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V. Raúl García-Aurrecoechea[a], Alma D. Gutiérrez-López[a], Solveig E. Rodríguez-Kuri[a], Marina Velázquez-Altamirano[a], and Carmen Fernández-Cáceres[b]

[a]Researcher of Clinical and Epidemiological Research Department, Centros de Integración Juvenil, A.C., Mexico City, Mexico; [b]General Director, Centros de Integración Juvenil, A.C., Mexico City, Mexico

ABSTRACT

Recent years have seen significant growth in methamphetamine use among patients at Youth Integration Centers (Centros de Integración Juvenil) in Mexico. Previous studies identified a cycle of expansion of cocaine use in patients with these characteristics: it began in the North Western Region, spread to the Western and Central regions and subsequently to the rest of the country. It took about a decade to cover national territory, with lifetime prevalence tending to stabilize at 70%. This study conducts national and regional linear and nonlinear trend analyses of a cycle of expansion of lifetime prevalence of methamphetamine use and the proportion of methamphetamine as a main impact drug between 2010 and 2016, and makes projections for the period between the 2016 and 2019. Results show linear and quadratic increases at the national and regional levels. The most pronounced trends are present in western, north-western, south-central, north-central, north-eastern and central regions. For the second half of this decade, sustained growth of methamphetamine use in patients is predicted; with methamphetamine consolidate its place as the second main drug for which treatment is sought. Findings may enable professionals to be better prepared to address this problem. This phenomenon could subsequently spread to the general population.

Introduction

The first half of the second decade of this century has seen significant growth in methamphetamine use among patients treated for illicit drug use at Youth Integration Centers (Centros de Integración Juvenil) in Mexico [CIJ],[1] at both national and regional levels, with the resulting damage to health (Gutiérrez, 2016a, 2016b). For the second half of this decade, a time series analysis of trends predicts a sustained increase in methamphetamine use, which consolidates its place as the second main drug for which treatment is sought.

Previous trend studies of patients identified acute linear growth trends, at both the national and regional level, of cocaine use in the 1990s (Diaz, Balanzario, Castillo, Gutiérrez, & García, 2001; García, Diaz, & Balanzario, 2001; Garcia et al., 1998; García, Diaz, et al., 1999), which enabled professionals to be better prepared to address this problem. In these studies, the following characteristics were identified:

- The trends began in the north western region
- They spread first to the western and central regions, and subsequently to other regions
- It took a cycle of approximately a decade to cover the entire country
- Lifetime prevalence of cocaine use tended to stabilize at 70%

There was a previous regional epidemic increase of methamphetamine use in the early 1990s (García, Balanzario, et al., 1999), when the Tijuana CIJ drug treatment unit began to report problems in the registration of the use of a new substance called methamphetamine. This substance was being recorded as crack and cocaine, which led to a clinical and epidemiological study being conducted on methamphetamine use in the north western and western regions of Mexico, nevertheless national lifetime prevalence of methamphetamine use among CIJ patients remained at low levels (3.7%) between 1994 and 1997, with rates being much higher in the north western region (30.3%).

After a regional decrease was registered between 2005 and 2007, and rates stabilized between 2007 and 2009 (Gutiérrez & Castillo, 2010), in from 2010, a significant increase was recorded in this region and in the rest of the country, albeit with different levels and intensity (Gutiérrez, 2016a).

The high rates of methamphetamine use in the northwestern region largely reflect the rates observed in San Diego (Gruenewald, Johnson, Ponicki, Remer, & Lascala, 2010), a city with which Tijuana forms an important trans-boundary metropolitan area, whose strategic geographic position has enabled it to become an important point of illegal production and worldwide trafficking.

According to the World Drug Report (WDR) 2016 (United Nations Office on Drugs and Crime, 2016), methamphetamine

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[1]CIJ is a non-profit incorporated into the Health sector, with the aim of preventing and treating drug use. It was founded in 1969, and has national coverage, with presence in all the states in Mexico.

use has become a global problem, with a particular impact in countries such as Australia (Degenhardt et al., 2008; Lai, O'Brien, Thai, Hall, & Mueller, 2016; Macgregor & Payne, 2011), the Czech and Slovak republics (Griffiths, Mravcik, Lopez, & Klempova, 2008), Greece (European Monitoring Centre for Drugs and Drug Addiction, 2014), and Southeast and East Asia – where it has become an epidemic in the past decade, beginning in about 1997 and peaking in 2001 – (Chiang, Chen, Chang, Sun, & Chen, 2007; McKetin et al., 2008; Mehrjerdi, Barr, & Noroozi, 2013; Nowicki, Klos, & Kokot, 2014).

