Monitoring illicit psychostimulants and related health issues
Brunt, T.M.

Citation for published version (APA):
Chapter 3

The relationship of quality and price of the psychostimulants cocaine and amphetamine with health care outcomes

Tibor M. Brunt, Margriet van Laar, Raymond J.M. Niesink and Wim van den Brink

Based on:

Drug and Alcohol Dependence (2010), 111(1-2): 21-29
Abstract

A major component of the illicit drug market can be subcategorized as the psychostimulant drug market, with cocaine and amphetamine as popular constituents. In the Netherlands, an increase in both health care outcomes addiction treatment and hospital admissions was noted for both psychostimulants amphetamine and cocaine throughout a period of 17 years (1992-2008). Both cocaine price and quality showed a decrease in the Netherlands during the studied period. We used time-series regression analysis to investigate whether price or quality of the drugs were associated with health care outcomes. Drug seizures were also added to the time-series regressions, in order to check for possible effects of drug availability and supply. Price and quality of cocaine were strongly associated with both health care outcomes. Price of amphetamine also showed a decrease during these 17 years, but was associated with an increase in addiction treatment only. Other amphetamine market variables did not show any relationship with the health care outcomes. It could be stated that following basic market logics does not apply equally to all psychostimulants of abuse. Other factors might play a role, such as the addictiveness or desirability of a specific drug in question. This finding is supportive of the dynamics of the illicit psychostimulant market affecting actual use and thereby health care outcomes.

Introduction

Over the years, the European market of illicit psychoactive drugs has become increasingly diverse. Drugs with various appearances are distributed on the street, such as powders, tablets, capsules, paper trips, liquids and aerosols. A major component of the illicit drug market can be subcategorized as the psychostimulant drug market. Among the main drugs that are distributed on this market are cocaine and amphetamine (Shearer and Gowing, 2004). Amphetamine is an illicit substance that is found both in tablets and in powders, and is mostly referred to by the consumers as "speed". Although this substance has been frequently found
in tablets, it seems that the majority of amphetamine in Europe is sold in powder form (Ramsey et al., 2001; EMCDDA, 2009). Cocaine hydrochloride is a substance distributed exclusively in powder form (UNODC, 2008; Van Laar et al., 2008). Both cocaine and amphetamine are snorted, whereas amphetamine can also be taken orally. Cocaine can also be injected and smoked. Especially the smokable form, often referred to as crack or basecoke, is very prevalent among the chronic, marginalized drug users, often in combination with or as substitute for opiates (EMCDDA, 2007).

The EU average of the last year estimated prevalence of cocaine use in the general population in 2007 was around 1.2% (4 million) and for amphetamine 0.6% (2 million) (EMCDDA, 2009). For the Netherlands, these percentages were on the low end of the scale, with 0.6% for cocaine and 0.3% for amphetamine (Van Laar et al., 2008). These psychostimulants are snorted frequently among visitors of clubs and raves, which is a younger age group than the users that smoke cocaine, usually outside of these recreational settings (EMCDDA, 2007; Van Laar et al., 2008).

In the Netherlands, the National Alcohol and Drugs Information System (LADIS) reported an increasing prevalence of clients in addiction treatment for cocaine- and amphetamine-related problems (Van Laar et al., 2008). One third of all cocaine clients are snorting the substance, often in combination with alcohol or other substances, the rest is smoking cocaine or crack, often in combination with heroin as primary problem substance. Regarding physical health, both psychostimulants are characterized by specific clinical risks, such as cardiotoxicity, neuropathology and a whole range of systemic complications (Lange and Hillis, 2001; Knuepfer, 2003; McCann and Ricaurte, 2004; Glauser and Queen, 2007; Westover et al., 2007; Bertol et al., 2008). Averaged for the period from 2002 to 2006, approximately one third of hospitalized drug victims in the Netherlands (34%) indicated having used cocaine (Van Laar et al., 2008). In most of these cases cocaine was involved as secondary substance. This number is surely an underrepresentation, since a lot of drug-related emergencies go undetected. Regarding amphetamine, the percentage is considerably
lower, not exceeding ten percent of the total amount of drug victims in hospitals.

