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Age, period and cohort trends in drug abuse hospitalizations within the total Swedish population (1975–2010)☆

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ABSTRACT

Background: The societal consequences of drug abuse (DA) are severe and well documented, the World Health Organization recommending tracking of population trends for effective policy responses in treatment of DA and delivery of health care services. However, to correctly identify possible sources of DA change, one must first disentangle three different time-related influences on the need for treatment due to DA: age effects, period effects and cohort effects.
Methods: We constructed our main Swedish national DA database (spanning four decades) by linking healthcare data from the Swedish Hospital Discharge Register to individuals, which included hospitalisations in Sweden for 1975–2010. All hospitalized DA cases were identified by ICD codes. Our Swedish national sample consisted of 3078,129 men and 2921,816 women. We employed a cross-classified multilevel logistic regression model to disentangle any net age, period and cohort effects on DA hospitalization rates.
Results: We found distinct net age, period and cohort effects, each influencing the predicted probability of hospitalisation for DA in men and women. Peak age for DA in both sexes was 33–35 years; net period effects showed an increase in hospitalisation for DA from 1996 to 2001; and in birth cohorts 1968–1974, we saw a considerable reduction (around 75%) in predicted probability of hospitalisation for DA.
Conclusions: The use of hospital admissions could be regarded as a proxy of the population's health service use for DA. Our results may thus constitute a basis for effective prevention planning, treatment and other appropriate policy responses.

1. Introduction

The overall health, social and financial costs of drug abuse (DA) are well documented (United Nations Office on Drugs and Crime, 2012), with the World Health Organization (WHO) recommending tracking of population trends in DA for appropriate policy responses and effective prevention planning, treatment and delivery of health services (WHO, 2000).

A previous study compared the use of health services between chronic drug users and non-drug users and found that chronic drug users consumed significantly more inpatient and emergency care but less outpatient care relative to non-drug users. The same study also found that the total health care cost per individual was higher among chronic drug users (French et al., 2000). Another study found that chronic drug use in those aged 18–44 years who were admitted to hospital was 14% (Smothers and Yahr, 2005). This indicates that it is highly relevant to study hospital admissions in the context of DA, which was the purpose of the present study.

There are several individual and contextual predictors of hospital admissions for DA, such as ethnicity (Leao et al., 2006; Patterson et al., 1999), socioeconomic factors (Kendler et al., 2012), having health care insurance (DiCola et al., 2013; Santora and Hutton, 2008) and neighborhood characteristics (Kendler et al., 2013a; Sundquist and Frank, 2004). However, individual and contextual DA risk factors may exert different levels of influence in different time periods. Established DA monitoring agencies in the United States (Johnston et al., 2011) and Europe (European Monitoring Centre for Drugs and Drug Addiction, 2012) have reported fluctuations in

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DA over past decades, which make it difficult to predict the use of health services over time. It is, therefore, important to disentangle three different time-related influences: *age effects*, *period effects* and *cohort effects*.

Age effects reflect variation in risk of DA attributable to the ageing process. Conversely, period effects reflect variations in risk of DA that influence all age groups simultaneously, e.g. period-specific changes in the popularity and availability of substances of abuse (Nyabadza and Hove-Musekwa, 2010; Smith, 2006; Yu, 2012). Finally, cohort effects reflect variation in risk of DA among individuals who are defined by some shared historical experience, such as year or decade of birth.

The three time-related influences are not independent and are inherently confounded (Degenhardt et al., 2008; Holdcraft and Iacono, 2004; Mason et al., 1973; Roxburgh et al., 2010). The most appropriate solution is, therefore, to consider all three effects simultaneously by performing an age–period–cohort analysis (Smith, 2008).

Only three studies have employed age–period–cohort analyses in the field of DA, all focusing on only one specific substance (marijuana) and utilising national cross-sectional survey data (Kerr et al., 2007; Miech and Koester, 2012; Piontek et al., 2012). However, survey data can be inherently biased (Johnson and Fendrich, 2005), especially when estimating health care use among individuals with DA. There is therefore a need for studies using relevant proxies for health care use for DA, such as hospital admissions.

In Sweden, data from multiple nationwide registries and healthcare data can be linked via the unique 10-digit personal identification number assigned at birth (or immigration) to *all* Swedish residents. This has enabled the creation of a unique Swedish national-level DA dataset, spanning many decades and avoiding the problems of reporting bias common to survey-based data (Kendler et al., 2013b, 2012). However, results obtained from registry-based data used in age–period–cohort analyses are only valid if assessment of the outcome under investigation is also stable, accurate and complete over time. Of all the Swedish DA data available, only the Hospital Discharge Register fulfils these criteria. It contains data on all individual hospital admissions from all regions in Sweden and spans over four decades. The use of hospital admissions is a relevant proxy of the population's health service use for DA, which may constitute a basis for effective prevention planning, treatment and other appropriate anti-DA policy responses (WHO, 2000).