At the same time, the World Drug Report (WDR, 2016) notes that North America has consistently declared the largest amount of methamphetamine seized annually. Methamphetamine use in the United States increased progressively in the 1990s in the west and northwest of the country (with similar growth being recorded in the northwestern region of Mexico) and by the turn of the millennium, it had reappeared in many areas of the mid-west and south, emerging to a lesser degree in the northeast and Mid-Atlantic (Hunt et al., 2006). Recent national student surveys show a significant linear decrease between 1999 and 2015, without showing significant quadratic trends during that period or statistically significant changes between 2013 and 2015 (Kann et al., 2016).

Methamphetamine is an extremely addictive drug causing severe deterioration (Jiménez & Castillo, 2011), in a white crystalline powder form. In Mexico, it is smoked (inhaling the vapors produced by combustion) (Garcia, Balanzario, et al., 1999), which is quickly delivered to the brain, producing immediate euphoria, as a result of an increase in the amount of dopamine in areas of the brain related to rewards, motivation, pleasure, and motor function (National Institute on Drug Abuse, 2017).

Garcia, Balanzario, et al. (1999) found that most patients with methamphetamine use problems had a diagnosis of dependence. Clinical symptoms most frequently found in the study included depression, anxiety, suicidal ideation, and the presence of psychotic symptoms, including flash-backs with visual or auditory hallucinations, in addition to panic attacks and suicide attempts. Furthermore, the main symptoms related to the discontinuation of use were anxiety, depression, irritability, isolation, and fainting.

A cross-sectional overview of national lifetime prevalence of methamphetamine use in CIJ patients, during the first semester of 2016 (Figure 1), places it at 24.1%, exceeding rates for crack since 2015–1, meaning that it ranks sixth in lifetime use after marijuana, alcohol, tobacco, cocaine, and inhalants (Gutiérrez, 2016a).

Moreover, as the drug with the greatest impact, methamphetamine has exceeded alcohol since the first half of 2016 (2016–1), ranking second only to marijuana (Gutiérrez, 2016b). Furthermore, at the regional level, worrying rates of methamphetamine use can be seen, above national averages, in the north western and western regions (Figure 1), which is consistent with the data reported by the Epidemiological Surveillance System for Addictions (Sistema Nacional de Vigilancia Epidemiológica de las Adicciones, 2011) and student surveys (Villatoro et al., 2016).

These high rates of methamphetamine use can largely be explained by the fact that Mexico is a methamphetamine producing country, and even though it is mostly intended for external markets, there is a growing internal demand (Medina-Mora & Real, 2013), particularly in the states on the north-western border of Mexico that act as a corridor for transporting the drug into the north American market (Brouwer et al., 2006), resulting in widespread violence in these regions (López & Uribe, 2015).

High rates are currently observed in regions that are unrelated to production or international trade routes, such as the south central, north central, and central regions, suggesting the presence of a process of expansion similar to that observed with cocaine in the 1990s (Garcia et al., 2001).

