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Pharmaceutical sales of pseudoephedrine: the impact of electronic tracking systems on methamphetamine crime incidents

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ABSTRACT

Background and aims Electronic tracking systems (ETS) are used extensively in pharmacies across the United States and Australia to control suspicious sales of pseudoephedrine. This study measures the impact of one ETS—Project STOP—on the capacity of police to reduce production, supply and possession of methamphetamine. Design Using official police data of incidents of production, supply and possession from January 1996 to December 2011 (n = 192 data points/months over 16 years), we used a quasi-experimental, time-series approach. Setting The State of Queensland, Australia. Participants No individual participants are included in the study. The unit of analysis is reported police incidents. Measurements The study examines the impact of the ETS on production (n = 5938 incidents), drug supply and trafficking (n = 20094 incidents) and drug possession or use (n = 118926) of methamphetamine. Findings Introduction of the ETS in November 2005 was associated with an insignificant decrease (P = 0.15) in the production of methamphetamine. The intervention was associated with a statistically significant increase in supply incidents (P = 0.0001). There was no statistically significant effect on the incidence of possession (P = 0.59). Conclusions Electronic tracking systems can reduce the capacity of people to produce methamphetamine domestically, but seem unlikely to affect other aspects of the methamphetamine problem such as possession, distribution and importation.

Keywords Drug production, drug supply, electronic tracking systems, methamphetamine, Project STOP, pseudoephedrine.

INTRODUCTION

The production and supply of and demand for methamphetamine is a global problem, with the increasing illicit use of methamphetamine since 2010 creating significant problems for Australia and countries throughout the world [1–3]. The reliance upon precursor chemicals in methamphetamine production both defines and distinguishes methamphetamine problems from patterns of production, supply and possession of other types of illicit drugs (see [4]). Government responses to methamphetamine problems, therefore, are often focused upon controlling the diversion of precursor chemicals from the licit to the illicit market (see [5,6]). Cherney and colleagues [5] refer to this form of regulatory control as ‘meta-regulation’. Meta-regulation involves tackling diversion of precursor chemicals using various legal and agency interventions at the various levels of government.

One type of meta-regulation activity is recording and monitoring sales of precursor chemicals by non-state agents, such as pharmacists [7–9]. In the United States, various states developed ETS after 2008 to monitor pseudoephedrine (PSE)-based medication sales. ETS initiatives aim to support law enforcement, reduce ‘pseudo running’ and counteract limitations in the legislative requirements for recording PSE sales. By December 2015, 29 states in the United States had implemented online real-time tracking of PSE sales and another 11 states had reclassified PSE sales of pseudoephedrine.
as a Schedule V product available for purchase from pharmacies only, with valid identification and signing of logbooks [10,11]. Two states in the United States (Mississippi and Oregon) have rescheduled PSE as a prescription-only medicine, ensuring that sales are monitored via prescription monitoring programs, an approach also introduced in New Zealand in 2011. In the United States, one of the most commonly implemented ETS is the National Precursor Log Exchange (NPLEX) [12,13]. The National Association of Drug Diversion Investigators (NADDI) provides the service and the technology that is used in MethCheck: 17 states use NPLEX, although Freeman & Talbert argue that ‘...published data demonstrating the impact of tracking programs is somewhat lacking as the approach is relatively new’ ([10], p. 21).

In Australia, stringent recording and monitoring requirements were introduced into Queensland in November 2005, and rolled out fully by January 2006 [14], while other Australian states followed later (see [15]). The first requirement of the legislation obligated pharmacists to supervise the sale of PSE directly to establish customers’ therapeutic need for the drug. The second requirement was for all PSE products to be rescheduled as pharmacy-only medicine, and formulations of a specified amount to become prescription-only medicine. Thus, pharmacies became the only legal outlet for PSE and pharmacists were effectively criminalized if they did not comply with these regulatory requirements.

The Queensland Branch of the Australian Pharmacy Guild, together with the Chemical Diversion Desk of the Queensland Police Service, developed the real-time ETS, Project STOP [7]. The aim of this ETS was to assist pharmacists to comply with the anticipated regulatory changes that came into effect in January and April of 2006 [14]. The database was developed with an investment from the Queensland Police Service, developed the real-time ETS, Project STOP was launched initially in Queensland in November 2005 [15].

The ETS software was provided at no cost to all pharmacies by the Queensland Pharmacy Guild. In order to augment the capacity of the web-based computer tracking system to apprehend ‘pseudo runners’, law enforcement was provided with specialist training for frontline police and investigators [16].