Measurements of the stability of illicit drug markets can be important in understanding specific changes in drug use, and subsequently changes in drug-related health care outcomes, e.g. addiction treatment or drug-related hospitalizations (Hyatt, Jr. and Rhodes, 1995; Darke et al., 2002; Brownstein and Taylor, 2007; Callaghan et al., 2009). For instance, previous studies have shown that the price of cocaine is an important predictor for the level of drug-related medical emergencies (Hyatt, Jr. and Rhodes, 1995; Caulkins, 2001, 2007; Dave, 2006). Generally, it was found that when the price of cocaine decreased, the level of cocaine-related medical emergencies increased as consequence of increased cocaine consumption. In addition, quality of cocaine may play a role in the level of drug use and could therefore be a predictor for health care outcomes as well (Hyatt, Jr. and Rhodes, 1995; Schifano and Corkery, 2008).

The Dutch Drugs Information and Monitoring System (DIMS) monitors trends in price, purity and adulteration of illicit drugs on the consumer level. In this study, we used the DIMS data from 1992 to 2008 as indicator of the market variables price and quality (in terms of purity and adulteration) of the psychostimulants amphetamine and cocaine. We utilized time-series regression methods to examine the relationship of market variables for cocaine and amphetamine with health care outcomes over 17 years. For this aim, we used the data available from the LADIS and the National Medical Registration (LMR) as indicators of health care outcomes. We also used the number of cocaine and amphetamine seizures to control for possible changes in overall drug supply and availability (Weatherburn, 2003). The aim of this study is to shed some light on the impact of illicit drug markets on health for prevention and policy purposes and may add to the existing insights gained from countries with different national drug policies than the Netherlands.

**Methods**

*Consumer samples and market variables (DIMS data)*
All drug samples were collected according to the methods described by Brunt et al. (2009). Shortly, consumers hand in their drugs voluntarily and free of charge to a test office, in order to find out if there is any unexpected health hazard present in the contents of the drugs they have purchased. This system is carried out on behalf of the ministry of health in The Netherlands for preventive and monitoring purposes only. A detailed description of the DIMS system can be found in a paper by Spruit (1999).

We used only the data available from consumers that snorted cocaine, since we scarcely received samples from consumers smoking cocaine/crack, which is not primarily within the scope of the communication and prevention activities of the DIMS network.

Since consumers hand in illicit drug samples each week, we consider the DIMS data as the best possible up-to-date indicator for the situation on the illicit drug market in The Netherlands. Verification of the DIMS representativeness has been done by comparing with 'seized samples' by the police from various cafés, clubs and dance venues in The Netherlands (Vogels et al., 2009). Market variables concerning quality of the drugs were derived from laboratory analyses. Prices were based on consumer's reports, experts in the field and governmental reports. Prices were adjusted for purity to get a realistic picture of what was effectively spent on the illicit drug in question (Caulkins, 2007). Prices were given in euro's, prices before 2001 were recalculated from Dutch guilders (1 Euro = 2.23 Dfl). Prices were inflation-adjusted per year.

Addiction treatment (LADIS data)

Addiction treatment information was obtained from the National Alcohol and Drugs Information System (LADIS), a database managed by the Organisation for Information Systems in Care (SIVZ). LADIS covers all major addiction outpatient care services in The Netherlands. It anonymously traces clients and new registrations throughout each year (Van Laar et al., 2008). Clients can be subdivided according to substance abuse profile with this database. Because we tried to directly relate cause and effects regarding market variables and health care outcomes, we only considered data from clients with primary problems associated with
cocaine or amphetamine, excluding those that exposed secondary problems with these substances of abuse. Furthermore, we only included clients that experienced problems with snorting the substance and left out the group of cocaine/crack smokers, which allows for equal comparison with the DIMS data. We included all clients in addiction treatment per year, combining newly registered and previously registered. Furthermore, we corrected the number of clients in addiction treatment for population growth in the Netherlands per year, taking the population in 1992 as reference value.