Moreover, a visual analysis of the graphs of drug use in CIJ patients during the period 2004–2016 (Gutierrez, 2016a, 2016b) shows a growing trend in methamphetamine use at the national and regional level, among both men and women. This raises a number of questions: How has the rising and regional expansion of methamphetamine use in patients
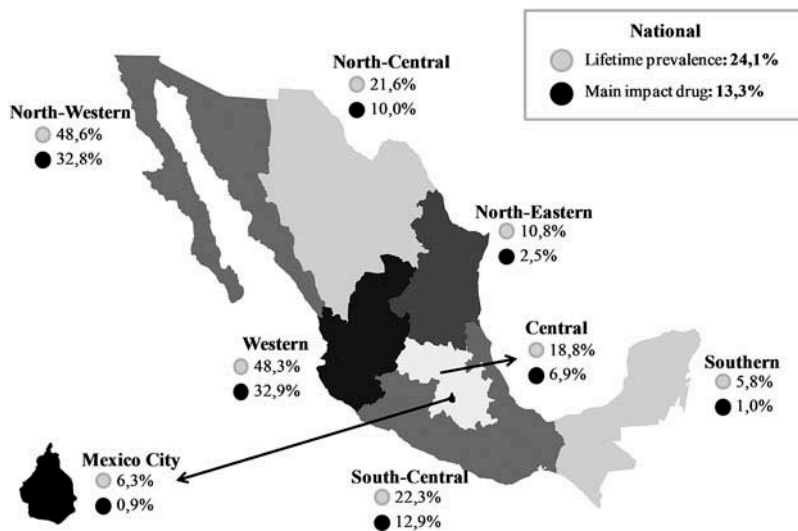

Figure 1. Methamphetamine use by region in first admitted patients at Centros de Integración Juvenil in Mexico during the first semester of 2016 (N=10.934).

occurred in Mexico? Which are the most severely affected regions? When did the trend begin in each region? And what are the national and regional projections for the end of the second decade of the 21st century?

Answers to these questions could yield significant information for health services and the epidemiological monitoring of drug use. This is important, because surveys on special groups, as in the case of students (Villatoro et al., 2016), or in our case with patients, allow one to detect phenomena that may subsequently appear in the general population.

Accordingly, the purpose of this study is to undertake a set of national and regional trend analyses of a cycle of expansion of methamphetamine use in patients treated at CIJ units.

Method

The study undertakes a time series analysis of the national and regional linear and nonlinear trends of a cycle of expansion of the **lifetime prevalence of methamphetamine use** (*LPMU*) and the proportion of patients who reported **methamphetamine as the main impact drug** (*MMID*) between the first half of 2010 (2010–1) and the first half of 2016 (2016–1), and makes projections for the period between the second half of 2016 (2016–2) and the second half of 2019 (2019–2). Cuts to carry out time series analysis were biannual.

LPMU refers to the patient's report of having used methamphetamine at least once in his/her lifetime, while the main impact drug, as mentioned earlier, is the substance that has caused the user most problems regarding his or her health, and personal, family, school, work or social life, in the last year and is the main reason s/he is seeking treatment at CIJ.

Time series analyses examine databases that collect information at regular time intervals, making it possible to conduct trend analyses through linear or nonlinear regression, and in some cases both, being chosen, to explain and project the trends, the quadratic or linear equation with the highest R^2 determination coefficient, within the framework of an analysis of cyclical variations (Arellano, 2017; Badii, Guillen, Cerna, Valenzuela, & Landeros, 2012; Balding, 2006).

The **Epidemiological Information System of Drug Use** (*SIECD*) of CIJ generates a database that provides information on first-time treatment seekers, at any of the 113 units for drug treatment, throughout the country.

The database compiles epidemiological information for each semester of the period 2004–2016, making it possible to conduct trend analyses, and identify cycles of emerging trends and expansion of drug use in Mexico, since the bases are disaggregated by state and region. It provides information on illicit drug users seeking treatment for the first time at CIJ, which ensures that cases are not repeated. The data are directly captured in a national database by the patient's physician during an interview.

For the first semester of 2016 (Gutiérrez, 2016c), 10,934 patients were admitted to CIJ, with a ratio of 4.2 men per woman, and a mean age of 22.3 years (*SD* = 10.6). The most important lifetime drugs used were cannabis (87.5%), alcohol (85.0%), tobacco (83.6%), cocaine/crack (39.5%), inhalants (27.6%), methamphetamine (24.1%), ecstasy (5.9%),

Table 1. Size of regional databases used to perform the regional trend analyses*

Region	Lapse analyzed	n (LPMU)**	n (MMID)***
North western	2005–1–2016–1	32.304	31,185
North central	2010–1–2016–1	12,474	11,860
North eastern	2010–1–2016–1	8,457	8,095
Western	2010–1–2016–1	21,361	20,690
Central	2010–1–2016–1	34,248	32,694
Mexico City	2010–1–2016–1	37,733	35,161
South central	2010–1–2016–1	9,337	8,771
Southern	2012–1–2016–1	6,110	6,051

*Cuts to carry out time series analysis were biannual
**Lifetime prevalence of methamphetamine use
***Methamphetamine as main impact drug

depressants (14.6%), hallucinogenic and dissociative drugs (9.5%) and opioids (4.2%). The substances with the main impact reported were marijuana (45.5%), alcohol (10.7%), methamphetamines (13.3%), tobacco (6.5%), solvents and removers (5.7%), crack (5.5%), and cocaine powder (3.9%).

