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ORIGINAL RESEARCH

Shifting Drug Landscapes in China: A Multilevel Analysis of Traditional vs New Psychoactive Substance Use and Interregional Differences

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Background: China's drug landscape is rapidly evolving, yet existing research remains fragmented, lacking a comprehensive national perspective. This study analyzes current drug use patterns, trends, and regional differences in China, providing critical insights to guide effective anti-drug policies.

Methods: We conducted a comprehensive multilevel analysis of secondary data of drug use data from the China Drug Situation Report (2005–2023) and 34 academic articles (1990–2021). Our analysis includes descriptive statistics, time series, regional differences, and population-specific trends.

Results: This study identifies a declining trend in traditional drug use, while the use of new synthetic drugs and new psychoactive substances (NPS) is increasing. Strong negative correlations were found between law enforcement intensity and overall drug use (r: −0.89 to −0.92). Significant regional disparity in NPS use was identified, with prevalence substantially higher in southern China than in the north ($p = 0.019$). Traditional drugs are more prevalent in the northwest and central regions, while new drugs and NPS are more commonly found in the eastern coastal and central urban areas. The use of NPS is notably higher among adolescents in economically developed regions.

Conclusion: The analysis delineates a clear shift in China's drug landscape from traditional drugs to NPS, with concentrations in southern, coastal, and adolescent demographics. These patterns suggest that effective policy responses should be regionally tailored and prioritize youth prevention in economically advanced areas. Future research is needed to verify these associations and explore underlying causal mechanisms.

Keywords: drug use, new psychoactive substances, regional differences, adolescents, China, 21st century

Background

As a public health and security challenge, drug abuse inflicts severe damage on individual health and imposes significant socioeconomic burdens. *World Drug Report 2023* underscores the scale of this issue, documenting an estimated 292 million global drug users in 2022—a 20% increase over the past decade. The supply and demand for emerging synthetic opioids and new psychoactive substances (NPS) have reached record levels, worsening health disorders, and environmental damage.[1] Since Lin Zexu's Humen Opium Destruction, China has maintained a zero-tolerance stance on drug, enforcing strict anti-drug policies.[2] Despite challenges from international pressures and the COVID-19 pandemic, the government's initiative to "Eliminate Sources and Supply Chain Severance" reflects its strong commitment to tackling drug issues.[3]

In China, drugs are classified into traditional drugs, new synthetic drugs, and NPS based on their emergence. *The Criminal Law*[4] and *the Anti-Drug Law*[5] provide the legal definitions for illicit substances, which include opioids, stimulants, and cannabinoids. The United Nations designates NPS as a "third wave" of drugs, distinguished by their rapid chemical evolution

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and adaptable production. This inherent flexibility makes them a particularly persistent and fast-mutating threat to drug control regimes both globally and within China.[6]

Understanding domestic drug trends is crucial for evaluating China's anti-drug achievements and improving strategies. While existing studies focus on infectious diseases,[7] drug issues among specific populations,[8] policy development[9] and testing methods.[10] However, this literature remains largely fragmented, often constrained by a singular focus on specific provinces, a single drug type, or a particular demographic group. This fragmentation has created a critical gap in our understanding of the integrated, national-level drug landscape. Our study addresses this gap by synthesizing these disparate data sources to provide a comprehensive, multilevel analysis of drug use trends and regional patterns across China over nearly two decades.

To interpret the regional disparities and temporal shifts in China's drug landscape—particularly the decline of traditional drugs and the rise of NPS—we draw on two complementary perspectives. The epidemiological model of substance use conceptualizes drug trends as shaped by interactions among the agent (drug), the host (user), and the socioeconomic environment, offering a structured explanation for shifts toward new substances.[11,12] In parallel, illicit-market economics suggests that intensified enforcement targeting traditional drugs may inadvertently stimulate the production and adoption of more adaptable substitutes such as NPS. Together, these perspectives form the conceptual basis for our multilevel analysis.[3,13]

This study integrates data from academic literature (*PubMed, CNKI*) and official reports (*China Drug Situation Report*, 2005–2023) to conduct a multilevel secondary analysis of drug use in China. It aims to synthesize fragmented evidence into a comprehensive overview of national trends and regional variations.

This study integrates data from official reports and academic sources to conduct a comprehensive, multilevel secondary analysis. By employing time series and regional clustering, it aims to synthesize fragmented evidence into a cohesive overview of China's drug use trends. The overall analytical framework is illustrated in Figure 1.

