]     | 0.015   |
|                      | Non-initiators | 2052   | 2860         | 0.72 [0.69, 0.75]              | Ref                   |         |

(National Treatment Agency for Substance Misuse, 2011). The lack of evidence for criminal justice referral as a method of accessing treatment has been identified in a recent systematic review (Hayhurst et al., 2015).

The results presented may be due to poor treatment adherence amongst those who started treatment and the negative effects of leaving treatment. It is noted that 6.4% of initiators (81/1271) did not receive any treatment following their triage appointment and we cannot expect treatment contact to be effective for these. A future analysis could use a similar design to investigate the effect of discontinuing treatment, selecting patients in long-term treatment and comparing those who discontinue treatment with those who do not. Irrespective of the lack of an effect on crime, it is striking that a very small proportion of those identified at a formal OASys assessment interview as regular heroin users, for whom treatment would appear to be indicated, subsequently went on to seek treatment.

The findings reported here raise questions concerning the referral of drug using offenders for treatment as a means to reduce crime, insofar as *initiation of contact* was not associated with a lower risk of offending among these CJS-involved participants. However, if the effect on DRP-deaths was established with further good-quality evidence, this could provide sufficient justification for continued investment, especially given the record-high number of DRP-deaths in the most recent statistics published in England and Wales (Office for National Statistics, 2016). It has been previously noted that the criminal justice system has lagged behind medical research in adopting RCTs (Bird, Goldacre, & Strang, 2011) and this ought to be addressed if we are to improve outcomes for offenders.

#### Declarations of interest

**Millar** has received research funding from the UK National Treatment Agency for Substance Misuse and the Home Office. He has been a member of the organising committee for conferences supported by unrestricted educational grants from Reckitt Benckiser, Lundbeck, Martindale Pharma, and Britannia Pharmaceuticals Ltd, for which he received no personal remuneration. He is a member of the Advisory Council on the Misuse of Drugs.

**Bird** holds GSK shares. She is formerly an MRC programme leader and has been elected to Honorary Professorship at Edinburgh University. She chaired Home Office's Surveys, Design and Statistics Subcommittee (SDSSC) when SDSSC published its report on 21st Century Drugs and Statistical Science. She has previously served as UK representative on the Scientific Committee for European Monitoring Centre for Drugs and Drug Addiction. She is co-principal investigator for MRC-funded, prison-based N-ALIVE pilot Trial.

**Marsden** works in an integrated university (Institute of Psychiatry, Psychology and Neuroscience [IOPPN], King's College London) and National Health Service Academic Health Sciences Centre (King's Health Partners) and declares the following financial relationships: in addition to university-based addiction treatment-related research grants from the Department of Health, Institute for Health Research (Health Technology Assessment programme), and the Biomedical Research Centre for Mental Health (South London and Maudsley NHS Foundation Trust and IOPPN), he has part-time employment as Senior Academic Advisor for the Alcohol, Drugs and Tobacco Division, Health and Wellbeing Directorate, Public Health England; educational grant funding at King's College London via Reckitt Benckiser Pharmaceuticals (RBP) to Action on Addiction for a study of psychological interventions in opioid dependence (2010–2016); consultation to RBP (2011) and Merck Serono (2013), and honoraria as co-chair of the Improving Outcomes in Treatment of Opioid Dependence conference

(2015) via educational grant funding from RBP [Indivior PLC] to PCM Scientific. He holds no stocks in any company.

**Seddon** has received research funding from the UK National Treatment Agency for Substance Misuse and the Home Office. No further declarations

#### Acknowledgements

The project was funded by the Medical Research Council: grant reference number G1000021. SMB is funded by the Medical Research Council: programme U105260794.

The funder of this study had no role in the study design, data linkage, statistical analysis and interpretation, or the writing of the manuscript. M.P. took the final decision to submit for publication.

A number of organisations and individuals enabled access to data to support this research, including: The Office for National Statistics, The Home Office, The Ministry of Justice, Dr Sara Skodbo, Maryam Ahmad, Anna Richardson, Hannah Whitehead, and Nick Manton.

#### Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at <https://doi.org/10.1016/j.drugpo.2017.09.017>.