The graphs on the period 2004–2016 (Gutiérrez, 2016a, 2016b) show that 2010–1 was the start of the growing trend in *LTMU* and *MMID* at the national level, for both men and women, and in most of the regions, with the exception of southern region, where it seems to have begun in 2012–2 and the north western region, where its use started earlier. The study therefore analyzed a national database from the first semester of 2010 to the first semester of 2016, and regional databases for the same period, with the exception of the north western region, where the information covered the period from 2005–1 to 2016–1, and the Southern region, where the growth trend began in 2012–2.

For the analysis of the *MMID*, the national *N* and regional *n* are smaller than for *LPMU* because they only comprise cases that used drugs last year. Thus, the *N* for the national analysis of the period 2010–1–2016–1 was 153,530 for *LPMU* and 145,743 for *MMID*. Regional database sizes are shown in Table 1.

The purpose of the study is to:

- Assess the trends in *LPMU* and the proportions of *MMID* during the first half of the second decade of the 21st century (and for the north western region since the middle of the first decade of the 21st century),
- Project values until the end of the second decade of the 21st century.
- Not to increase projected values beyond 70%

Instrument: Initial Interview format, which is part of the CIJ electronic clinical record.

Results

At the national level, rising linear and quadratic trends in *LPMU* can be seen, the most significant one being the quadratic one (R^2 = .980, *F* = 239.309, *df* = 2, *p* < .000), rising from 10.5% in 2010–1 to 24.1% in 2016–1. As a result of this trend, the national *LPMU* for 2019–2 could be over 40% (Figure 2).

Likewise, at the national level, increasing linear and quadratic trends in the proportions of *MMID* can also be seen, the most significant one being the quadratic one (R^2 = .985, *F* = 324.356, *df* = 2, *p* < .000), which rose from 3.6% in

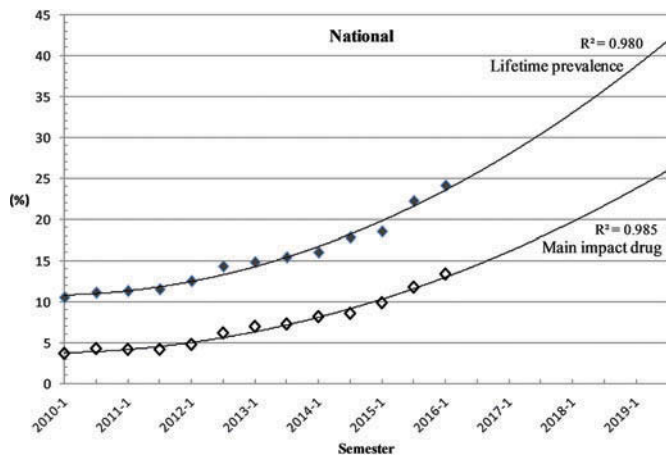**Figure 2.** Methamphetamine's national quadratic trends of lifetime prevalence (N = 153,530), and as main impact drug (N = 145,743) in first admitted patients at CIJ in Mexico in 2010-1 – 2016-1 with projections for 2016-2 – 2019-2.

Figure 4. Methamphetamine's quadratic trends of lifetime prevalence (n = 12,474), and as main impact drug (n = 11,860) in first admitted patients at the north central region's CIJ in 2010-1 – 2016-1 with projections for 2016-2 – 2019-2.

2010–1 to 13.3% in 2016–1. As a result of this trend, the national proportion of *MMID* for 2019–2 could be over 25% (Figure 2).

