Injecting drug users in Scotland, 2006: listing, number, demography, and opiate-related death-rates

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ABSTRACT

Using Bayesian capture-recapture analysis, we estimated the number of current injecting drug users (IDUs) in Scotland in 2006 from the cross-counts of 5670 IDUs listed on four data-sources: social enquiry reports (901 IDUs listed), hospital records (953), drug treatment agencies (3504) and recent Hepatitis C virus (HCV) diagnoses (827 listed as IDU-risk). Further, we accessed exact numbers of opiate-related drugs-related deaths (DRDs) in 2006+2007 to improve estimation of Scotland's DRD rates per 100 current IDUs.

Using all four data-sources, and model-averaging of standard hierarchical log-linear models to allow for pairwise interactions between data-sources and/or demographic classifications, Scotland had an estimated 31700 IDUs in 2006 (95% credible interval: 24900 to 38700); but 25000 IDUs (95% CI: 20700 to 35000) by excluding recent HCV diagnoses whose IDU-risk can refer to past injecting. Only in the younger age-group (15-34 years) were Scotland's opiate-related DRD rates significantly lower for females than males. Older males' opiate-related DRD rate was 1.9 (1.24 to 2.40) per 100 current IDUs without or 1.3 (0.94 to 1.64) with inclusion of recent HCV diagnoses.

If, indeed, Scotland had only 25000 current IDUs in 2006, with only 8200 of them aged 35+ years, the opiate-related DRD rate is higher among this older age group than has been appreciated hitherto. There is counter-balancing good news for the public health: the hitherto sharp increase in older current IDUs had stalled by 2006.

[229 words]

Key words: Bayesian, capture-recapture, injectors, opiate-related deaths, sex, age.

Key points: None of the four Scottish data-sources used to estimate how many IDUs there were in 2006 listed more than 15% of them and three each listed fewer than 5%. Since the majority of Scotland's IDUs were 'hidden' from data-sources that typically launch studies of IDUs' mortality, it is unsurprising if record-linkage studies estimating *listed* IDUs' death-rates give different answers than estimation of opiate-related death-rates by sex and age-group for *all* injectors revealed, as here, by capture-recapture estimation. Importantly, differences between capture-recapture data-sources in how IDU-status is assigned may also be estimation-critical, as we have illustrated.

INTRODUCTION

Scotland's injecting drug users: By applying capture-recapture (CRC) methods to the cross-counts from four Scottish data-sources which list current injecting drug users (IDUs), our aim is to provide an update for 2006 on Scotland's prevalence of current IDUs, including by gender and age-group (15-34, 35+ years). We also make comparison with earlier estimates for Scotland in 2000 and 2003. In particular, we determine if the 21st century increase in Scotland's current IDUs aged 35+ years has begun to plateau. The increase was mainly a consequence of the ageing of Scotland's epidemic wave of IDU-initiates in the early to mid 1980s.

Following work by Bird and Robertson (2011) on the toxicology of Scotland's drugs-related deaths (DRDs), we have improved our computation of DRD rates per 100 current IDUs by accessing toxicology results directly to obtain, as numerator, the numbers of opiate-related DRDs in 2006+2007 – rather than our earlier reliance on approximation, see King et al. (2009). It remains problematic that IDU-risk is not reliably ascribed for each DRD and so IDU-related DRDs have to be inferred – here as opiate-related DRDs.

Quality-assurance in opiate substitution therapy was achieved in Scotland by 2000 (Strang et al., 2010) and so stability, rather than further decrease, in opiate-related DRDs per 100 current IDUs in Scotland would be unsurprising. However, debate continues about how greatly gender and age-group influence DRD rates per 100 current IDUs and we provide new data on this issue.

One of four data-sources that Scotland's capture-recapture analyses rely upon is recent Hepatitis C virus (HCV) diagnoses in persons who have acknowledged injecting as their HCV risk-factor. However, IDU-risk is not synonymous with current injecting. Increasingly, there has been outreach to Scotland's former IDUs, born in 1956-75, to engage them in HCV testing because many (over half) are HCV carriers and at risk of progression to cirrhosis, see Hutchinson et al. (2005), Hepatitis C Action Plan for Scotland Phase II: April 2008 – March 2011 (2008), and Bird et al. (2010a). Earlier still, in their April 2004 consensus statement on HCV, the Royal College of Physicians of Edinburgh had advocated that: "High priority for case finding should be given to former injecting drug users." We have therefore had to consider that IDU-risk, particularly in respect of HCV diagnoses since 2004, has encompassed both current and former IDUs and, increasingly, could lead us to over-estimate Scotland's number of current IDUs aged 35+ years. Accordingly, we provide two sets of prevalence results for current IDUs in 2006, the second by applying CRC methods to cross-counts from only three data-sources, that is: after exclusion of recent HCV diagnoses. We compare these results with previous estimates of current IDUs in 2000 and 2003 which were obtained using similar CRC analyses including the HCV database as one of the data sources.

Before proceeding, we briefly provide some background on three aspects of IDUs' DRD-rate, namely: i) CRC methods to estimate IDU-prevalence; ii) drug-induced deaths (see also Advisory Council on the Misuse of Drugs, 2000 and National Forum on Drug-Related Deaths in Scotland, 2007); and iii) studies of the mortality of *listed* IDUs.