#### References

- Amato, L., Minozzi, S., Davoli, M., & Vecchi, S. (2011a). Psychosocial and pharmacological treatments versus pharmacological treatments for opioid detoxification. *Cochrane Database of Systematic Reviews*(9)CD005031. <http://dx.doi.org/10.1002/14651858.CD005031.pub4>.
- Amato, L., Minozzi, S., Davoli, M., & Vecchi, S. (2011b). Psychosocial combined with agonist maintenance treatments versus agonist maintenance treatments alone for treatment of opioid dependence. *Cochrane Database of Systematic Reviews* (10)CD004147. <http://dx.doi.org/10.1002/14651858.CD004147.pub4>.
- Amato, L., Davoli, M., Minozzi, S., Ferroni, E., Ali, R., & Ferri, M. (2013). Methadone at tapered doses for the management of opioid withdrawal. *Cochrane Database of Systematic Reviews*(2)Cd003409. <http://dx.doi.org/10.1002/14651858.Cd003409.pub4>.
- Austin, P. C. (2011a). Optimal caliper widths for propensity-score matching when estimating differences in means and differences in proportions in observational studies. *Pharmaceutical Statistics*, 10(2), 150–161. <http://dx.doi.org/10.1002/pst.433>.
- Austin, P. C. (2011b). An introduction to propensity score methods for reducing the effects of confounding in observational studies. *Multivariate Behavioral Research*, 46(3), 399–424. <http://dx.doi.org/10.1080/00273171.2011.568786>. Pii 938470000.
- Bennett, T., Holloway, K., & Farrington, D. (2008). The statistical association between drug misuse and crime: A meta-analysis. *Aggression and Violent Behavior*, 13(2), 107–118. <http://dx.doi.org/10.1016/j.avb.2008.02.001>.
- Bird, S. M., Goldacre, B., & Strang, J. (2011). Personal view: We should push for evidence based sentencing in criminal justice. *British Medical Journal*, 342. <http://dx.doi.org/10.1136/bmj.d612>.
- Bird, S. (2008). *21st century drugs and statistical science in UK*. London: Surveys, Design and Statistics Subcommittee of Home Office Scientific Advisory Committee. Retrieved from [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/167912/SDSSC-21st-century-drugs.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/167912/SDSSC-21st-century-drugs.pdf).
- Bukten, A., Skurtveit, S., Stangeland, P., Gossop, M., Willersrud, A. B., Waal, H., . . . Clausen, T. (2011). Criminal convictions among dependent heroin users during a 3-year period prior to opioid maintenance treatment: A longitudinal national cohort study. *Journal of Substance Abuse Treatment*, 41(4), 407–414. <http://dx.doi.org/10.1016/j.jsat.2011.06.006>. S0740-5472(11)00115-2 [pii].
- Campbell, D. T., Stanley, J. C. joint author, & Gage, N. L. ed. H. of research on teaching (1966). *Experimental and quasi-experimental designs for research*. Chicago: R. McNally.
- Cornish, R., Macleod, J., Strang, J., Vickerman, P., & Hickman, M. (2010). Risk of death during and after opiate substitution treatment in primary care: Prospective observational study in UK General Practice Research Database. *BMJ*, 341, c5475. <http://dx.doi.org/10.1136/bmj.c5475>. <http://dx.doi.org/10.1136/bmj.c5475> [pii].
- Danaei, G., Rodriguez, L. A., Canero, O. F., Logan, R., & Hernan, M. A. (2013). Observational data for comparative effectiveness research: An emulation of randomised trials of statins and primary prevention of coronary heart disease. *Statistical Methods in Medical Research*, 22(1), 70–96. <http://dx.doi.org/10.1177/0962280211403603>. 0962280211403603 [pii].
- Degenhardt, L., Whiteford, H. A., Ferrari, A. J., Baxter, A. J., Charlson, F. J., Hall, W. D., . . . Vos, T. (2013). Global burden of disease attributable to illicit drug use and dependence: Findings from the Global Burden of Disease Study 2010. *Lancet*, 382(9904), 1564–1574. [http://dx.doi.org/10.1016/S0140-6736\(13\)61530-5](http://dx.doi.org/10.1016/S0140-6736(13)61530-5).