In the north western Region (comprising the states of Baja California, Baja California Sur, Sonora and Sinaloa), there are growing linear and quadratic trends, at high levels, in *LPMU*, the most significant one being the quadratic one (R^2 = .865, F = 63.808, df = 2, p < .000), which rose from 43.0% in 2010–1 to 48.6% in 2016–1. If this trend continues, the *LPMU* for 2019–2 could exceed 70% (Figure 3).

Rising linear and quadratic trends can also be seen in this region, at high levels, in the proportions of *MMID*, the most significant one being the quadratic one (R^2 = .893, F = 83.394, df = 2, p < .000), which increased from 22.1% in 2010–1 to 32.8% in 2016–1. As a result of this trend, the proportion of *MMID* drugs for 2019–2 could be approximately 70% (Figure 3).

In north central region (comprising the states of Coahuila, Chihuahua, and Durango), there are increasingly significant linear and quadratic trends in *LPMU*, the most significant one
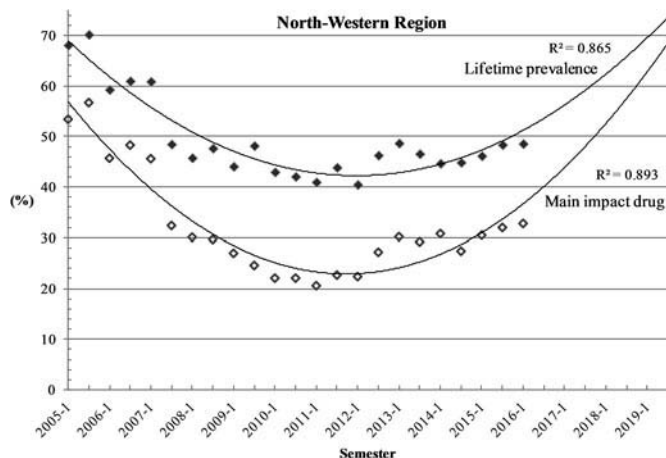
being the quadratic one (R^2 = .960, F = 121.020, df = 2, p < .000), rising from 10.0% in 2010–1 to 21.6% in 2016–1. As a result of this trend, the *LPMU* for 2019–2 could exceed 50% (Figure 4).

In this region, growing significant linear and quadratic trends in the proportions of *MMID* can also be seen, the most significant one being the quadratic one (R^2 = .882, F = 37.316, df = 2, p < .000), rising from 2.7% in 2010–1 to 10.0% in 2016–1. As a result of this trend, the proportion of *MMID* for 2019–2 could be 20% (Figure 4).

In the north eastern region (comprising the states of Nuevo León, Tamaulipas, and San Luis Potosí), there are increasing significant linear and quadratic trends in *LPMU*, the most significant one being the quadratic one (R^2 = .778, F = 17.517, df = 2, p ≤ .001), rising from 3.1% in 2010–1 to 10.8% in 2016–1 (n = 8,434). If this trend continues, *LPMU* for 2019–2 could exceed 25%.

In this region, increasingly significant linear and quadratic trends in the proportions of *MMID* at low levels can also be seen, the most significant one being the quadratic one (R^2 = .682, F = 10.713, df = 2, p < .01), rising from 0.3% in 2010–1 to 2.5% in 2016–1 (n = 8,095). If this trend continues, the proportion of *MMID* for 2019–2 could be 5%.

In the western region (comprising the states of Zacatecas, Aguascalientes, Jalisco, Colima, and Nayarit), there are increasing significant linear and quadratic trends, at high levels, in *LPMU*, the most significant one being the quadratic one (R^2 = .953, F = 101.289, df = 2, p < .000), showing a sharp increase between 2010–1 (15.9%) and 2016–1 (48.3%). If this trend continues, *LPMU* for 2018–1 could reach 70% (Figure 5).

In this region, increasing linear and quadratic trends in the proportions of *MMID* can also be seen at high levels, the most significant one being the quadratic one (R^2 = .953, F = 101.289, df = 2, p < .000), showing a sharp increase between 2010–1 (4.9%) and 2016–1 (32.9%). As a result of this trend, the proportion of *MMID* for 2019–1 could be approximately 70% (Figure 5).