*Hospital admissions (LMR data)*

Information concerning hospital admissions related to drug abuse was obtained from the National Medical Registration (LMR). LMR is managed by Prismant, the research and advisory agency for the Dutch Health Care Service. Most general and academic hospitals in The Netherlands are connected to the LMR. Information upon hospital discharge is sent to the LMR and coding is according to World Health Organization (WHO) international guidelines: ICD-CM (Clinical Modification of the International Classification of Diseases). Hospital admissions in relation to cocaine and amphetamine were defined as ICD-9 codes 304.2, 305.6 and 304.4, 305.7 respectively. Unfortunately, no distinction is made between smoked or snorted cocaine in these hospital admissions. We also corrected the number of hospital admissions for population growth in the Netherlands per year, taking 1992 as reference value.

*Adulteration*

In this article we use the term "adulterants" and "adulteration". We hereby refer to pharmacologically active substances which may alter the characteristics of a drug in question. For instance, caffeine is regarded as an adulterant on account of its mechanism of action as central nervous system stimulant. This is in contrast to other components in psychostimulant powders, such as sugars, which are not recognized as adulterants, as they have no psychopharmacological effects. Adulteration
is measured in this article as the proportion adulterated (in %) of total powders per year, purity is measured as the average percentage cocaine or amphetamine in the powders.

**Laboratory analysis**

Laboratory analysis was performed using at least two analytical techniques for quantification and qualification of the pharmacological drug substances, Thin Layer Chromatography (TLC) and gas chromatography nitrogen phosphorous detection (GC-NPD). First, samples are crushed and homogenized, then TLC is used for identification (using the ToxiLab® procedure). The analytes are identified by relating their position (RF) and colour to standards. Cocaine is typically identified with RF 0.78, amphetamine with RF 0.38 and caffeine with RF 0.60. Marquis reagents is used for the colour identification of amphetamine in stage I (vanishing fluorescent yellow spot) and Dragendorff reagents is used for caffeine and cocaine in stage IV (orange and brown spots, respectively). Quantification of the sample is done using gas chromatography nitrogen phosphorous detection (GC-NPD: Interscience GC8000/NP-800). An internal standard was added to the solution (Chiral™, Sigma-Aldrich, Zwijndrecht, The Netherlands). In an optional third step, validation or identification with gas chromatography-mass spectrometry (GC-MS: Varian Saturn 4D, Varian Medical Systems, Houten, The Netherlands) is used. The NIST (National Institute of Standards and Technology) library is used to identify the various mass fragments.

**Time-series regression analysis**

In order to explore the causal relationships between the market variables price, purity, adulteration and seizures the Granger causality method for time-series regression was used. Granger causality originates from econometrics, but has been applied increasingly in the biomedical field as well (Lütkepohl, 2006; Ladroue et al., 2009; Peterson et al., 2009). In short, it studies the relationship of one time-series with another. Y is said to be Granger-caused by x if x helps in the prediction of y, or equivalently if the
coefficients on the lagged x’s are statistically significant. To implement the Granger causality test with multiple variables, we determined autoregressive lags and estimated vector autoregression (VAR) models by the ordinary least squares (OLS) estimation method. A VAR model determines the regressive association of each vector at the appropriate lag with another vector at the subsequent time of measurement t. Vector autoregression includes regressions of one variable to the other as well as the lags of autocorrelation that denote the impact of each variable on itself. By minimizing the Akaike Information Criteria (AIC), the best parametric model with optimal number of lags was chosen.

The time series were differenced to become stationary (detrended). This led to causality tests using Granger approach with first-order differenced VARs for each of the dependent variables (health care outcomes) tested. Next, we checked for cointegration of variables with the Johansen cointegration test (Johansen, 1995). This test provides evidence if one or more variables in an equation model are cointegrated, which could lead to spurious regression results in the VAR. Indeed, in both the case of cocaine and amphetamine, market variables seemed to be cointegrated (which is not an uncommon phenomenon when one deals with market dynamics). Therefore, a special type of VAR was performed: the Vector error correction model (VECM). This is the most stringent of Granger type time-series modeling, in which an additional error-correction term is added as a variable to the equation. The error-correction term denotes if there is a Granger causality present in a regression. Finally it has to be noted that Granger causality is not causality in an absolute sense of the word. In its best sense it is linear prediction, with one variable predicting another.