- Hayhurst, K. P., Leitner, M., Davies, L., Flentje, R., Millar, T., Jones, A., . . . Shaw, J. (2015). The effectiveness and cost-effectiveness of diversion and aftercare programmes for offenders using class a drugs: A systematic review and economic evaluation. *Health Technology Assessment*. <http://dx.doi.org/10.3310/hta19060>.
- Hernan, M. A., Alonso, A., Logan, R., Grodstein, F., Michels, K. B., Willett, W. C., . . . Robins, J. M. (2008). Observational studies analyzed like randomized experiments: an application to postmenopausal hormone therapy and coronary heart disease. *Epidemiology (Cambridge, Mass)*, 19(6), 766–779. <http://dx.doi.org/10.1097/Ede.0b013e3181875e61>.
- Hill, J. (2004). *Reducing bias in treatment effect estimation in observational studies suffering from missing data*. Retrieved from <http://academiccommons.columbia.edu/catalog/ac:129151>.
- Holland, R., Maskrey, V., Swift, L., Notley, C., Robinson, A., Nagar, J., . . . Kouimtsidis, C. (2014). Treatment retention, drug use and social functioning outcomes in those receiving 3 months versus 1 month of supervised opioid maintenance treatment. Results from the Super C randomized controlled trial. *Addiction*, 109(4), 596–607. <http://dx.doi.org/10.1111/add.12439>.
- Home Office (2010). *DRUG STRATEGY 2010: Reducing demand, restricting supply, building recovery: Supporting people to live a drug free life*. London. Retrieved from <http://www.homeoffice.gov.uk/publications/alcohol-drugs/drugs/drug-strategy/consultation-responses?view=Binary>.
- Howard, P., & Moore, R. (2009). *Measuring changes in risk and need over time using OASys*. London. Retrieved from <http://webarchive.nationalarchives.gov.uk/20110201125714/http://www.justice.gov.uk/publications/docs/research-summary-oasys-10-09.pdf>.
- Howard, P. (2011). *Hazards of different types of reoffending*. London. Retrieved from <https://www.gov.uk/government/publications/hazards-of-different-types-of-reoffending>.
- Larney, S., Toson, B., Burns, L., & Dolan, K. (2012). Effect of prison-based opioid substitution treatment and post-release retention in treatment on risk of re-incarceration. *Addiction*, 107(2), 372–380. <http://dx.doi.org/10.1111/j.1360-0443.2011.03618.x>.
- Lind, B., Chen, S. L., Weatherburn, D., & Mattick, R. (2005). The effectiveness of methadone maintenance treatment in controlling crime – An Australian aggregate-level analysis. *British Journal of Criminology*, 45(2), 201–211. <http://dx.doi.org/10.1093/Bjc/Azh085>.
- Mattick, R. P., Breen, C., Kimber, J., & Davoli, M. (2009). Methadone maintenance therapy versus no opioid replacement therapy for opioid dependence. *Cochrane Database of Systematic Reviews*Cd002209. <http://dx.doi.org/10.1002/14651858.Cd002209.Pub2>.
- Mattick, R. P., Breen, C., Kimber, J., & Davoli, M. (2014). Buprenorphine maintenance versus placebo or methadone maintenance for opioid dependence. *The Cochrane Database of Systematic Reviews*, 2. <http://dx.doi.org/10.1002/14651858.CD002207.pub4>.
- McSweeney, T. (2014). Calling time on “alcohol-related” crime? Examining the impact of court-mandated alcohol treatment on offending using propensity score matching. *Criminology and Criminal Justice*, 15(4), 464–483. <http://dx.doi.org/10.1177/1748895814561471>.
- Millar, T., Ahmad, M., Richardson, A., Skodbo, S., Donmall, M., & Jones, A. (2012). *The drug data warehouse: Linking data on drug misusers and drug-misusing offenders. Home Office research report, Vol. 63* London: Home Office.
- Morton, S. (2009). *Can OASys deliver consistent assessments of offenders? Results from the inter-rater reliability study*. London. Retrieved from <http://webarchive.nationalarchives.gov.uk/20110201125714/http://www.justice.gov.uk/publications/docs/oasys-research-summary-01-09.pdf>.