In the central region (including 6 of the 7 states: Puebla, Morelos, State of Mexico, Hidalgo, Querétaro, and Guanajuato),

Figure 3. Methamphetamine's quadratic trends of lifetime prevalence (n = 32.304), and as main impact drug (n = 31,185) in first admitted patients at the north western region's CIJ in 2005-1 – 2016-1 with projections for 2016-2 – 2019-2.
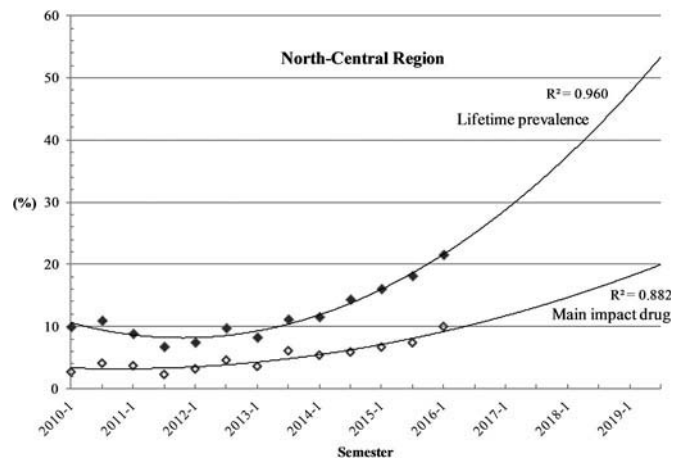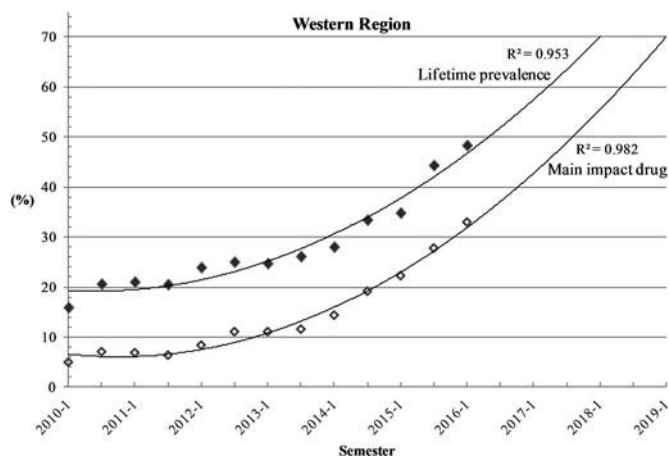
Figure 5. Methamphetamine's quadratic trends of lifetime prevalence (n = 21,361), and as main impact drug (n = 20,690) in first admitted patients at the western region's CIJ in 2010-1 – 2016-1 with projections for 2016-2 – 2019-1.

Figure 6. Methamphetamine's quadratic trends of lifetime prevalence (n = 9,337), and as main impact drug (n = 8,771) in first admitted patients at the south central region's CIJ in 2010-1 – 2016-1 with projections for 2016-2 – 2019-2.

rising linear and quadratic trends in *LPMU* were found, the most significant one being the quadratic one (R^2 = .968, F = 150.086, df = 2, p < .000), as the result of a sharp increase between 2010–1 (3.7%) and 2016–1 (18.8%) (n = 34,248). If this trend continues, *LPMU* for 2019–2 could be over 35%.

In this region, growing linear and quadratic trends in the proportions of *MMID* can also be seen, the most significant one being the quadratic one (R^2 = .961, F = 123.421, df = 2, p < .000), rising from 0.5% in 2010–1 to 6.9% in 2016–1 (n = 32,694). If this trend continues, the proportion of *MMID* for 2019–2 could be approximately 15%.

In Mexico City (including 12 of the 16 boroughs: Álvaro Obregón, Azcapotzalco, Benito Juárez, Coyoacán, Cuajimalpa, Cuauhtémoc, Gustavo A. Madero, Iztapalapa, Miguel Hidalgo, Tlalpan, Venustiano Carranza, and Xochimilco), an increasing linear trend was identified at low levels, in *LPMU* (R^2 = .740, F = 31.247, β = .86, df = 1, p < .000), which has risen from 3.1% in 2010–1 to 6.3% in 2016–1 (n = 37,733). As a result of this trend, *LPMU* for 2019–2 could exceed 7%.