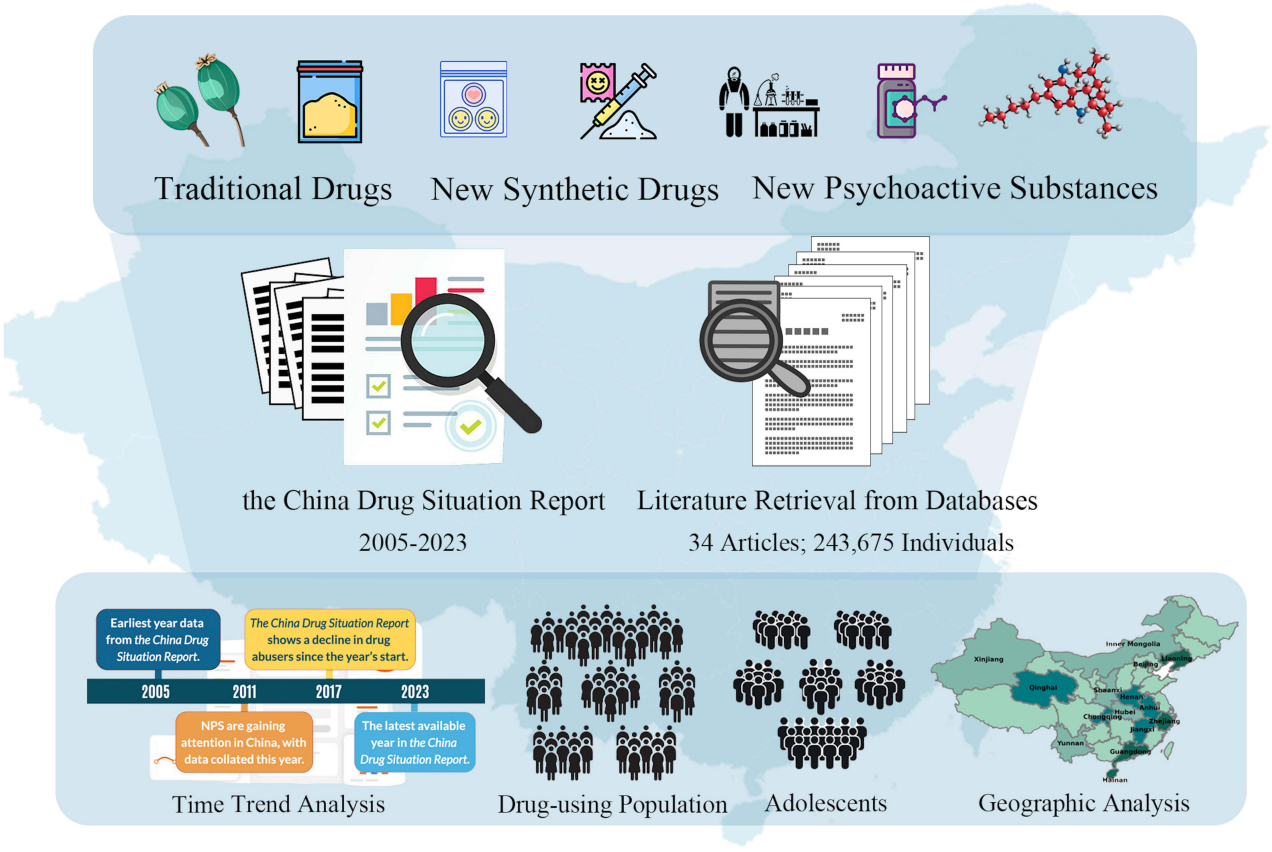

Figure 1 Framework for a Multidimensional Systematic Analysis of China's Drug Situation.

Methods

Data Sources

This study draws on two primary sources: official drug reports and academic literature, to capture the multidimensional nature of China's drug issues.

Official Reports

Data were collected from *the China Drug Situation Reports* spanning 2005–2023 in Table 1, covering key metrics like drug use trends, user numbers, and drug-related cases. Reports from 2005 to 2013 were sourced from the Shanghai Anti-Drug Education Center[14] and from 2014 to 2023 from the China National Narcotics Control Commission.[15]

Academic Literature

A rigorous literature search in PubMed and CNKI yielded 34 studies,[19–50] comprising 62 entries across 23 provinces over nearly 30 years (1993–2021) (Table 2). The Studies focused on drug use by region in China (1990–2023), with criteria excluding articles without specific data, duplicates, and non-peer-reviewed work.

A systematic literature search was conducted following PRISMA 2020 guidelines. CNKI was searched using subject terms and free-text keywords related to drug use ("drug abuse," "drug users," "substance use," "psychoactive substances," "new drugs," "new psychoactive substances [NPS]," "illicit drugs," "sentinel surveillance," "monitoring," "surveillance data") and population terms ("adolescents," "school students," "college students"), with Boolean operators (AND, OR, NOT). The PubMed strategy was: (((illicit drug[Title/Abstract]) OR (drug abuse[Title/Abstract])) OR (drug user*[Title/Abstract])) OR (psychoactive substances[Title/Abstract]).

Records were screened by title and abstract, followed by full-text review against predefined criteria. Studies were included if they reported primary data on traditional drugs, new drugs, or NPS in China, with explicit sample sizes, study periods (1990–2023), and a single identifiable location. Exclusion criteria were as follows: studies outside China, multi-province studies without location-specific data, unclear drug classifications, lack of extractable quantitative data, or non-original research. For overlapping datasets, the most complete or recent study was retained.