In November 2011, the European Monitoring Centre for Drugs and Drug Addiction (EMCDDA) issued its review of *Mortality related to drug use in Europe: public health implications* (http://www.emcdda.europa.eu/publications/selected-issues/mortality). The EMCDDA had utilized: i) national estimates of problem opioid users or injecting drug users (IDUs), which are typically derived by CRC methods, see Fienberg (1972), Frischer et al. (1993), King and Brooks (2001) and *below*; ii) national statistics on drug-induced deaths, some subject to substantial registration delays (see http://www.rss.org.uk/site/cms/newsarticle.asp?chapter=15&nid=33; accessed on 12 April 2012), others to under-reporting, see Janssen (2011); and iii) studies of mortality among problem drug users who, for the most part, were enlisted because they had attended drug treatment services, been arrested, or been diagnosed with a blood-borne virus (see, for example: Strang et al., 2003; Davoli et al., 2007; Hickman et al., 2009; McDonald et al., 2009; Bird on behalf of European COSMO Workshop, 2010; Kimber et al., 2010; Gibson et al., 2011; Merrall et al., 2012). Follow-up in mortality studies was either by consent or by record-linkage with safeguards against deductive disclosure about individuals' identity, see Bird and Hutchinson (2003).

Capture-recapture methods to estimate IDU prevalence: In Scotland, CRC methods were first used by Frischer et al. (1993) to estimate Glasgow's number of current IDUs in the late 1980s: see also Frischer et al. (1997). Covariate-adjusted, Bayesian, and even single-list (Mascioli and Rossi, 2008; Hay and Smit, 2003) CRC methods have been variously deployed to estimate the number of IDUs. There has been serial use of CRC methods in Scotland and England (King et al., 2009; Hay et al., 2009; Surveys, Design and Statistics Subcommittee, 2008); use in resource-poor

countries, as reviewed by van Hest et al. (2011), in Eastern Europe (Uuskula et al., 2007), in multiple cities of England or France (Hickman et al., 2004; Vaissade and Legleye, 2009); and within a primary care trust where CRC analysis focused additionally on IDUs who were matchable to the primary care register ("registered") and for whom 2–year mortality could therefore be ascertained directly (Hickman et al., 2009). Hickman et al. (2009) neatly showed that the upper 95% confidence limit for the number of "registered" IDUs was *below* the lower 95% confidence limit for the totality of IDUs in the Bristol primary care trust. Whereas 2348 (72%) of around 3300 "registered" IDUs were listed on one or more of three data-sources, only 638 (28%) were of Bristol's roughly 2,300 "unregistered" IDUs. Neither death-rates nor how demography influences them need coincide between "registered" and "unregistered" IDUs, as a much higher proportion of the latter was hidden from services and, therefore, unlisted.

Drug-induced deaths: The EMCDDA report registered surprise - which we do not share (Bird et al., 2010b) - that, despite harm reduction measures such as opiate-substitution therapy, see Kimber et al. (2010), the numbers of drug-induced deaths have remained stable or increased in most countries since 2003. By contrast, Bird et al. (2003) and King et al. (2005; 2009; 2012) have drawn attention not only to higher drug-related death (DRD) rates per 100 IDUs in older IDUs but also to higher numbers of DRDs at older ages consequent upon the ageing (to 35+ years) in the 21st century of epidemic waves of IDUs who had commenced injecting in the 1980s – earlier in Scotland, for example, than in England.

Record-linkage studies of mortality: Record-linkage studies (and some cohorts) have been crucial for identifying listees' time-specific hazards for DRDs, such as: in the first and second fortnight after release from prison (Bird and Hutchinson, 2003; Farrell and Marsden, 2008; Merrall et al, 2010; Lyons et al., 2011); after inpatient detoxification (Strang et al., 2003), or in the first four weeks of, or after expiry of, methadone script (Cornish et al., 2010). See Kimber et al. (2010) for competing impacts of opiate substitution therapy on an Edinburgh IDU cohort's mortality and length of injecting career. Such studies have also highlighted demographic and other influences on listees' cause-specific mortality (McCowan et al., 2009; Bird on behalf of European COSMO Workshop, 2010; Merrall et al, 2012), and have been deployed to explain the divergence in mortality rates at ages 15-54 years between Scotland and England (Bloor et al., 2008), or to investigate how the relative importance of specific causes of death changes over time (McDonald et al., 2010; Gibson et al., 2011).

Published CRC studies for current IDUs typically reveal that a low to modest percentage (5% to 40%) only is listed on any particular data-source. The same data-sources tend to be used not only for CRC studies but also for mortality studies on IDUs who have accessed services. It is therefore plausible that DRD-rates and cofactors in unlisted current IDUs may differ from those who were listed (or captured).

Estimation of Scotland's DRD rates per 100 current IDUs: Rather than adhering just to record-linkage or cohort studies, important although these undoubtedly are, we have also tackled the estimation of Scotland's DRD-rates per 100 current IDUs by bringing together national statistics on drug-induced deaths (as numerator) and

Bayesian CRC estimates of current IDUs (as denominator). In doing so, we have taken account of IDUs' demography, namely: region, sex and age-group, see King et al. (2005, 2009, 2012). Our Bayesian CRC analyses allow for differential source by source, source by cofactor, and cofactor by cofactor capture-propensities, otherwise known as pairwise interactions.