- National Probation Services (2003). *OASys: The new offender assessment system*. Retrieved from <http://www.justice.gov.uk/about/probation>.
- National Treatment Agency for Substance Misuse (2006). *Models of care for treatment of adult drug misusers: Update 2006*. [http://www.nta.nhs.uk/uploads/nta\\_modelsofcare\\_update\\_2006\\_moc3.pdf](http://www.nta.nhs.uk/uploads/nta_modelsofcare_update_2006_moc3.pdf). (Retrieved 2 April 2015).
- National Treatment Agency for Substance Misuse (2011). *Statistics from the National Drug Treatment Monitoring System (NDTMS) 1 April 2010–31 March 2011*. Department of Health.
- Office for National Statistics (2016). *Deaths related to drug poisoning, England and Wales – 2014*. .
- Perry, A. E., Neilson, M., Martyn-St James, M., Glanville, J. M., Woodhouse, R., Godfrey, C., & Hewitt, C. (2015). Pharmacological interventions for drug-using offenders. *The Cochrane Database of Systematic Reviews*, 6(6). <http://dx.doi.org/10.1002/14651858.CD010862.pub2>.
- Pierce, M., Bird, S. M., Hickman, M., & Millar, T. (2015). National record linkage study of mortality for a large cohort of opioid users ascertained by drug treatment or criminal justice sources in England, 2005–2009. *Drug and Alcohol Dependence*, 146, 17–23. <http://dx.doi.org/10.1016/j.drugalcdep.2014.09.782>.
- Pierce, M., Bird, S. M., Hickman, M., Marsden, J., Dunn, G., Jones, A., & Millar, T. (2016). Impact of treatment for opioid dependence on fatal drug-related poisoning: A national cohort study in England. *Addiction (Abingdon, England)*, 111(2), 298–308. <http://dx.doi.org/10.1111/add.13193>.
- Pierce, M., Dunn, G., & Millar, T. (2016). Confounding in longitudinal studies in addiction treatment research. *Addiction Research & Theory*, 25(3), 236–242. <http://dx.doi.org/10.1080/16066359.2016.1247812>.
- Pierce, M., Hayhurst, K., Bird, S. M., Hickman, M., Seddon, T., Dunn, G., & Millar, T. (2015). Quantifying crime associated with drug use among a large cohort of sanctioned offenders in England and Wales. *Drug and Alcohol Dependence*, 155, 52–59. <http://dx.doi.org/10.1016/j.drugalcdep.2015.08.018>.
- Rassen, J. A., Shelat, A. A., Myers, J., Glynn, R. J., Rothman, K. J., & Schneeweiss, S. (2012). One-to-many propensity score matching in cohort studies. *Pharmacoepidemiology and Drug Safety*, 21 Suppl. 2, 69–80. <http://dx.doi.org/10.1002/pds.3263>.
- Rosenbaum, P. R., & Rubin, D. B. (1985). Constructing a control-group using multivariate matched sampling methods that incorporate the propensity score. *American Statistician*, 39(1), 33–38. <http://dx.doi.org/10.2307/2683903>.
- Royston, P., & White, I. R. (2011). Multiple imputation by chained equations (MICE): Implementation in Stata. *Journal of Statistical Software* 45(4)Retrieved from <http://www.jstatsoft.org/v45/i04/paper?ref=driverlayer.com/web>.
- Sordo, L., Barrio, G., Bravo, M. J., Indave, B. I., Degenhardt, L., Wiessing, L., . . . Pastor-Barriuso, R. (2017). Mortality risk during and after opioid substitution treatment: Systematic review and meta-analysis of cohort studies. *BMJ*1550. <http://dx.doi.org/10.1136/bmj.j1550>.
- Toh, S., & Manson, J. E. (2013). An analytic framework for aligning observational and randomized trial data: Application to postmenopausal hormone therapy and coronary heart disease. *Statistics in Biosciences*, 5(2). <http://dx.doi.org/10.1007/s12561-012-9073-6>.
- UN Office On Drugs and Crime (2010). *World drug report*. Vienna: United Nations.
- World Health Organization (2010). *ICD-10 Version: 2010*.