In this study, traditional drugs are defined as opium, heroin, cocaine, and cannabis;[51] new synthetic drugs as stimulants like methamphetamine and ecstasy;[52] *The 2015 China Drug Situation Report*[18] categorizes these synthetic drugs into nine classes, including synthetic cannabinoids, synthetic cathinones, and phenethylamines. NPS are defined here as chemically modified analogs of traditional and synthetic drugs, posing severe risks to individuals and society. Some NPS studies also include certain controlled substances of abuse.[53]

Data Processing and Analysis Methods

All analyses were conducted in Python 3.10.12 using standard scientific libraries, including pandas 1.5.3, numpy 1.23.5, scipy 1.9.3, statsmodels 0.13.5, scikit-learn 1.1.3, matplotlib 3.6.2, seaborn 0.12.1, geopandas 0.12.2, and Pillow 9.3.0. These libraries were used for data processing, statistical analysis, clustering, time-series modeling, and visualization. All statistical tests were performed with a significance level of $\alpha = 0.05$.

Data preprocessing involved multiple imputation for missing values and time series standardization to ensure continuity. Missing values were imputed using the variable-specific median, assuming data were missing at random (MAR). This approach provided robust estimates and enabled complete-case correlation, regression, and time series analyses. Multiple imputation was not applied due to the small number of missing entries and limited sample size, which could increase estimate variability. Normalization was applied to improve comparability, focusing on the relative proportions of drug use.

National Descriptive Statistics and Trend Analysis

Descriptive Analysis

Descriptive statistics covered total drug users, traditional and synthetic drugs, and NPS. Non-linear trends, mean shifts, and segmentation were used to address data constraints. Quadratic polynomial fitting assessed overall trends, with 3- and 5-year moving averages highlighting long-term patterns. Z-scores (threshold ±3 SD) were used to identify outliers, while find_peaks detected turning points. The data was segmented into three periods for trend analysis.

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Table 1 Summary of *The China Drug Situation Reports* Spanning 2005–2023

Year	Synthetic Drug Abuse	Proportion (%)	Opioid Abuse	Proportion (%)	Traditional Drugs	Proportion (%)	New Synthetic Drugs	Proportion (%)	New Psychoactive Substances Proportion (%)	Drug Users	Drug Crime Cases Solved	Drug Crime Suspects Arrested	Seized Drugs	Newly Discovered Drug Users
2005	7.6*	6.70%								114.0				2.2
2006										116	4.54	5.8		10.1
2007		16.10%				93.30%		6.70%			4.63	5.62		
2008	20.4*	21.30%			80.3*	83.90%	15.4*	16.10%		95.7	5.6	6.7		
2009	30.4*	27.00%	90		88.7*	78.70%	24.0*	21.30%		112.7	6.19	7.34		
2010	37.4*	28%	92.1*	69%	97.5*	73.00%	36.0	27.00%		133.5	7.7	9.1		
2011	50.5*	32.70%	99.7*	64.50%	106.5*	69%	43.2*	28%	3.00%*	154.5				21.4
2012		38%		59.30%		64.50%		32.70%	2.80%*					
2013	79.8	38.00%	127.2	60.60%	127.2	60.63%	79.8	38.00%	1.37%*	209.8	12.2	13.3	45.1	30.5
2014	145.9	49.40%	145.8	49.30%	145.8	49.30%	145.9	49.37%	1.33%*	295.5	14.9			48
2015	134	57.10%	98	41.80%	98	41.80%	134	57.10%	1.10%*	234.5	16.5	19.4	102.5	53.1
2016	151.5	60.50%	95.5	38.10%	95.5	38.10%	151.5	60.50%	1.40%*	250.5	14	16.8	82.1	44.5
2017	153.8	60.20%	97	38%	97	38%	153.8	60.20%	1.80%*	255.3	14	16.9	89.2	34
2018					91.3	37.98%	141.3	58.78%	3.24%*	240.4	10.96	13.74	67.9	25.3
2019					83.1	38.62%	123.5	57.50%	3.88%*	214.8	8.3	11.3	65.1	22.3
2020	103.1	57.20%	73.4	40.80%	73.4	40.80%	103.1	57.20%	2.00%*	180.1	6.4	9.2	55.49	15.5
2021					57.4	38.63%	83	55.85%	5.52%*	148.6	5.4	7.7	27	12.1
2022					41.6	37.01%	62	55.16%	7.83%*	112.4	3.5	5.3	21.9	7.1
2023					33.5	37.39%	45.5	50.78%	11.83%	89.6	4.2	6.5	25.9	