Previously, see King et al. (2009), we estimated the number of Scotland's IDUs in 2003 as 27400 to nearest 100 (95% credible interval: 20700 to 32100). Our estimate was higher than had emerged when pairwise interactions were restricted to a maximum of two, see Bird et al. (2010b). Intriguingly, the posterior distribution for Scotland's IDUs in 2003 was bimodal with the lower mode around 21,000 which was similar to the estimate released by the then-Scottish Government. We were concerned by an apparent paradox: that, if the lower mode were genuine, the implication would be that Scotland's drugs-related death (DRD) rate per 100 IDUs had increased since 2000 – despite harm reduction efforts, see Bird et al. (2010b).

Not until 2010 did we have access to the cross-counts from Scotland's CRC study in 2006 which have enabled us to apply Bayesian CRC analysis to estimate Scotland's current IDUs in 2006 with the same prior assumptions as in 2003 and 2000, see King et al. (2009; 2005).

The new estimates are important for four reasons. First, CRC prevalence estimates, and consequently DRD rates per 100 current IDUs, are shown to be sensitive to the exclusion (as data-source) of recent HCV diagnoses, for whom IDU-risk may relate to past injecting. Secondly, we improved on how we count opiate-related DRDs by

accessing toxicological results directly, in the manner of Bird and Robertson (2011). The underlying, unproven assumption remains: that all Scotland's opiate-related DRDs pertain to current IDUs. Thirdly, Scotland's regions have changed so that the new geographical definition which applies from 2006 is Greater Glasgow and Clyde (GGC) versus the rest of Scotland whereas previously published Bayesian estimates were for Greater Glasgow versus elsewhere in Scotland.

METHODS

Drugs-related deaths: Since 2000, Scotland's deaths are coded by the 10th edition of the International Classification of Diseases (ICD10). We investigated Scotland's DRDs in 2006+2007 as defined UK-wide, see Jackson (2001) and General Register Office for Scotland, which comprised deaths involving drugs or attributed to drug dependence: mental and behavioural disorders due to psychoactive substance misuse (ICD10: F11-F16, F19); accidental poisoning (ICD10: X40-X44); intentional self-poisoning by drugs, medicaments and biological substances (ICD10: X60-X64); assault by drugs, medicaments and biological substances (ICD10: X85); and events of undetermined intent, poisoning (ICD10: Y10-Y14). Opiate-related DRDs are DRDs for whom toxicology revealed the presence of heroin/morphine or methadone.

Data-sources and designation as current IDU: In Scotland's national CRC study for current IDUs in 2006, individuals were recorded by four possible data-sources: social enquiry reports, DS1 (designation: if drug injecting was noted as an issue); hospital records, DS2 (ICD10 diagnoses indicative of injecting: 135, 180 and L02); drug treatment agencies (DTAs), DS3 (where designation was based on having injected in the past month); and recent Hepatitis C virus (HCV) diagnoses, DS4, for

whom designation was based on self-reported IDU-risk (past or present). Each individual was categorised by age (<35/35+), gender (male [M]/female [F]) and region (Greater Glasgow and Clyde [GGC]/rest of Scotland [rest]). In total, 5670 unique individuals were observed from the combination of sources. The cross-counts are provided in **Table 1** together with summary statistics.

Analysis: Bayesian analysis allowed the incorporation of independent, expert prior information on the total IDU-population size. The additional external information related to the observed number of opiate-related DRDs coupled with a prior interval for IDUs' DRD rate, which provided a prior interval for Scotland's number of IDUs. We used hierarchical log-linear models (Fienberg, 1972) to fit the cross-count data provided in **Table 1.**

We considered approximately 2 million log-linear models: those corresponding to all possible combinations of pairwise interactions (that is: interactions such as source *by* source, category *by* category and source *by* category). Pairwise interactions represent capture-dependencies between the data-sources and/or categorical variables. For example, a positive interaction between data-sources DS2 and DS3 indicates that being observed by data-source DS2 renders the individual more likely to be observed on DS3, and vice versa. A computationally intensive algorithm (Reversible jump Markov chain Monte Carlo) was used, see Green (1995), to explore the set of admissible models and obtain posterior summary statistics of the parameters of interest within each model including IDU-population size (median, mean and 95% "symmetric" credible interval, CI) for each of eight strata defined by region, gender and age-group as well as Scotland-wide. In addition, this algorithm permits the

estimation of the corresponding posterior model probabilities, which is a quantitative comparison of competing models, and thereby allows model-averaged estimates to be obtained that incorporate both parameter and model uncertainty in the population estimates. Model-averaged estimates are obtained by weighting the estimates from each individual model by the corresponding posterior model probabilities (King and Brooks, 2001). Of technical interest, simulations were run for 50 million iterations with the first 10% discarded as burn-in. To reduce memory-storage, simulations were thinned every 50 iterations.