Unfortunately, neither the LADIS or the LMR assembled data more frequently until 2008, so neither monthly or quarterly data could be used, so it has to be emphasized that this study uses annual time series and the analysis therefore is conducted under the constraint of a small sample size. With short time series, the power of certain time-series analysis tests (ARIMA for example) is insufficient, which may lead to lower probabilities of rejecting the null hypothesis or otherwise misleading results. We have looked at the statistical power through various parameters of the models,
such as the effect size and likelihood inference as described by Johansen (Johansen, 1995). Most of these measures were within the acceptance range. However, other issues could still be argued, the implications of the long sampling lag period (one year) are therefore briefly discussed in the discussion section of this article. Granger causality with VARs and VECMs was done with Stata software, version 11.

Results

Drug samples

From 1992 to 2008, DIMS collected 14,763 individual illicit psychostimulant drug powders from anonymous drug consumers that were sold as either "speed/amphetamine" or "cocaine ". Quantitative laboratory analysis on purity and adulteration was based only on those powders containing the actual psychostimulant (7,091 powders contained amphetamine and 6,248 cocaine).

Demographic profiles of clients in addiction treatment and admitted to hospital

The average age of amphetamine clients in addiction treatment in 2008 was 28 years (25 to 28 years for 1992-2008), for cocaine clients it was 36 years (40 to 36 for 1992-2008). The ratio man/ woman for amphetamine clients between 1992-2008 was about 4, the same ratio as for cocaine. For the hospital admitted cases very similar profiles were seen. For users snorting cocaine the general client registration profile between 1992 to 2008 is that they were of Dutch origin, with jobs and housed. Users of amphetamine were also primarily of Dutch origin, housed but more often without job incomes. For hospital admissions, such data weren’t available.

Health care outcomes

The amount of clients in addiction treatment for primary problems associated with snorting cocaine has been steadily increasing, about fourfold between 1992 and 2008 (Fig. 1). In 2008, 25 people per 100,000
inhabitants in The Netherlands were in addiction treatment for cocaine snorting related problems. Also, the amount of hospital admissions related to cocaine abuse showed an increase from 1992 until 2008 (Fig 1).

The amount of clients in addiction treatment with primary problems associated with amphetamine has increased over the period 1992 to 2008, especially after 2001, albeit more modest than that for cocaine in the same time period (Fig. 2). Hospital admissions related to amphetamine use show a relatively constant picture, although since 2004 numbers have modestly increased (Fig. 2).
Figure 1. Health care outcomes for cocaine.
Figure 2. Health care outcomes for amphetamine.
Market variables

Both average purity and price of cocaine gradually decreased from 1992 to 2008, with a maximum drop in purity of 70.8% to 52.8% and a maximum drop in price from 135 to 73 euro/gram respectively (Fig. 3). At the same time, the incidence of adulterated powders on the Dutch drug market increased considerably, from 10% in 1992 to 58.2% of total cocaine powders in 2008. All kinds of adulterants were present in cocaine powders, such as caffeine, lidocaine, procaine, phenacetin and more (as previously described in Brunt et al., 2009).
For amphetamine powders, the situation looks quite different. The purity and adulteration of amphetamine showed a fluctuating pattern (Fig. 4). The overall average purity of amphetamine between 1992 and 2008 balanced around 30%, and about 50% of these powders were adulterated. The year 2000 shows a clear drop in average purity of amphetamine powders. In amphetamine powders, the primary adulterant encountered throughout the entire measured time period was caffeine. Only 0.5-3.5% (mean about 2.0%) of the amphetamine powders in the Netherlands contained methamphetamine.

Relationship of market variables with health care outcomes

Firstly, we established that no bivariate relationships were found for any of the variables in this study. Obviously, market variables should be influencing health outcomes, and not the other way round. We used first-order differenced time-series for cocaine, since these were all trends and had to be stationarized first. With simple exploratory Granger causality tests, all relationships between the market variables and the health care outcomes turned out to be univariate.
All cocaine VAR models could be described as third-degree autoregressive models VAR(3). Then we did cointegration analysis and 2 market variables seemed to be cointegrating, so we decided on a VECM regression with 3 lags and cointegration rank 1. All cocaine time series were first-order differenced to become stationary. Results from the VECM regression
analyses for the relationship between market variables and health care outcomes are summarized in table 1.
Figure 3. The market variables, cocaine price, purity, adulteration and seizures. Prices were adjusted for both inflation and purity. Purity is given as mean purity per year, adulteration is given as the proportion (in %) of the total cocaine powders per year.
Figure 4. The market variables, amphetamine price, purity, adulteration and seizures. Prices were adjusted for both inflation and purity. Purity is given as mean purity per year, adulteration is given as the proportion (in %) of the total amphetamine powders per year.
Table 1. Granger causality tests using vector-error correction for the interaction of cocaine health care outcomes and market variables.