The aim of this study was to investigate the *net* effects of age, period and cohort on overall DA hospitalization rates within the total Swedish population, from 1975 to 2010. We hypothesised that the net effect of age on DA hospitalization rates would be strongest in young adults, with rates later declining in line with age-related psychological and sociological life course changes. We further hypothesised that DA hospitalization rates would be influenced by significant net period effects, as changes (for example) in substance popularity or national health policy occurred over time. As this study spanned four decades, we also expected to identify net birth cohort effects on DA hospitalization rates.

2. Methods

We formed our database from the national Swedish Hospital Discharge Register, linking them to individuals using Swedish 10-digit personal ID numbers. We identified DA cases using main and secondary diagnosis ICD codes (ICD8: Drug dependence (304); ICD9: Drug psychoses (292) and Drug dependence (304); and ICD10: Mental and behavioural disorders due to psychoactive substance use (F11–F19), excluding alcohol (F10) or tobacco (F17)). This study was approved on 30th November 2011 by the Regional Ethical Review Board in Lund, Sweden (approval no. 2011/675).

2.1. Sample

We based all age–period–cohort analyses on individuals aged fifteen years or more, born between 1950 and 1994. We divided the population into fifteen three-year birth cohorts (1950–1952, 1953–1955 ... 1992–1994). We also created twelve three-year periods (1975–1977, 1978–1980... 2008–2010) within which to estimate our overall DA hospitalization rates. Individuals born in the first five cohorts had the potential to be recorded as drug abusers across all twelve periods; individuals born in the last birth cohort (1992–1994) across the final two periods only. For each period, we estimated a three-year DA hospitalization rate within each birth cohort from hospital discharge diagnoses that contained any of the ICD codes previously described. As past DA research has identified that men are approximately twice more likely to use and abuse illicit substances than women (Fothergill and Ensminger, 2006; Hicks et al., 2007; Kloos et al., 2009; Wetherington, 2007), we stratified our sample according to gender.

In total, we had 48,267,747 observations from the total Swedish population: 24,734,203 for males and 23,533,544 for females. For each of the twelve periods, we calculated the age of each individual as the 'middle' period year minus the year of birth. For example, in period 2 (1978–1980), a person born in 1950 would be considered aged 29 years (their age in year 1979). Individuals had to be alive at the beginning of each period in order to be included in the analyses for that period.

2.2. Statistical analysis

We used a cross-classified multilevel logistic regression model to disentangle the age–period–cohort effects (Fielding and Goldstein, 2006; Yang and Land, 2008) with age being the only fixed effect. Such a model comprises observations nested within a cross-classification of two different hierarchies and takes into account any 'cohort' and 'period' influences on DA. We estimated two variance components, one for period and one for cohort. We addressed the linear dependency problem (Mason et al., 1973) by including a non-linear (quadratic) age effect in the model ('age squared').

We present the variance components attributed to the different classifications and the sum of the two variance components, together with a 95% credible interval (CI), as the intra-class correlation (ICC). The ICC measures the correlation between the responses of individuals from the same period/cohort, and may be interpreted as the proportion of the total residual variation in DA that is due to differences between periods and/or cohorts. We calculated the ICC using the latent variable method (Snijders and Busker, 1999), which assumes the existence of a latent individual variable that follows a logistic distribution with a variance equal to 3.29 ($\pi^2 - 3$).

As the number of observations exceeded 24 million for each gender, we took a random 10% sample for the estimation process. We repeated our analyses using a further three random 10% samples to ensure the robustness of our results. All statistical analyses were performed using SAS 9.2 (SAS Institute Inc, 2008) and MLwiN (Rasbash et al., 2012).

An ancillary analysis was performed to disentangle net age, period and cohort effects using all available Swedish DA data sources (see supplemental material) in an attempt to reflect the overall need for treatment for DA in the Swedish population over four decades.

3. Results

The estimated hospitalization rates for DA across each birth cohort and period, stratified by sex, is shown in Table 1a and Table 1b as percentages. Patterns of hospitalization rates within each cohort over the thirteen study periods relate to the age curves shown in Fig. 1. Hospitalization rates for DA will below, in some cases, be referred to as only "DA".

3.1. Net age effects

3.1.1. Men. The net effects of centred 'age' and 'age-squared' on DA are shown in Table 2 as odds ratios (ORs). 'Age' was positively associated with DA, whereas the quadratic term was negatively associated (OR = 1.062 and 0.996, respectively). These ORs correspond to the predicted probability curve shown in Fig. 1a, which represents the total net effect of age on overall DA hospitalization rates during the study period (1975–2010) for all men born in Sweden in 1950–1994. The predicted probability is about 0.1% at 15 years of age, rising steadily to 0.6% by age 35 before steadily declining, i.e. 0.6% of all Swedish men aged 35 years are recorded for hospitalization due to DA.

3.1.2. Women. The net effects of age on DA in women are also shown in Table 2 as ORs, with similar patterns of association seen in women as in men (OR = 1.034 and 0.997, respectively). Fig. 1b represents the total net effect of age on the predicted probability of DA hospitalization rates during the study period for all women born