Notes: Data Units: The units for data are people (in ten thousands), cases (in ten thousand cases), and drugs (in tons). The proportion of new psychoactive substances (NPS) is calculated as the total minus the combined proportions of traditional and new synthetic drugs. Multiple Drug Use: Individuals using multiple drugs are counted separately for each drug. Year Standardization: The year refers to the report year, which reflects data from the previous year. Asterisk (*) Data: Data marked with an asterisk (*) are calculated values. Missing Data: Empty cells indicate that the relevant data is missing from the report for that year. NPS Calculations: NPS-related calculations began in 2011. Testing was initiated in 2010,[16] with the 2011 report first mentioning 14 types of NPS.[17] The term was officially introduced in 2014, and a formal definition was established in 2015.[18]

Table 2 Summary of Relevant Data from the Database

Year	City	Province	Region	Number of People	Population Label	Traditional Drugs	Proportion (%)	New Synthetic Drugs	Proportion (%)	Dual Use of Both Categories	Proportion (%)	Drug Users	Proportion (%)	NPS	Proportion (%)	Literature DOI
2010-2018	Anhui	Anhui	East China	18925	Drug Users	7645	40.40	9750	51.52	1517	8.02	18,912	99.93			DOI:10.3784/j.issn.1003–9961.2019.08.008[19]
2016	Ma'anshan	Anhui	East China	427	Drug Users	145	33.96	282	66.04			427	100.00			DOI:10.11847/zgggws1128033[20]
2017	Ma'anshan	Anhui	East China	438	Drug Users	138	31.51	300	68.49			438	100.00			DOI:10.11847/zgggws1128033[20]
2018	Ma'anshan	Anhui	East China	411	Drug Users	139	33.82	272	66.18			411	100.00			DOI:10.11847/zgggws1128033[20]
1998	Beijing	Beijing	North China	565	Adolescents	5	0.88	9	1.59			14	2.48	495	87.61	DOI:10.15900/j.cnki.zylf1995.1998.05.007[21]
2015	Fangshan District	Beijing	North China	224	Drug Users	15	6.70	209	93.30		0.00	224	100.00		0.00	DOI:10.13419/j.cnki.aids.2021.04.19[22]
2016	Fangshan District	Beijing	North China	200	Drug Users	22	11.00	178	89.00		0.00	200	100.00		0.00	DOI:10.13419/j.cnki.aids.2021.04.19[22]
2017	Fangshan District	Beijing	North China	201	Drug Users	26	12.94	175	87.06			201	100.00			DOI:10.13419/j.cnki.aids.2021.04.19[22]
2018	Fangshan District	Beijing	North China	209	Drug Users	42	20.10	167	79.90			209	100.00			DOI:10.13419/j.cnki.aids.2021.04.19[22]
2019	Fangshan District	Beijing	North China	262	Drug Users	72	27.48	190	72.52			262	100.00			DOI:10.13419/j.cnki.aids.2021.04.19[22]
2018	Beijing	Beijing	North China	2853	Drug Users	263	9.22					263	10.45	1591	85.77	DOI:10.1016/j.legalmed.2022.102086[23]
2019	Beijing	Beijing	North China	4828	Drug Users	500	16.77					500	16.77	2481	83.23	DOI:10.1016/j.legalmed.2022.102086[23]
2020	Beijing	Beijing	North China	3622	Drug Users	437	19.02					437	19.02	1861	80.98	DOI:10.1016/j.legalmed.2022.102086[23]
2003	Guangdong	Guangdong	South China	11184	Drug Users	10448	93. 60	178	1.59			10,626	95.20	558	4.99	DOI:10.15900/j.cnki.zylf1995.2005.02.019[24]
2007	Guangdong	Guangdong	South China	22681	Adolescents							306	1.35	1009	4.45	DOI:10.16835/j.cnki.1000–9817.2020.11.014[25]
2010	Guangdong	Guangdong	South China	21325	Adolescents							232	1.09	1303	6.11	DOI:10.16835/j.cnki.1000–9817.2020.11.014[25]
2013	Guangdong	Guangdong	South China	25305	Adolescents							225	7.54	1442	5.70	DOI:10.16835/j.cnki.1000–9817.2020.11.014[25]
2016	Guangdong	Guangdong	South China	25036	Adolescents							1888	62.06	1154	4.61	DOI:10.16835/j.cnki.1000–9817.2020.11.014[22]
2010	Jieyang	Guangdong	South China	1100	Drug Users	834	75.82	260	23.64	6	0.55	1100	100.00			DOI:10.13215/j.cnki.jbyfkztb.210601[26]
2011	Jieyang	Guangdong	South China	1292	Drug Users	986	76.32	292	22.60	14	1.08	1292	100.00			DOI:10.13215/j.cnki.jbyfkztb.210601[26]
2012	Jieyang	Guangdong	South China	1201	Drug Users	877	73.02	296	24.65	28	2.33	1201	100.00		0.00	DOI:10.13215/j.cnki.jbyfkztb.210601[26]
2013	Jieyang	Guangdong	South China	1200	Drug Users	674	56.17	465	38.75	61	5.08	1200	100.00			DOI:10.13215/j.cnki.jbyfkztb.210601[26]
2014	Jieyang	Guangdong	South China	1200	Drug Users	563	46.92	581	48.42	56	4.67	1200	100.00			DOI:10.13215/j.cnki.jbyfkztb.210601[26]

(*Continued*)

Table 2 (Continued).