The objective of Project STOP is to reduce the diversion of pseudoephedrine-based products into illicit drug manufacture in three ways [17,18]: first, to enhance pharmacists’ ability to identify suspicious requests for pseudoephedrine products; secondly, to assist pharmacists to determine whether customers have a legitimate therapeutic need for the product; and thirdly, to provide intelligence to police and health agencies regarding illicit activities by ‘pseudo runners’ and ‘rogue’ pharmacies (see [14,15,17,18]). The Project STOP database enables pharmacists to record three types of transactions: sales, non-sales and ‘safety’ sales, which are sales under duress. The database also records entries where a transaction is begun, but the entry is not completed [19].

The state of Queensland is a ‘hotbed’ for local methamphetamine production in Australia [19]. The production of the drug grew significantly in the 1990s in Australia and was reported to represent a substantially increased share of the global market by the mid-1990s [4]. During the decade from the mid-1990s to 2005 the Australian Crime Commission reported an almost sevenfold increase in the detection of clandestine laboratories Australia-wide, with the vast majority concentrated in Queensland [9].

This paper has three aims. First, we measure the impact of the ETS—Project STOP, introduced in November 2005—on monthly counts of reported methamphetamine production police incidents during a 16-year period (1996–2011). Secondly, we assess the impact of the ETS on reported methamphetamine supply and trafficking police incidents; and thirdly, we assess the impact of the ETS on reported methamphetamine possession police incidents during the same 16-year period.

**METHODS**

**Design**

This paper examines the impact of the ETS—Project STOP—on methamphetamine-related crime incidents in Queensland, Australia using a quasi-experimental method: interrupted time–series analysis. We used autoregressive integrated moving average (ARIMA) interrupted time–series analytical techniques to model the causal impact of the Project STOP program on the production, possession and supply of methamphetamine. Interrupted time–series analysis is a quasi-experimental design, one that ‘rivals the true experiment’ [20]. The method is now well established in the substance abuse and policy literature for causal analysis, so only its most salient features are offered [21,22]. Unlike simple pre- and postintervention mean or percentage difference tests, ARIMA techniques take into account the potentially confounding effects of other causal mechanisms explicitly and, consequently, allow assessment of the change in the level of any outcome series independently of ongoing stochastic processes [23]. We used Regression Analysis of Time Series (RATS) econometric statistical software to analyse the series (Available at: https://www.estima.com/ (accessed 28 October 2016) (Archived at http://www.webcitation.org/6laWrIMLM on 28 October 2016)).

**Measures**

The Queensland Police Service (QPS) provided monthly crime incident data from 1996 to 2011. The data consist of monthly counts of methamphetamine production, supply and possession. These offences were linked to a
unique crime occurrence where methamphetamine was seized. The criminal occurrence (or incident) is the primary counting unit used by the QPS. An occurrence is brought to the attention of police through a call to service or their own investigation. Police attend the incident at a particular time and place and report the offence(s) to the Information and Communications Technology Command (ICT). Offences are classified and recorded in the Queensland Police Records and Information Management Exchange (QPRIME) database [24]. An ‘offence’ is an act considered to be in breach of the criminal law. QPRIME is an administrative by-product database and the QPS statistical services branch extracted the data used in the analysis from this data source.

The unit of analysis for the series data used was monthly counts of crime incidents. There were 192 time-points between January 1996 and December 2011. Three types of drug offence for methamphetamine were examined: (1) production, (2) supply and trafficking combined (forthwith referred to as supply) and (3) possession.

The counting rule followed by the QPS for ‘victimless’ crimes such as drug offences is to count each distinct criminal act (offence) per criminal incident [24]. Table 1 provides a summary of the three different drug offence series created for the purposes of analyses.

Statistical analysis

We used the Box & Jenkins [25] approach to fitting statistical models that can account for the autocorrelation contained in each series: production, supply and possession. The analysis comprised three steps: identification, estimation and diagnosis. This is also referred to as the ARIMA analysis whereby production, supply and possession are checked for stationarity by estimating an ARIMA (0,0,0) model and examining the key statistic for time-series analysis, the autocorrelation function (ACF) plot. For processes that drift or trend, the ARIMA (0,1,0) filter integrates random shocks. Once the series has been rendered stationary, the remaining autocorrelation processes can be identified and statistical modelling is conducted (the ‘estimation’ stage) to estimate the parameters of the model revealed in the correlograms. The two fundamental tools used to identify autocorrelation in a given series are the autocorrelation function (ACF) and the partial autocorrelation function (PACF). Different patterns in the ACF and PACF plots provide information about the type of autocorrelation still present in the series after differencing. One manifestation of autocorrelation is the autoregressive process (1,0). The other major type of autocorrelation process is the moving average process (0,1). The final source of non-stationarity for time-series is the presence of extreme observations or outliers. The adequacy of the model is assessed during the diagnosis stage. The residuals from the estimated models are assessed using ACF and PACF plots, and Q statistics test formally the null hypothesis that the residuals are not significantly different from white noise.