<table>
<thead>
<tr>
<th>Dependent variables</th>
<th>Addiction treatment</th>
<th>Hospital admissions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimate</td>
<td>S.E.</td>
</tr>
<tr>
<td>Market variables</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Price</td>
<td>-6.607</td>
<td>2.332</td>
</tr>
<tr>
<td>Adulteration</td>
<td>10.808</td>
<td>2.124</td>
</tr>
<tr>
<td>Purity</td>
<td>-11.679</td>
<td>3.278</td>
</tr>
<tr>
<td>Seizures</td>
<td>-1.677</td>
<td>2.604</td>
</tr>
<tr>
<td>EC</td>
<td>-0.154</td>
<td>0.037</td>
</tr>
</tbody>
</table>

R-squared          0.921          0.856
Durbin-Watson stat  1.976          2.021
AIC                19.959         11.776
Log likelihood     -115.730       -50.657
S.E. of regression 72.787         3.158

S.E.: standard error; regression coefficient estimates and t statistics for the vector-error correction models. AIC: Akaike information criterion, EC: error correction term.
Table 2. Granger causality tests using vector-error correction for the interaction of amphetamine health care outcomes and market variables.

<table>
<thead>
<tr>
<th>Dependent variables</th>
<th>Addiction treatment</th>
<th>Hospital admissions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimate</td>
<td>S.E.</td>
</tr>
<tr>
<td>Market variables</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Price</td>
<td>-5.811</td>
<td>2.129</td>
</tr>
<tr>
<td>Adulteration</td>
<td>3.805</td>
<td>2.651</td>
</tr>
<tr>
<td>Purity</td>
<td>3.101</td>
<td>2.658</td>
</tr>
<tr>
<td>Seizures</td>
<td>-0.057</td>
<td>0.030</td>
</tr>
<tr>
<td>EC</td>
<td>-0.250</td>
<td>0.155</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.824</td>
<td></td>
</tr>
<tr>
<td>Durbin-Watson stat</td>
<td>2.520</td>
<td></td>
</tr>
<tr>
<td>AIC</td>
<td>26.193</td>
<td></td>
</tr>
<tr>
<td>Log likelihood</td>
<td>-182.445</td>
<td></td>
</tr>
<tr>
<td>S.E. of regression</td>
<td>53.197</td>
<td></td>
</tr>
</tbody>
</table>

S.E.: standard error; regression coefficient estimates and t statistics for the vector-error correction models. AIC: Akaike information criterion, EC: error correction term.
Results indicate that all three DIMS market variables price, purity and adulteration Granger cause (i.e. show an intrinsic univariate relationship) both health care outcomes addiction treatment and hospital admissions. As the table shows, the coefficient of the error-correction term (EC) is significant in both equations. Thus, the error-correction term provides an additional channel of causal relationship. In contrast, cocaine seizures can be ruled out in these models as factor influencing health care outcomes. Amphetamine time series were somewhat differently characterized using initial exploratory analyses. Amphetamine health care outcomes were described as second-degree autoregressive models. Health care outcome time series were differenced to become stationary. Amphetamine market variables time series were stationary, except for price (first-ordered difference). As with cocaine, market variables showed cointegration, so VECM regression with 2 lags and rank 1 was chosen. Results are shown in table 2. In contrast to cocaine, no amphetamine market variables showed any relationship with health care outcomes, except for some moderate effect of price on addiction treatment. As can be seen for the EC term, the model for causality of this market variable and addiction treatment just falls out of the 95% significance level in the Granger sense.