Priors: The prior estimate for total IDU-population size was based on the number of opiate-related DRDs in 2006+2007 (any deaths with mention of heroin/morphine or methadone) and using the prior 90% interval of (0.5%, 2%) for IDUs' DRD-rate. Assuming a log-Normal prior on the total IDU-population, we specified the prior with median 34800 and 90% interval (17400, 69600). For all other parameters, we specified uninformative priors. As a sensitivity check, we repeated the analysis by specifying only vague uniform prior on the total IDU-population size, and confirmed that the CRC data dominated the informative prior anyway.

Exclusion of fourth data-source: A further, more critical sensitivity analysis was undertaken to investigate the effect of excluding one of the four Scottish data-sources, see **Figure 1**. Designation as current IDUs differed between data-sources: strictest for DTAs (DS3), least stringent for recent HCV diagnoses (DS4). We report the results of the sensitivity analysis when recent HCV diagnoses were excluded. Of the four data-source exclusions, only DS4 was associated with a high probability, 0.92, that IDU-population size was thereby reduced (and the reduction was primarily for IDUs aged

35+ years, as anticipated). The other probabilities were: 0.66, 0.35 and 0.61 for exclusion of DS1, DS2 and DS3 respectively.

RESULTS

Prevalence of current IDUs: Using all four data-sources first, and after exclusion of recent HCV diagnoses (DS4), we present, in **Table 2**, the model-averaged posterior median [mean] and symmetric 95% CI for the total IDU-population size and for each cross-classification of covariates. All posterior densities had a single uncomplicated mode.

Table 3 shows that, irrespective of inclusion/exclusion of DS4, Scotland's estimated mean numbers of current IDUs aged 15-34 years were closely similar for 2000 (King et al., 2005), 2003 (King et al., 2009) and 2006, namely: 22300 in 2000; 19900 in 2003; and 19300/18700 in 2006 (to nearest 100). By contrast, whether the sharp increase in Scotland's estimated number of current IDUs aged 35+ years that was apparent between 2000 and 2003 has continued into 2006 depends critically on inclusion/exclusion of DS4: from 4100 in 2000 through 7500 in 2003 to 12400/6300 in 2006 (to nearest 100). For both genders, Scotland had a nearly 3-fold increase in its older IDUs between 2000 and 2006 when using all four data-sources; but the rise stalled in 2006 if recent HCV diagnoses are excluded from our CRC analysis.

Irrespective of inclusion/exclusion of DS4, we note that the posterior median [mean] male to female IDU ratio was 2.9 [2.9/3.0] with 95% symmetric credible interval respectively (2.7, 3.1)/(2.6, 3.6) for DS4 included/excluded.

Opiate-related DRDs per 100 current IDUs: Scotland's numbers of opiate-related DRDs in 2006+2007 (those with any mention of heroin/morphine or methadone) were used in conjunction with stratum-specific prevalences in **Tables 4** and **5** (respectively according to inclusion and exclusion of DS4) to provide, for strata defined by region, gender and age-group, an estimated annual opiate-related DRD rate per 100 current IDUs and 95% credible interval. The higher rates are in **Table 5**, on which we base our initial commentary.

Table 5 confirms the pattern (but not level) of IDUs' DRD-rates in King et al. (2009), namely: among younger IDUs, males' opiate-related DRD rate is substantially higher than for females. But, among IDUs aged 35+ years, females do not experience a significantly lower opiate-related DRD rate.

For older males, there were 1.9 opiate-related DRDs annually per 100 current IDUs (95% CI: 1.2 to 2.4) by exclusion of DS4, but 1.3 per 100 current IDUs (95% CI: 0.9 to 1.6) otherwise, see **Table 4**.

For younger males, the rates were respectively 1.4 (95% CI: 1.0 to 1.8) in **Table 5** and 1.3 (95% CI: 1.0 to 1.5) in **Table 4**.

Please see **Appendix** for discussion of capture propensities in 2006.

DISCUSSION

Scotland's CRC studies in 2000, 2003 and 2006 have each relied on DS4, recent HCV diagnoses (with self-reported IDU-risk taken as proxy for current IDU), as one of four

data-sources. This reliance has been more questionable since the HCV consensus statement by the Royal College of Physicians of Edinburgh in April 2004 that "high priority for case finding should be given to former injecting drug users" and the conclusion of Hutchinson et al. (2005) that Scotland's HCV testing and treatment should focus on older former IDUs because of their high HCV carriage, likely progression towards cirrhosis, and negligible risk of HCV re-infection. Moreover, increase in such testing was a specific aim in Phase II of Scotland's Hepatitis C Action Plan, which had prompted us to check more recent reliance on DS4 in 2009 and to back-check on 2006. Dramatically, the 2006 CRC estimation of Scotland's older current IDUs is reduced by a third when DS4 is excluded as an inadmissible data-source for identifying current IDUs. Further work, both methodological and epidemiological, is ongoing to determine if we can re-instate at least partial use of DS4-listed IDUs, only some of whom are current IDUs.