Once the series are rendered white noise, the intervention or impact can be modelled. Three possible impact patterns are outlined by McLeary & Haye [26]: (1) an abrupt, permanent shift in the level of production, supply and possession, (2) an abrupt shift in production, supply and possession that gradually diminishes and (3) a gradual shift to a new permanent level of production, supply and possession. The intervention is represented by a binary (dummy) variable, also called a step function. The components of this step function include the regression coefficient of the intervention $\omega_0$, and the intervention indicator variable $I_t$, which is coded as a zero or a one to indicate its absence or presence [23]. The intervention will be introduced into the time-series as a dummy variable (i.e. pre-intervention = 0, postintervention = 1). There were 192 time-points in each of the series and Project STOP (the intervention) was coded 0 to time-point 93 (October 2005) and 1 from time-point 94 to December 2011.

RESULTS

Growth in the production, supply and possession of methamphetamine in Queensland during the study period is reflected in the plots of the crime incident data. Figures 1–3 present the patterns, over time, in the number of incidents of methamphetamine production, supply and possession, respectively. Within each graph a vertical line at November 2005, denoting the point at which the ETS Project STOP went into effect, is included. Two patterns of interest emerge from the inspection of these time-series scatter plots.

<table>
<thead>
<tr>
<th>Series</th>
<th>Description</th>
<th>$n$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drug production</td>
<td>Production of a dangerous drug (methamphetamine)</td>
<td>5938</td>
</tr>
<tr>
<td>Drug supply and trafficking</td>
<td>Includes offences coded as either trafficking ($n = 1666$) or supply ($n = 18428$) of a dangerous drug (methamphetamine)</td>
<td>20094</td>
</tr>
<tr>
<td>Drug possession or use</td>
<td>Includes possession of things for use or used in the administration, consumption, smoking of a dangerous drug (methamphetamine)</td>
<td>118926</td>
</tr>
</tbody>
</table>
First, the graphs show a substantial, but short-lived, increase in incidence of methamphetamine production (see Fig. 1) and supply (see Fig. 2) in October 2003. Further investigation revealed that this shift in the level of these two dependent series resulted from more than 2100 offences laid against a single offender in that month [27]. The presence of an outlier of this magnitude greatly impedes our ability to interpret the graphic displays of the production and supply series. As such, its effect on the intervention analyses can be removed by the specification of an additional parameter as part of the construction of the noise component of the model, enabling our ability to discern the effect of Project STOP on the methamphetamine-related outcome series [28].

Secondly, the plots show that the ETS had no effect on methamphetamine production but may have led to an increase in the level of supply and possession. There is no measurable change in the count of methamphetamine production offences (see Fig. 1). The methamphetamine supply patterns, however, are somewhat different. After the introduction of the ETS there seems to be an increase, for at least 1 year, in the number of supply offences (see Fig. 2). The methamphetamine possession series shows a similar pattern of increase (at least initially) to that exhibited prior to the initiation of Project STOP, followed by a decrease in incident numbers (see Fig. 3).

In sum, based on the examination of the scatter plots for the three dependent series, a probable conclusion is that the ETS did little, if anything, to suppress the production, supply or possession of methamphetamine. It is possible, however, that the outlier at October, 2003, as well as ongoing stochastic processes (serial correlation), could be masking the effects of the intervention on the raw time-series presented in Figs 1–3. Therefore, the ARIMA interrupted time-series analyses are used to discern the impact of the ETS on each of the outcome series, controlling for confounding effects of other factors (the presence of an outlier, serial correlation).

Table 2 contains the results of the interrupted time-series analyses of the impact of the introduction of the ETS on each of the three dependent series. The ARIMA analysis for possession resulted in the specification of the (0,1,1) model; in other words, the series were differenced once and a moving average component was included which rendered the series white noise. For production and supply, the ARIMA model was complicated by the presence of outliers in both the production and supply series. As reported in panels (a) and (b), the effects of the outlier are well accounted for by the application of a zero-order transfer function to a first-differenced intervention series for the month in which the methamphetamine-related arrests occurred. Thus, as suggested by inspection of Figs 1 and 2,
and supported by the ARIMA analyses, the methamphetamine arrests led to a dramatic, short-lived increase of more than 2000 production and supply offences [see panels (a) and (b)]. However, in the succeeding month, production and supply offence counts returned to their previous levels. As such, we estimated the noise components for the production, supply and possession time-series through the application of first-order, non-seasonal differencing, and the specification of a first-order moving average parameter reduced each of these series to a white noise process (0,1,1) [see panels (a)–(c)].