Year	City	Province	Region	Number of People	Population Label	Traditional Drugs	Proportion (%)	New Synthetic Drugs	Proportion (%)	Dual Use of Both Categories	Proportion (%)	Drug Users	Proportion (%)	NPS	Proportion (%)	Literature DOI
2015	Jieyang	Guangdong	South China	1220	Drug Users	490	40.16	670	54.92	60	4.92	1220	100.00			DOI:10.13215/j.cnki.jbyfkztb.2106014[26]
2016	Jieyang	Guangdong	South China	1311	Drug Users	516	39.36	699	53.32	96	7.32	1311	100.00			DOI:10.13215/j.cnki.jbyfkztb.2106014[26]
2017	Jieyang	Guangdong		1166	Drug Users	520	44.60	523	44.85	123	10.55	1166	100.00			DOI:10.13215/j.cnki.jbyfkztb.2106014[26]
2018	Jieyang	Guangdong	South China	1202	Drug Users	671	55.82	425	35.36	106	8.82	1202	100.00			DOI:10.13215/j.cnki.jbyfkztb.2106014[26]
2019	Jieyang	Guangdong	South China	1046	Drug Users	552	52.77	361	34.51	133	12.72	1046	100.00			DOI:10.13215/j.cnki.jbyfkztb.2106014[26]
2018	Meizhou	Guangdong	South China	400	Drug Users	36	9.00					36	9.00			DOI:10.15975/j.cnki.gsyy.2022.09.03[27]
2019	Meizhou	Guangdong	South China	430	Drug Users	44	10.23					44	10.23			DOI:10.15975/j.cnki.gsyy.2022.09.03[27]
2020	Meizhou	Guangdong	South China	400	Drug Users	10	2.50					10	2.50			DOI:10.15975/j.cnki.gsyy.2022.09.03[27]
2016-2018	Taishan	Guangdong	South China	1159	Drug Users	571	49.27	398	34.34	190	16.39	1159	100.00			DOI: 10. 3969 / j. issn. 1006–3110. 2019. 07. 030[28]
2003	Hainan	Hainan	South China	2270	Adolescents	24	1.06	0	0.00			24	1.06	58	2.56	Issn:1009-9727[29]
2017	Lingbao	Henan	Central China	329	Drug Users	192	58.36	137	41.64			329	100.00			DOI:10.13515/j.cnki.hnjpm.1006–8414.2018.10.013[30]
2005	Hubei	Hubei	Central China	36706	Drug Users	35756	97.41	163	0.44			36,158	97.86	787	2.14	issn:1004-0781[31]
2016	Jiangxi	Jiangxi	East China	344	Adolescents	21	6.19	318	93.81			335	97.38	9	2.62	DOI:10.13764/j.cnki.ncdm.2017.02.021[32]
2016	Jiangxi	Jiangxi	East China	1472	Drug Users	216	14.67	1256	85.33			1472	100.00	0	0.00	DOI:10.13764/j.cnki.ncdm.2017.02.021[32]
2017	Jiangxi	Jiangxi	East China	629	Adolescents	95	15.10	470	74.72			565	89.83	64	10.17	DOI:10.16835/j.cnki.1000–9817.2018.04.022[33]
2017	Nanchang	Jiangxi	East China	263	Adolescents	71	27.00	150	57.03			221	84.03	42	15.97	DOI:10.13936/j.cnki.cjdd1992.2017.01.013[34]
2018	Liaoning	Liaoning	Northeast China	12598	Adolescents		0.00	184	95.34			184	95.34	9	4.66	DOI:10.16835/j.cnki.1000–9817.2021.08.011[35]
2021	Inner Mongolia	Inner Mongolia	North China	2019	Drug Users	1605	79.49	283	14.02	131	6.49	2019	100.00			DOI:10.19485/j.cnki.issn2096-5087.2022.11.010[36]
2015-2018	Qinghai	Qinghai	Northwest China	5059	Drug Users	2802	59.18	1555	32.84	378	7.98	4735	100.00			DOI:10. 13419/j. cnki. aids. 2020. 05. 17[40]
1993	Xi'an	Shaanxi	Northwest China	118	Drug Users	72	61.02					72	61.02	46	38.98	ISSN:1672-0369[37]
1996	Xi'an	Shaanxi	Northwest China	218	Drug Users	113	71.07					113	71.07	46	28.93	ISSN:1672-0369[37]
2008	Xinjiang	Xinjiang	Northwest China	491	Drug Users	350	71.28		0.00			350	71.28	141	28.72	issn:1006–902X[38]
2013	Kunming	Yunnan	Southwest China	10090	Drug Users	8914	88.34	485	4.81			9405	93.21	691	6.85	DOI:10. 3969/j.issn.1006–902X.2014.04.008[39]