With DS4, there has been a near trebling in Scotland's number of current IDUs who are aged 35+ years between 2000 and 2006. Without DS4, the doubling in Scotland's number of current IDUs between 2000 and 2003 appears to have stalled by 2006. Scotland has seen a doubling between 2000 and 2006 in DRDs in those aged 35+ years (206 in 2000+2001, 255 in 2003+2004, 409 in 2006+2007, 555 in 2009+2010), see General Register Office for Scotland (2009) and Drug Misuse Statistics Scotland 2010 (2011). Corresponding statistics on opiate-related DRDs in those aged 35+ years are not routinely published but were: 140 in 2000+2001, 169 in 2003+2004, 306 in 2006+2007, 424 in 2009+2010. Neither rise is as dramatic as Scotland's estimated increase in older current IDUs by inclusion of DS4.

As shown in **Tables 4** and **5**, the counterpoint to lower estimated prevalence of older current IDUs is acknowledgement that their experienced estimated rate of opiate-related DRD per 100 current IDUs is higher (1.9; 95% credible interval: 1.2 to 2.4). If older current IDUs' rate of opiate-related DRD is also higher, even for males, than at 15-34 years of age, then Scotland's continued, albeit slower, increase in older opiate-related DRDs in and beyond 2006+2007 may be accounted for more by the said higher rate than by increasing prevalence.

For the 2003 estimation of opiate-related DRDs per 100 current IDUs, King et al. (2009) assumed that 80% of Scotland's DRDs at ages 15-44 years were opiate-related but only 20% thereafter. Although we have now improved the toxicological basis for the numerator, for opiate-related deaths in the younger age-group, there was about a 25% increase between the estimated rates for 2003 and **Table 4**'s rates for opiate-related DRD per 100 IDUs in 2006 but consistency in the older age-group. However, by exclusion of DS4 as an admissible data-source together with direct access to toxicology, we should conclude that opiate-related DRD rates have increased by about a third in all three summary strata (females aged 15-34 years, males aged 15-34 years, all aged 35+ years) between 2003 and 2006. The latter has more uncomfortable connotations for public health policy than to have supposed that the increase in Scotland's DRDs in the older age-group was primarily a consequence of the ageing of an epidemic wave of IDU-initiates in the early to mid 1980s.

Females' opiate-related DRD rate per 100 IDUs at 15-34 years of age is about half that of their male counterparts but, in Scotland, this female advantage is not maintained into the older age group. A more powerful Bayesian analysis, with no

reliance on recent HCV diagnosis, of current IDUs' opiate-related deaths in England in 2005/06 (King et al., 2012) offers a gender-qualification – whereby there may be some residual, but reduced, female advantage in older age.

The sensitivity of Scotland's estimated prevalence of older current IDUs to inclusion/exclusion of recent HCV diagnoses as an admissible data-source, wherein IDU-risk was past or current, shows that attention needs to be paid to how current IDUs are identified in cross-linked CRC data-sources. Failure to recognise, or capture, all current IDUs within a particular data-source may be a less serious problem than mis-attribution of current IDU-status to past injectors. Differences in prevalence estimates per stratum with/without inclusion of Scotland's recent HCV diagnoses were primarily as anticipated: in the older cohort.

Early in 2012, Scotland released cross-counts to enable Bayesian estimation of its numbers of current IDUs in 2009, for which the present analysis, unlike that for 2003, see King et al. (2009), is a geographically-consistent benchmark. The CRC prevalence estimates for 2009, like those for 2006, are sensitive to exclusion (as data-source) of recent HCV diagnoses.

Besides how current IDU is defined, it is important to consider and, as Hickman et al (2004) did, to report listees' representativeness when we are tempted to generalize from DRD-rates or prognostic factors that were revealed by record-linkage studies of *listed* IDUs' mortality. Even the largest of Scotland's four CRC source-datasets (DTAs) listed only an estimated 11%/14% (3504 out of 31700/25000) of Scotland's

IDUs in 2006 (with 95% credible intervals of (9%, 14%)/(10%, 17%)) whereas, for example, the needle and syringe programme of Bristol's primary care trust had listed 35% (1929) of that trust's current IDUs and its DTAs in combination with laboratory records had listed 43% (2365).

Explanations for the lower age-differential in DRD-rates seen in European cohort studies, see for example Bird on behalf of European COSMO Workshop (2010), as compared with bringing together national numerators and denominators include: firstly, that sex and age-group may interact (as here) in their influence on opiate-related DRD-rate; secondly, the limited representativeness of those enlisted into cohorts or record-linkage studies; and thirdly, the impact of harm-reduction interventions offered to listees, especially if designed to mitigate DRD-risk, see Kimber et al. (2010), whereas the unlisted have not accessed these and so may have correspondingly higher unmitigated risk.

The third of Scotland's serial four data-source Bayesian CRC estimations has been complicated by the IDU-risk of older recent HCV diagnoses being, to an increasing extent, non-current due to the early impact of findings by Hutchinson et al. (2005) on high Hepatitis C carriage by older former IDUs which have since been formalised as the testing and treatment aims in Phase II of Scotland's Hepatitis C Action Plan for 2008-11.