Discussion

This study describes 17 years of monitoring the illicit psychostimulants cocaine and amphetamine on the Dutch drug market. Changes in the illicit drug market can be anticipated by monitoring and aid the development of proper responses, such as the implementation of interventions on the level of health care. Based on the time trends described in this study, the situation concerning the drug market does not seem to differ much between the Netherlands and many countries with a stricter drug policy. The decrease in price of cocaine we describe is consistent with other international reports (Caulkins, 2001; Dave, 2006; Schifano and Corkery, 2008; Costa Storti and De Grauwe, 2009). Likewise, there is support that cocaine purity is declining throughout the years in Europe (EMCDDA, 2007; EMCDDA, 2009). For amphetamine, trends were less straightforward, there is a large spread in price and purity in Europe (from
10 to 30 euros per gram retail price and 10% to 30% respectively in 2007; EMCDDA, 2009). To our knowledge, adulteration has never been described in this context. On one hand, adulteration can be considered as a compensatory mechanism to substitute (lack of) the main psychostimulant, on the other hand adulteration takes place independent from this to continuously increase profits by selling more and more diluted product. Additionally, the accessibility of potential adulterants nowadays may have improved considerably (Pai et al., 2003).

Our cocaine health care outcome trends were also reflected by data from most European countries (EMCDDA, 2007). Regarding the trends in hospitalizations associated with cocaine use it is apparent from various studies that cocaine plays an important role in drug-related hospitalizations (Weber et al., 2000; Leikin et al., 2001; Glauser and Queen, 2007). Unfortunately, studies on cocaine hospitalizations in Europe are rather sparse, making international comparisons difficult (Vitale and van de Mheen, 2006). Addiction treatment care for amphetamine abuse has remained relatively stable during the period from 2002 to 2006 in most of Europe (EMCDDA, 2009). Interestingly, the Netherlands (LADIS) showed the highest increase of clients in addiction treatment for amphetamine abuse during this period in Europe, although the relative proportion of amphetamine clients to all drug clients remains small. Regarding trends in hospitalizations concerning amphetamine, far less information is available from literature than is the case for cocaine. In recent years, quite a lot of data was assembled on hospitalizations after methamphetamine use (Degenhardt et al., 2008), but this substance was only marginally available on the Dutch drug market.

As our exploratory time-series regression results indicate, the socioeconomic of cocaine use most likely plays a role in related health care outcomes, such as addiction treatment or hospital admissions. This is not an unique finding, several previous studies have reported this relationship (Hyatt, Jr. and Rhodes, 1995; Caulkins, 2001; Caulkins, 2007; Dave, 2006). Mainly cocaine price was found to be an important predictor for hospital admissions. These studies mainly found (very high) negative correlations between cocaine price and cocaine-related hospital
admissions. Conversely, utilizing econometric time-series modelling as well, previous research demonstrated a decrease in drug-related health care outcomes when the prices of drugs like cocaine or heroin increased (Caulkins, 2001; Smithson et al., 2004; Dave, 2006). Fitting in with the market logics; a decrease in the price of cocaine leads to increased purchase and consumption pattern, whereas an increase leads to the opposite (Darke et al., 2002; Sumnall et al., 2004; Williams et al., 2006). Noteworthy is the fact that this has been explicitly described for a drug like cocaine, whereas for amphetamine this has not been investigated (Goudie et al., 2007).

The quality of cocaine also proved to be related to health care outcomes in this study. This is in line with a number of studies from countries such as the United Kingdom and the United States (Hyatt, Jr. and Rhodes, 1995; Caulkins, 2001, 2007; Dave, 2006). However, other studies have predicted hypothetical negative decision making in purchasing cocaine when quality was perceived as being poor among potential users (Goudie et al., 2007; Cole et al., 2008). Although this may seem contradictory, there may be several arguments to explain this. Firstly, the decrease in price might be a prevailing argument over the loss in quality in the purchase and consumption of cocaine. Secondly, it could be argued that a decrease in quality will lead to a compensatory increase in consumption to maintain the desirable effects (Schifano and Corkery, 2008). In addition, adulteration of cocaine has been known to be the cause of specific detrimental effects on the consumer's health (Behrman, 2008; Brunt et al., 2009).