2018	Kunming	Yunnan	Southwest China	442	Drug Users	171	38.69	152	34.39			323	73.08	119	26.92	DOI: 10.27202/d.cnki.gkmyc.2019.000540[41]
2021	Yunnan	Yunnan	Southwest China	1554	Adolescents	15	0.97	41	2.64			56	3.60	1498	96.40	DOI:10.15900/j.cnki.zylf1995.2021.05.007[42]
2000	Yuxi Region, Yunnan	Yunnan	Southwest China	1034	Adolescents	20	1.93	4	0.39			24	2.32	566	54.74	issn:42–1333/R[43]
2008	Hangzhou	Zhejiang	East China	2145	Adolescents							3	0.14	53	2.47	DO I:10.1 3936/j.cnki.cjdd1992.2009.0 6.023[44]
2007	Lishui Region	Zhejiang	East China	2196	Adolescents							13	0.59	45	1.59	issn:1001-5213[45]
2007	Wenzhou	Zhejiang	East China	1467	Adolescents							6	0.41	15	1.02	issn:1001-5213[45]
2011-2020	Wenzhou	Zhejiang	East China	4052	Drug Users	1240	30.65	2671	66.02	135	3.34	4046	100.00			DOI:10.19485/j.cnki.issn2096-5087.2021.10.024[46]
2008	Zhejiang	Zhejiang	East China	3215	Adolescents							7	0.22	75	2.33	DOI:10.13936/j.cnki.cjdd1992.2011.06.016[47]
2015	Beibei District	Chongqing	Southwest China	400	Drug Users	232	64.27	129	35.73			361	100.00			DOI:10. 7629 / yxdwfz202104005[48]
2016	Beibei District	Chongqing	Southwest China	400	Drug Users	182	50.56	178	49.44			360	100.00			DOI:10. 7629 / yxdwfz202104005[48]
2017	Beibei District	Chongqing	Southwest China	400	Drug Users	144	42.86	192	57.14			336	100.00			DOI:10. 7629 / yxdwfz202104005[48]
2018	Beibei District	Chongqing	Southwest China	400	Drug Users	127	38.14	206	61.86			333	100.00			DOI:10. 7629 / yxdwfz202104005[48]
2019	Beibei District	Chongqing	Southwest China	400	Drug Users	121	36.67	209	63.33			330	100.00			DOI:10. 7629 / yxdwfz202104005[48]
1996	China	China	China	785	Drug Users	783	99.87					783	99.87	1	0.13	DOI: 10.1046/j.1360–0443.2002.00197.x[49]
1996	China	China	China	1418	Drug Users	1331	93.86					1331	93.86	87	6.14	DOI: 10.1046/j.1360–0443.2002.00197.x[49]
2018	China	China	China	59518	Drug Users			859	82.44			859	82.44	183	17.56	DOI: 10.1016/j.psychres.2018.08.088[50]

Notes: Missing data reflects information not extracted from the paper; Drug users are counted multiple times when using multiple drugs to ensure accuracy; Dual drug use refers to the simultaneous consumption of both traditional and new drugs; Drug proportions are calculated as the number of users for a specific drug type divided by the total identified population, multiplied by 100%.

Missing values in Drug Crime Cases Cracked, Drug Crime Suspects Arrested, Various Drugs Seized, and Drug Users for 2015–2023 were imputed using the median within the respective variable. This approach assumes data are missing at random (MAR) and provides a robust estimate without extreme distortion. Imputation enabled complete-case correlation, regression, and time series analyses. No multiple imputation was applied due to the limited number of missing entries and small sample size, which could otherwise increase estimate variability.

Enforcement Action Analysis

We analyzed both the full dataset and the data from 2015 to 2023 to examine the impact of enforcement on drug use. Pearson's correlation and OLS models were used to evaluate linear relationships, while cross-correlation (lags −3 to +3 years) assessed temporal effects.

Provincial Data Analysis

Given the substantial variation in survey sample sizes across provinces, absolute counts may introduce bias. We therefore analyzed the within-province proportions of traditional drugs, new drugs, and NPS as primary outcomes. Using proportions ensures comparability of drug use patterns across provinces with differing sample sizes.

Provincial analysis excluded multi-region data and was normalized based on sample size and sampling unit differences, with proportions calculated as: proportion of a drug type = (users of a type/total sample) × 100%.

North-South Univariate Analysis

The dataset was divided into northern and southern regions based on the Qinling-Huaihe line for univariate analysis. Normality (Shapiro–Wilk test) and homogeneity of variance (Levene's test) were assessed for each drug type. Based on these tests, one-way ANOVA was applied to traditional and synthetic drugs, and the Mann–Whitney *U*-test was used for NPS to evaluate regional differences.