If, indeed, Scotland had only 25000 current IDUs in 2006, only 8200 of them aged 35+ years, their opiate-related DRD rate is higher at 1.9 (95% CI: 1.2 to 2.4) per 100 older current IDUs has been appreciated hitherto. The counter-balancing good news in

public health terms is, as shown in **Table 3**, that the hitherto sharp increase in older current IDUs had stalled by 2006. [3961 words]

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Table 1: Number of individuals observed: (a) in each combination of data-sources per demographic cross-classification; (b) by each demographic characteristic (GGC = Greater Glasgow & Clyde; Rest = rest of Scotland), or data-source (DS1 = social enquiry reports; DS2 = hospital records; DS3 = drug treatment agencies; DS4 = recent HCV diagnoses).

(a)

DS1	DS2	DS3	DS4	Male <35 GGC	Male 35+ GGC	Female < 35 GGC	Female 35+ GGC	Male <35 Rest	Male 35+ Rest	Female < 35 Rest	Female 35+ Rest	*Total*
0	0	0	0	?	?	?	?	?	?	?	?	*?*
1	0	0	0	97	60	41	13	278	67	86	12	*654*
0	1	0	0	77	111	48	34	173	144	108	56	*751*
1	1	0	0				0		0	5	0	*19*
0	0	1	0	292	149	117	26	1379	431	584	114	*3092*
1	0	1	0	7		5	0	110	16	53		*198*
0	1	1	0	6	5	7		39	27	24	9	*121*
1	1	1	0		0	0	0					*8*
0	0	0	1	122	135	48	38	134	104	78	25	*684*
1	0	0	1				0	6	0		0	*13*
0	1	0	1	5	10			7	7	5		*43*
1	1	0	1	0		0	0		0	0	0	
0	0	1	1					27	13	18		*69*
1	0	1	1		0	0	0	5		0	0	*7*
0	1	1	1		0	0	0					*9*
1	1	1	1	0	0	0	0	0	0	0	0	*0*
				620	482	276	120	2167	812	968	225	

Counts 1 to 4 have been replaced by blanks in (a) pending permission for disclosure.

(b)

Summary statistics by data-source, or characteristic	DS1	DS2	DS3	DS4	Male	Female	< 35	35+	GGC	Rest
IDUs observed	901	953	3504	827	4081	1589	4031	1639	1498	4172

Footnote to Table 1: It took 9 months in 2010 for us to be given access to the cross-counts for 2006, and we still do not have permission to disclose low cross-counts. Thus counts of 1 to 4 have temporarily been replaced by blanks. We hope that, by the time of publication, redaction should be unnecessary as a) we consider it good practice for other analysts to have access to basic data and b) there is no possibility of deductive disclosure about individuals.

Table 2: Posterior median [mean] and 95% "symmetric" credible intervals (CI) rounded to nearest 100 for number of current IDUs, overall and per-stratum: M = male, F = female; 15-34 and 35+ denote age-groups; GGC = Greater Glasgow and Clyde; Rest = rest of Scotland.

Current IDUs per stratum: to nearest 100	**2006: all 4 data-sources**		**2006: having excluded recent HCV diagnoses**	
	Model-averaged median [mean]	95% CI	Model-averaged median [mean]	95% CI
M, 15-34, GGC	4200 [4300]	(3000, 6000)	3300 [3400]	(2600, 4900)
M, 35+, GGC	4500 [4600]	(3100, 6500)	2800 [2900]	(2100, 4400)
F , 15-34, GGC	1800 [1800]	(1200, 2600)	1300 [1300]	(1000, 2000)
F , 35+, GGC	1100 [1100]	(700, 1600)	600 [600]	(400, 1000)
M, 15-34, Rest	9100 [9200]	(7100, 11300)	8200 [8400]	(6800, 11700)
M, 35+, Rest	5400 [5400]	(3800, 7000)	3900 [4000]	(3000, 5800)
F , 15-34, Rest	3900 [3900]	(3000, 4800)	3300 [3400]	(2700, 4700)
F , 35+, Rest	1300 [1300]	(900, 1700)	900 [900]	(700, 1300)
Total	**31500 [31700]**	**(24900, 38700)**	**24300 [25000]**	**(20700, 35000)**

Table 3: Posterior median [mean] and 95% "symmetric" credible intervals (CI) rounded to nearest 100 for the number of current IDUs per gender and age-group stratum in 2000, 2003 and 2006: 15-34 and 35+ denote the age-groups.

Gender & age-group stratum in serial Bayesian capture-recapture analyses	*Model-averaged median for Scotland's current IDUs*			
	2000[1 2] *(from King et al., 2005)*	*2003*[2] *(from King et al., 2009)*	2006: all 4 data-sources **2006: having excluded recent HCV diagnoses**	
			Median [mean]	95% CI
Male, 15-34	*16000*	*13400*	13400 [13500] **11500 [11800]**	(10600, 16500) **(9500, 16500)**
Male, 35+	*3300*	*5800*	9900 [10000] **6700 [6900]**	(7300, 12800) **(5200, 10100)**
Female , 15-34	*6300*	*6500*	5700 [5800] **4600 [4700]**	(4500, 7000) **(3700, 6600)**
Female , 35+	*800*	*1700*	2400 [2400] **1500 [1600]**	(1700, 3100) **(1100, 2300)**

[1] Footnote to **Table 3**: Outwith Greater Glasgow, four island and other health areas did not take part in the 2000 CRC study, to account for which a modest proportionate adjustment (by 1.15) was made by King et al. (2005). Also, only two CRC data-sources (social enquiry reports; recent HCV diagnoses) in 2000 were the same as in 2003 and 2006; and the numerator used was all DRDs rather than opiate-related DRDs.