Regarding the overall adequacy and structure of the final transfer function models, one of the characteristics of a statistically adequate model is that it accounts for all the systematic variation with a time-series. The Q statistic, which is distributed as χ², is used to evaluate the null hypothesis that model residuals are uncorrelated (are distributed as white noise). All three of the final models met this diagnostic criterion (i.e. each of the Q statistics is insignificant $P < 0.23$ for production, $P = 0.22$ for supply and $P = 0.28$ for possession).

The results of the ARIMA impact analysis show that the introduction of an ETS in Queensland in November 2005 was associated with a slight, insignificant ($P = 0.15$) impact on the production of methamphetamine. There was a reduction of approximately five-and-a-half incidents per month, but this was not statistically significant. By contrast, the intervention appears to be associated with a statistically significant increase in the level of supply offences ($P = 0.0001$). There was no statistically significant effect on the incidence of possession ($P = 0.59$) (see Table 2).

### DISCUSSION

Electronic tracking systems are fundamental components of regulatory frameworks that seek to restrict the sales and conditions of access to precursor substances [9]. One such substance, pseudoephedrine, is an important precursor chemical required for the manufacture of the illicit drug methamphetamine that has come under comprehensive and broad meta-regulation at the international and national levels. This paper evaluated the effectiveness of an ETS in Queensland, Australia—Project STOP. The focus of the paper was to assess the impact of an attempt to eliminate domestically available raw materials used in the manufacture of methamphetamine (production) and assess the concomitant impacts on supply and possession.

Overall, while the research found a slight reduction in incidents related to production, this was not statistically significant; nor did Project STOP have a measurable impact on possession. However, the results reveal a statistically significant increase in the number of incidents for sales and distribution (supply).

The finding that production of methamphetamine was suppressed, while possession was not, is congruent with studies that have not examined ETS but other forms of recording PSE sales [29,30]. Freeman & Talbert [10], for example, compared and contrasted recording systems in Oklahoma in 2004 and Iowa in 2005. Both states rescheduled PSE and restricted its access to licensed pharmacies, where purchasers were required to produce valid ID and sign a logbook. In both states there was a decline in methamphetamine production indicators, namely laboratory seizures and incidents. However, in neither state did methamphetamine use decline (as measured by emergency urine screening in Oklahoma [29] or entry into drug treatment in Iowa [30]). These findings suggest that while local production is suppressed, importation from other states (and countries) could occur, thus meeting the existing demand for the drug. Indeed, in 2005 in Australia, Queensland was the only state to have implemented an ETS, so it is highly likely that methamphetamine

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**Table 2** Transfer function models for the effects of Project STOP on methamphetamine production, supply/trafficking and possession within Queensland, Australia.

**(a) Production**

Final transfer function model: $(1 - B)Y_t = \omega_{01}(1 - B) 
\text{Incident}_t + \omega_{031} + 1/(1 - \theta_1 B)$

$$Q = 28.86 \quad \text{d.f.} = 24 \quad P < 0.23$$

where: $I_1 = 0$ for January 1996 to October 2005 and $= 1$ for November 2005 to December 2011

**Coefficient** | **t-Statistic** | **Q-statistic** |
--- | --- | --- |
$\omega_{01}$ | $-0.89$ | $-27.60$*** |
$\omega_{031}$ | $2105.26$ | $244.08$*** |
$\omega_{02}$ | $-5.58$ | $-1.43$* |

**(b) Supply/trafficking**

Final transfer function model: $(1 - B)Y_t = \omega_{01}(1 - B) 
\text{Incident}_t + \omega_{031} + 1/(1 - \theta_1 B)$

$$Q = 29.06 \quad \text{d.f.} = 24 \quad P < 0.22$$

where: $I_1 = 0$ for January 1996 to October 2005 and $= 1$ for November 2005 to December 2011

**Coefficient** | **t-Statistic** | **Q-statistic** |
--- | --- | --- |
$\omega_{01}$ | $-0.81$ | $-18.72$*** |
$\omega_{031}$ | $2473.20$ | $58.03$*** |
$\omega_{02}$ | $88.25$ | $3.34$** |

**(c) Possession**

Final transfer function model: $(1 - B)Y_t = \omega_{01}(1 - B) 
\text{Incident}_t + \omega_{031} + 1/(1 - \theta_1 B)$

$$Q = 28.84 \quad \text{d.f.} = 25 \quad P < 0.28$$

where: $I_1 = 0$ for January 1996 to October 2005 and $= 1$ for November 2005 to December 2011