Provincial Clustering Analysis

Analyzing the total survey populations and regional differences, we hypothesized that drug use characteristics might vary across regions. To investigate further, population survey data from China's provinces, autonomous regions, and municipalities were reorganized. Given substantial differences in sample sizes across provinces, clustering was based on the within-province proportions of traditional drugs, new drugs, and NPS.

Provinces were clustered using Ward's method with Euclidean distance, and dendrograms were optimized with optimal_leaf_ordering. Cluster membership was determined by the largest vertical gap in the dendrogram. Robustness was assessed using two alternative approaches: hierarchical clustering with average linkage and Manhattan distance, and agglomerative clustering with ward linkage and euclidean distance. Consistency across methods was quantified using the Adjusted Rand Index (ARI), ensuring observed regional patterns were not method- or metric-dependent.

Cluster Analysis of Total Study Populations. Provinces were clustered using Ward's method with Euclidean distance, and dendrograms were optimized with optimal_leaf_ordering. Cluster membership was determined by the largest vertical gap in the dendrogram. Robustness was assessed using two alternative approaches: hierarchical clustering with average linkage and Manhattan distance, and agglomerative clustering with ward linkage and euclidean distance. Consistency across methods was quantified using the Adjusted Rand Index (ARI), ensuring observed regional patterns were not method- or metric-dependent. The results were displayed in dendrogram form, with geopandas mapping clusters on a China map. Cluster Analysis by Drug Type Proportions. The same method analyzed provincial data on the proportions of traditional drugs, synthetic drugs, and NPS. Results were visualized in dendrograms and mapped onto China's provincial layout.

Analysis of Target Populations

This study examines two groups—drug users and adolescents—to explore their distinct drug-use patterns. Data were collected from 24 studies on drug users across 13 provinces and 12 studies on adolescents across 7 provinces. Spatial clustering, descriptive statistics, hierarchical clustering, and geospatial mapping were applied.

The analysis adopts multiple dimensions. First, descriptive statistics were used to calculate mean, standard deviation, and extrema for adjusted population size, and the proportions for traditional drugs, synthetic drugs, and NPS. Visualizations, including bar charts and box plots, illustrate differences in total population, demographics, and geographic distribution. The hierarchical clustering and heatmap methods align with those used in the Provincial Clustering Analysis section.

Results

National Data Analysis

Descriptive Analysis Results

Traditional and new synthetic drug use shows different overall trends (Figure 2A). Overall, the annual mean number of reported drug users was 877,900 for traditional drugs (mean share 54.16%, 95% CI 44.01–64.31%) and 894,700 for synthetic drugs (mean share 43.07%, 95% CI 33.92–52.22%). Means and confidence intervals were calculated across the reported annual values; proportions refer to each year's share of reported users. Since 2016, synthetic drugs have surpassed traditional drugs. Although NPS had a low average share (3.62%), their usage peaked at 11.83% and increased sharply from 2018 to 2023. Enforcement data showed averages of 1.739 million drug users, 86,890 drug-related cases, 103,130 suspects detained, and 58.22 tons of seized drugs.

Trend Analysis

This analysis of drug user numbers and the proportions of traditional drugs, new synthetic drugs, and NPS over time is shown in Figure 2B. The results reveal a parabolic trend in drug user numbers, rising until 2018 and then declining. Significant shifts occurred in 2007, 2014, and 2017, with rapid growth between 2012 and 2017, followed by a steady decrease from 2018.

Traditional drug use has consistently declined, with the sharpest drop occurring from 2018 to 2023, following a slight rise from 2005 to 2011 and a significant decrease between 2012 and 2017. New synthetic drug use has shown continuous growth, sharply increasing from 2016 and eventually surpassing traditional drugs. NPS use, initially low, has steadily grown, with a marked increase from 2018. A 2023 outlier indicates rapid expansion, reflecting the growing focus on NPS. The 2020–2022 period may partially reflect disruptions related to the COVID-19 pandemic, while the 2023 data point indicates continued growth, though short-term influences should be considered.

Enforcement Correlation

Correlation analysis (Figure 2C) shows that the number of drug users is positively associated with enforcement indicators. Pearson correlation coefficients were as follows: drug users vs drug-related cases, $r = 0.89$ ($p = 0.001$, 95% CI 0.56–0.98); vs suspects arrested, $r = 0.91$ ($p = 0.001$, 95% CI 0.61–0.98); vs drugs seized, $r = 0.92$ ($p = 0.001$, 95% CI 0.65–0.98). All correlations were calculated as two-tailed tests. Enforcement indicators were also strongly intercorrelated (cases vs arrests: $r = 1.00$, $p < 0.001$, 95% CI 0.99–1.00; cases vs drugs seized: $r = 0.97$, $p < 0.001$, 95% CI 0.85–0.99; arrests vs drugs seized: $r = 0.98$, $p < 0.001$, 95% CI 0.89–0.99).