[2] Footnote to **Table 3**: The estimates for 2000 and 2003 included the HCV database as a data source in the CRC analyses.

Table 4: Posterior median [mean] and 95% "symmetric" credible intervals (CI) by gender and age-group stratum for the annual opiate-related DRD rate per 100 current IDUs in 2006 – all 4 data-sources in play.

Stratum	Current IDUs: model-averaged median [mean]: to nearest 10	Opiate-related DRDs in 2006+2007	Annual mean opiate-related DRD rate per 100 current IDUs (95%CI)
All Scotland: summary strata			
Female, 15-34	5720 [5750]	57	**0.50** (0.40, 0.62)
Male, 15 - 34	13440 [13530]	333	**1.25** (0.99, 1.53)
Male & Female 35+ years	12280 [12390]	306	1.24 (0.90, 1.59)
All Scotland: Males			
15 - 34	13440 [13530]	333	**1.25** (0.99, 1.53)
35+ years	9900 [9990]	251	**1.28** (0.94, 1.64)
All Scotland: Females			
15 - 34	5720 [5750]	57	**0.50** (0.40, 0.62)
35+ years	2380 [2400]	55	**1.17** (0.84, 1.52)
Greater Glasgow & Clyde: Males			
15 - 34	4180 [4330]	115	**1.37** (0.91, 1.83)

35+ years	4450 [4600]	114	**1.29** (0.82, 1.74)
Greater Glasgow & Clyde: Females			
15 - 34	1770 [1830]	26	**0.73** (0.48, 0.98)
35+ years	1060 [1090]	26	**1.24** (0.78, 1.71)
Rest of Scotland: Males			
15 - 34	9140 [9200]	218	**1.20** (0.94, 1.50)
35+ years	5360 [5390]	137	**1.30** (0.94, 1.71)
Rest of Scotland: Females			
15 - 34	3900 [3920]	31	**0.40** (0.31, 0.50)
35+ years	1300 [1310]	29	**1.14** (0.81, 1.51)

Table 5: Posterior median [mean] and 95% "symmetric" credible intervals (CI) by gender and age-group stratum for the annual opiate-related DRD rate per 100 current IDUs in 2006 – after exclusion of recent HCV diagnoses (data-source DS4).

Stratum	Current IDUs: model-averaged median [mean]: to nearest 10	Opiate-related DRDs in 2006+2007	Annual mean opiate-related DRD rate per 100 current IDUs (95%CI) *Also from King et al. (2009) for 2003*
All Scotland: Summary Strata			
Female, 15-34	4600 [4720]	57	**0.61** (0.43, 0.76) *2003: **0.38** (0.31, 0.49)*
Male, 15 - 34	11480 [11810]	333	**1.43** (1.01, 1.75) *2003: **0.98** (0.81, 1.25)*
Male & Female 35+ years	8180 [8480]	306	**1.85** (1.24, 2.37) *2003: **1.21** (0.95, 1.63)*
All Scotland: Males			
15 - 34	11480 [11810]	333	**1.43** (1.01, 1.75) *2003: **0.98** (0.81, 1.25)*
35+ years	6680 [6920]	251	**1.86** (1.24, 2.40) *2003: **1.22** (0.95, 1.64)*
All Scotland: Females			
15 - 34	4600 [4720]	57	**0.61** (0.43, 0.76) *2003: **0.38** (0.31, 0.49)*
35+ years	1500 [1560]	55	**1.82** (1.19, 2.41) *2003: **1.18** (0.91, 1.62)*

Greater Glasgow & Clyde: Males			
15 - 34	3280 [3390]	115	**1.74** (1.17, 2.21)
35+ years	2800 [2910]	114	**2.02** (1.30, 2.67)
Greater Glasgow & Clyde: Females			
15 - 34	1310 [1350]	26	**0.99** (0.66, 1.28)
35+ years	610 [640]	26	**2.12** (1.33, 2.91)

Rest of Scotland: Males			
15 - 34	8190 [8420]	218	**1.32** (0.93, 1.60)
35+ years	3880 [4010]	137	**1.75** (1.17, 2.25)
Rest of Scotland: Females			
15 - 34	3290 [3370]	31	**0.47** (0.33, 0.58)
35+ years	890 [920]	29	**1.62** (1.08, 2.14)

APPENDIX on Capture Propensities

Using four data-sources: Posterior marginal probabilities of the presence of each possible two-way interaction are shown in **Table A1**. See King et al. (2009) for the 2003 version, but recall that regional geographies differ between the 2003 and 2006 analyses. We note that whereas in 2003 the interaction between hospital records and age was, perhaps surprisingly, non-essential, its inclusion in the 2006 analysis conveys that hospital record was more likely for IDUs aged 35+ years. In 2006, the only non-essential source by age interaction was recent HCV diagnosis (as also in 2003). Finally, age-group by gender was a key interaction which signalled, as in 2003, that the male to female ratio was less extreme for younger IDUs.