In Mexico City, a growing linear trend can also be seen, at low levels, in the proportions of *MMID* (R^2 = .646, F = 20.050, β = .804, df = 1, p < .001), rising from 0.0% in 2010–1 to 0.9% in 2016–1 (n = 35,161). If this trend continues, the proportion of *MMID* for 2019–2 could be approximately 1%.

In the south central region (comprising the states of Veracruz, Oaxaca, Guerrero and Michoacán), there have been sharply rising linear and quadratic trends in *LPMU*, the most significant one being the quadratic one (R^2 = .904, F = 47.134, df = 2, p < .000), rising up from 7.1% in 2010–2 to 22.3% in 2016–1. As a result of this trend, *LPMU* for 2019–2 could be approximately 60% (Figure 6).

In this region, sharply rising linear and quadratic trends in the proportions of *MMID* can also be seen, the most significant being the quadratic one (R^2 = .947, F = 88.732, df = 2, p < .000), rising from 1.2% in 2010–2 to 12.9% in 2016–1. As a result of this trend, the proportion of *MMID* for 2019–2 could be approximately 40% (Figure 6).

In the southern region (including the states of Yucatán, Quintana Roo, Campeche, Chiapas, and Tabasco) a rising linear trend, at low levels, was identified in *LPMU* (R^2 = .845,
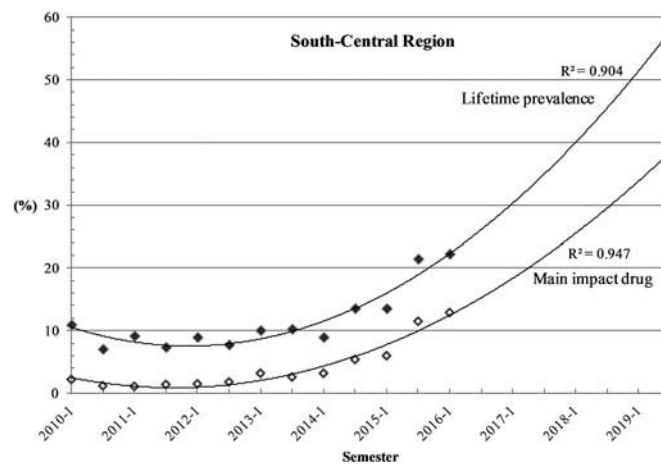
F = 32.708, β = .919, df = 1, p < .001), which has risen from 3.3% in 2012–2 to 5.8% in 2016–1 (n = 6,110). If this trend continues, *LPMU* for 2019–2 could be approximately 7%.

In this region a growing linear trend, at low levels, in the proportions of *MMID* (R^2 = .600, F = 8.994, β = .774, df = 1, p < .05 can also be seen, rising from 0.4% in 2012–2 to 1.0% in 2016–1 (n = 6,051). As a result of this trend, the proportion of *MMID* for 2019–2 could be approximately 2%.

Conclusions

The results show statistical evidence of significant growth of *LPMU* and *MMID* in CIJ patients between 2010 and 2016, at both the national and regional levels, albeit with different intensities inside the regions, adopting a similar pattern to the cycle of expansion of cocaine/crack in the 1990s (Garcia et al., 2001).

On the basis of the time series analyses undertaken, it is possible to forecast, at least for the second half of this decade, sustained growth of methamphetamine use in patients, consolidating its place, nationwide, as the second main drug for which treatment is sought.

Whereas the 1990s was the decade of the beginning and spread of cocaine and crack abuse among patients, the second decade of this century appears to be becoming the decade of spread of methamphetamine use.

Given the important trends identified, and the size of the population analyzed (153,530 patients at the national level) the Epidemiological Information System of Drug Use of CIJ has decided to issue an epidemiological alert about the increase of methamphetamine use in its patients at the national level, particularly in the western, north western, south central, north central, north eastern, and central regions.

Although the results are only generalizable to patients treated at CIJ, it has been shown that studies of special populations, such as students (Villatoro et al., 2016) or patients attended, may provide an early glimpse of phenomena that subsequently emerge in the general population.

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Disclosure of potential conflicts of interest

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