**Coefficient** | **t-Statistic** | **Q-statistic** |
--- | --- | --- |
$\omega_{01}$ | $-0.51$ | $-8.18$*** |
$\omega_{02}$ | $41.43$ | $0.60$ |

$\omega_{01}$ = zero-order input parameter estimate for the outlier; $\omega_{031}$ = zero-order input parameter estimate for the intervention; $\theta_1$ = moving average parameter; $Q$ = test statistic for the null hypothesis that the model residuals are distributed as white noise; $B$ = backward shift operator; Arrest = outlier series; $I_1$ = intervention series. *$P < 0.10$ (one-tailed test); **$P < 0.01$; ***$P < 0.001$. 

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was supplied from across state borders. This is one reason why it is suspected that the ETS used in Queensland did not lead to reductions in methamphetamine possession in Queensland.

The finding that incidents of supply increased as a result of introducing the ETS is consistent with findings from other research on the impact of precursor suppression regulations on arrests. Cunningham & Lui [31], for example, argue that a reduction in the production of methamphetamine could push users into self-production in smaller laboratories. Noted, however, is that the arrest data used in the Cunningham & Lui [31] analysis did not separate the different crimes of production, supply and possession. Our study, therefore, represents a more nuanced analysis of incidents specific to the methamphetamine problem.

Our study offers some important insights into the impact of introducing an ETS to control the sale of precursors used to produce methamphetamine; however, the study is not without some limitations. Five limitations are identified. First, the study relies upon official police data that comprise a number of weaknesses: police data only capture information on criminal offences coming to the attention of police, they are subject to the discretion of police to record incidents, they tend to under-report crimes against minorities significantly and they are dependent upon the accuracy of recording [32,33]. Additionally, the introduction of policing training and awareness of Project STOP probably increased police activity, thus creating some of the increase in the levels of apprehension of offenders for supply incidents.

Secondly, the study is limited in that it is unable to differentiate how the growth of methamphetamine supply might be linked to the sale of pseudoephedrine in Queensland. There are no data that measure the amount of pseudoephedrine that is diverted to the illicit market for the manufacture of methamphetamine.

Thirdly, the study does not examine any displacement or diffusion of crime control benefits operating across state boundaries. It is not known, for example, whether the ETS in Queensland reduced production in other states in Australia (a diffusion of the crime control benefit) and also whether introduction of the ETS displaced some of the production problems in Queensland into an adjoining state such as New South Wales.

Fourthly, the analysis does not take into account other metrics to assess the impact of the ETS on market dynamics. Methamphetamine markets are particularly volatile and highly adaptable to changes in policy aimed at controlling supply [10,34,35]. This study was not designed to assess the impact of the ETS on a range of market indicators. Additionally, the intervention effect of the ETS was introduced into the ARIMA model as a binary case: 0 indicating time prior to the introduction of the ETS on 8 November 2005, and 1 otherwise. This approach treats the intervention as an off/on event. This was not the case. According to Ferris et al. [7], on 8 November 2005 only 13 of the 951 pharmacies used Project STOP. Full coverage (90% or greater) of using Project STOP by pharmacies was not achieved until June 2008. This slow rollout of Project STOP may have dampened the effect of the ARIMA process to observe any statistically significant impact.

Finally, the adoption of an ETS, such as Project STOP, represents a major expansion in law enforcement efforts directed at the problem of local methamphetamine production. However, recording and reporting responsibilities impose significant compliance costs on non-police burden bearers, especially pharmacists, and the health agencies that regulate them [36].

Notwithstanding the limitations of the study, two key policy implications are highlighted. First, in countries such as the United States and Australia that have regulatory frameworks that require recording and monitoring of precursor sales, the findings suggest the need for uniformity in state-by-state adoption of ETS.

Secondly, the modest reduction in production of methamphetamine holds some promise, given the significant public health impacts of domestic methamphetamine production. These results suggest that drug control policy options need to target production, distribution and possession differentially. A policy option—such as the introduction of ETS—is probably best targeted at reducing the capacity of people to produce methamphetamine domestically and seems unlikely to impact upon other aspects (possession, distribution, importation) of the methamphetamine problem.

Declaration of interests

J.E. maintains a non-financial relationship with Mr Ross Gallagher, the Director of GuildLink and Mr Philip Alexander, the Data Manager of GuildLink, in order to retain access to Project STOP data. Mr Gallagher and Mr Alexander did not have any input into the study design or analysis or outcomes. The other authors have no interests to declare.

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