Despite many pharmacological similarities of both psychostimulants, the dynamics of the market and socioeconomic behaviour do not show much resemblance. This is a previously undescribed finding. Firstly, it has to be stressed that the markets are influenced by completely different trajectories. Whereas the cocaine market is influenced by illegal export and import activities, amphetamine is manufactured in dispersed clandestine laboratories throughout the world (UNODC, 2008; EMCDDA, 2009). Another finding in this study is that the amount of drugs seized barely seemed to be of any consequence to health care outcomes of either psychostimulant. This suggests that measuring availability or supply in this
way might not relate to direct use or consumption. Of special interest in this respect is a recent socioeconomic study done in Canada, were time-series analysis indicated increases in methamphetamine-related hospital admissions after federal regulation of availability of methamphetamine precursors and chemicals, contrary to what was expected (Callaghan et al., 2009). An explanation given for this was an adaptive strategy to this regulation of producers in synthesizing the illicit psychostimulant, with an increase in supply as consequence, instead of a decline. For instance, the instability of the amphetamine market we observed in 2000 may well be attributed to a shortage of its precursor, benzyl methyl ketone (BMK), whereas a dilution of the cocaine market could be the result of disrupting illegal import through increased law enforcement activities.

Regardless of the market dynamics, our results indicate there might be other underlying mechanisms of importance in the relationship between illicit drug markets and health care outcomes. Other factors might be of consequence, such as addictiveness or desirability of a specific drug. For instance, the fact that cocaine is more popular than amphetamine within a larger group of problem users might be important in the valuation of price decrements (Van Laar et al., 2008).

**Limitations**

Our study is hampered by some limitations. First of all, since only short annual time series were available from health care monitoring systems in The Netherlands we could not provide more detailed causality estimates or seasonal variations for instance. Although Granger causality tests can be quite straightforward and have been used increasingly for shorter time series, there is a considerable risk of overestimation which should be considered. However, a short time series does not necessarily mean that statistical power is insufficient (for more detail about this, see Gelper and Croux, 2006). The long sampling lag period (one year) enables us to spot only the gross patterns. Details about short-term effects are missed, whereas these will probably play an important part in cocaine related health issues. More frequent reports from the monitoring institutes of health would certainly provide a magnificent tool in order to state more about
cause and effect measures. Additionally, the inclusion of other variables than the market variables would have provided more detail on the specificity of the market variable effects on health care outcomes. Variables such as incidence rates of cocaine and amphetamine use or the level in which these drugs were used throughout the years. Whereas some sources exist in the Netherlands that have described the incidence rate of amphetamine and cocaine use, these figures are doubtful in that they lack quantitative accuracy. There are reports of declining incidence rates for both amphetamine and cocaine use over the period 1997 to 2005 at the level of the general population, but others have reported an increased popularity of cocaine during the same period (Rodenburg et al., 2007; Van Laar et al., 2008). Furthermore, about the level of use (frequency and amount) of cocaine or amphetamine in the Netherlands hardly anything is known at all. Another issue that remains is the information given by the LADIS and LMR databases regarding primary cocaine diagnoses. It cannot be ruled out that the health care outcomes of a number of cases were resulting from concomitant drug abuse. Cocaine snorting is often accompanied by alcohol abuse, and this particular combination poses its own risks (McCance-Katz et al., 1998; Pennings et al., 2002).

Conclusions

Our socioeconomic approach of the changes in psychostimulant related health care outcomes over almost two decades gives an indication about which illicit drug market variables could be of influence to the consumption pattern of users and subsequently explain some of the increases in health care outcome variables, most likely in much the same fashion as regular product market variables play a role in consumption and health. Our study also emphasizes the importance of judging different drug markets on their own merits, as shown for psychostimulants with similar psychological effects like cocaine and amphetamine. This underlines the necessity for health authorities and policymakers to keep systematically monitoring the market of illicit drugs (Brownstein and Taylor, 2007). Whereas Granger causality is not totally exclusive, it does give a degree of certainty about the relationship of one variable with another over time. Especially the fact that
Granger causality indicated univariate significant relationships between cocaine market variables and related health care outcomes, despite the long sampling period of one year, is an interesting finding which challenges to investigate more detailed time series in future for this purpose.