Table A1: Posterior probability of each two-way interaction, with its posterior mean (standard deviation) when present. DTA = Drug Treatment Agency

Interaction in 2006: *vs 2003*	**Posterior probability**	**Effect size: Mean (sd)**
Source by Source		
DS1 (social) x DS2 (hospital): *Lost significance*	0.083	0.002 (0.017)
DS1 (social) x DS3 (DTA): *Effect doubled in 2006*	**1.000**	**0.193 (0.041)**
DS1 (social) x DS4 (HCV)	0.079	0.000 (0.017)
DS2 (hospital) x DS3 (DTA): *Effect at least halved in 2006*	**0.700**	**0.068 (0.054)**
DS2 (hospital) x DS4 (HCV)	**0.998**	**0.212 (0.048)**
DS3 (DTA) x DS4 (HCV)	0.087	-0.001 (0.017)

Covariate by Covariate		
Age (35+) x Sex (Female)	**1.000**	**-0.144 (0.018)**
Age (35+) x Region (Rest)	**1.000**	**-0.134 (0.017)**
Sex (Female) x Region (Rest)	0.035	0.001 (0.004)
Source by Covariate		
DS1 (social) x Age (35+)	**1.000**	**-0.208 (0.030)**
DS2 (hospital) x Age (35+): *Acquired significance in 2006*	**0.912**	**0.075 (0.034)**
DS3 (DTA) x Age (35+)	**1.000**	**-0.178 (0.027)**
DS4 (HCV) x Age (35+)	0.133	0.006 (0.021)
DS1 (social) x Sex (Female): *Lost significance in 2003*	0.126	-0.005 (0.015)
DS2 (hospital) x Sex (Female): *Acquired significance in 2006*	**1.000**	**0.104 (0.020)**
DS3 (DTA) x Sex (Female)	0.047	0.001 (0.007)
DS4 (HCV) x Sex (Female)	0.138	0.006 (0.017)
DS1 (social) x Region (Rest)	0.509	0.052 (0.062)
DS2 (hospital) x Region (Rest) *Lost significance in 2006*	0.320	0.031 (0.051)
DS3 (DTA) x Region (Rest): *Acquired significance in 2006*	**1.000**	**0.247 (0.053)**
DS4 (HCV) x Region (Rest)	**0.768**	**-0.092 (0.057)**

After exclusion of recent HCV diagnoses: Posterior marginal probabilities of the presence of each possible two-way interaction are shown in **Table A2**. From **Table A1**, two significant

pairwise interactions, shown above in yellow, which involved recent HCV diagnoses became inadmissible in **Table A2**, where the only other change of note is further diminished importance for interaction between DS2 (hospital) & DS3 (DTA).

Table A2: Having excluded DS4 (recent HCV diagnoses) as data-source, posterior probability of each two-way interaction, with its posterior mean (standard deviation) when present. DS1= social enquiry reports; DS2= hospital records; DS3= drug treatment agencies.

Interaction in 2006	**Posterior probability**	**Effect size: Mean (sd)**
Source by Source		
DS1 (social) x DS2 (hospital)	0.139	-0.004 (0.024)
DS1 (social) x DS3 (DTA)	**0.998**	**0.145 (0.043)**
DS1 (social) x DS4 (HCV)	*Inadmissible*	
DS2 (hospital) x DS3 (DTA)	**0.207**	**0.013 (0.036)**
DS2 (hospital) x DS4 (HCV**)**	*Inadmissible*	
DS3 (DTA) x DS4 (HCV)	*Inadmissible*	
Covariate by Covariate		
Age (35+) x Sex (Female)	**1.000**	**-0.146 (0.020)**
Age (35+) x Region (Rest)	**1.000**	**-0.135 (0.019)**
Sex (Female) x Region (Rest)	0.057	0.001 (0.006)
Source by Covariate		
DS1 (social) x Age (35+)	**1.000**	**-0.164 (0.030)**
DS2 (hospital) x Age (35+)	**0.974**	**0.131 (0.041)**
DS3 (DTA) x Age (35+)	**1.000**	**-0.124 (0.040)**
DS4 (HCV) x Age (35+)	*Inadmissible*	

DS1 (social) x Sex (Female)	0.121	-0.003 (0.013)
DS2 (hospital) x Sex (Female**)**	**0.997**	**0.123 (0.020)**
DS3 (DTA) x Sex (Female)	0.384	0.019 (0.029)
DS4 (HCV) x Sex (Female)	*Inadmissible*	
DS1 (social) x Region (Rest)	0.299	0.016 (0.029)
DS2 (hospital) x Region (Rest)	0.096	0.001 (0.014)
DS3 (DTA) x Region (Rest)	**1.000**	**0.211 (0.024)**
DS4 (HCV) x Region (Rest)	*Inadmissible*	

For the most part, interactions that were salient in 2003 were so also in 2006 with exceptions potentially reflecting changes in how current IDUs access services. Some of the changes, such as hospital listing, may be a consequence of the ageing of Scotland's IDU-population, others a reflection of regional variation in service delivery. We shall know more when the 2010 CRC analysis is complete so that a fourth pillar can be added to the demographic tallies of IDUs in Scotland in the 21st century.