Time series analysis (Figure 2D) shows a decline in drug users from 2015 to 2023, with a significant drop from 2019. Arrests and case numbers followed a similar trend, while drug seizures remained stable until 2021 before also decreasing. This suggests a correlation between stricter enforcement and fewer drug users.

Cross-correlation analysis (Figure 2E) supports this finding. Although the trend is not significant in the full dataset, the analysis of complete data (2015–2023) reveals a negative correlation between the number of drug users and enforcement actions within a 0–3-year lag. This suggests that increased enforcement could reduce the number of drug users in the subsequent years.

Regional Analysis Results

North-South Univariate Analysis

Univariate analysis (Figure 3A) showed no significant north-south differences in traditional drug (F=0.612, p=0.438) or synthetic drug (F=2.821, p=0.101) use. However, NPS use shows a statistically significant regional difference (U=114.0, p=0.019), suggesting notable geographic patterns in NPS consumption.

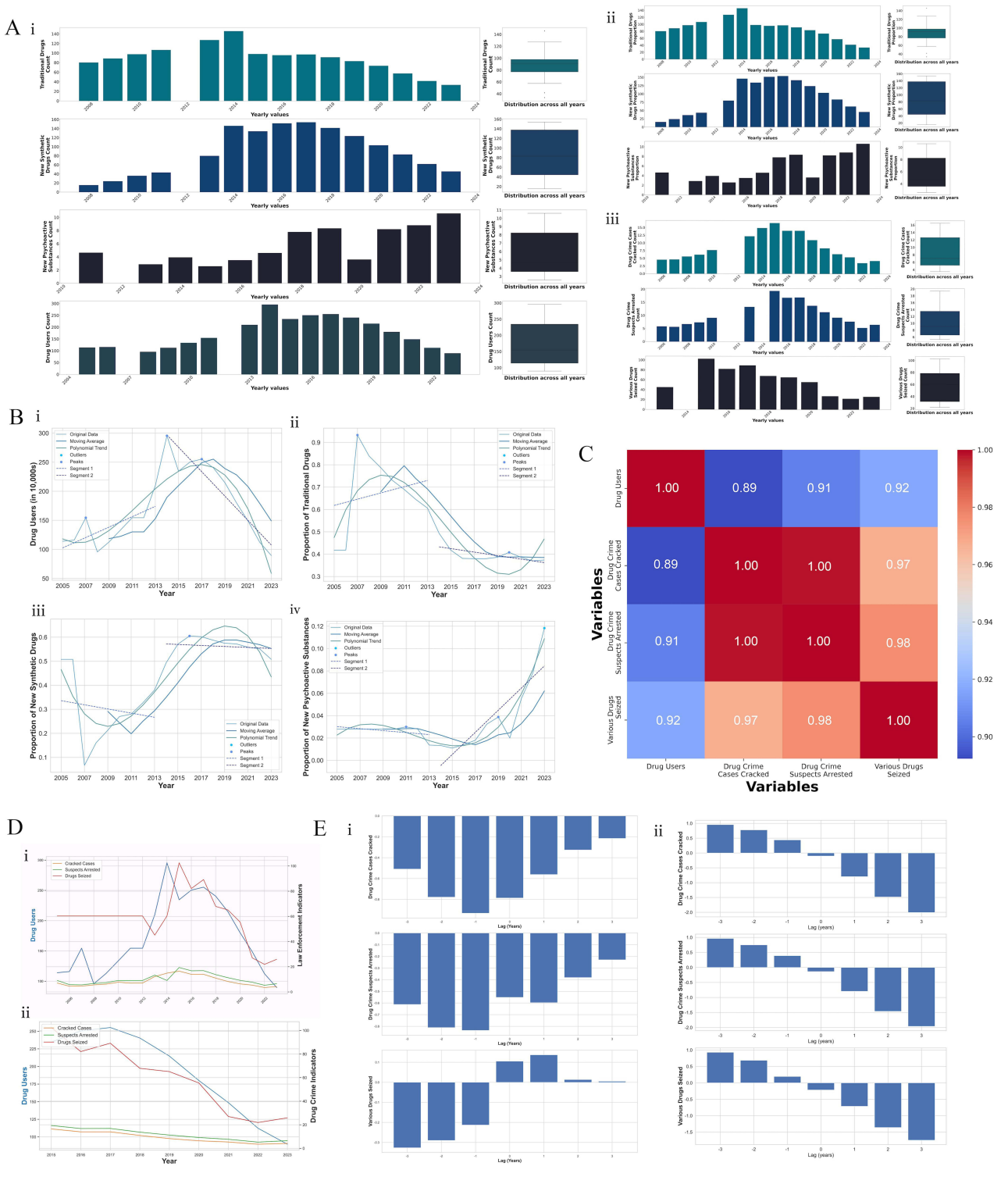

Figure 2 National Data Analysis Results. (**A**) Descriptive analysis of drug types and drug users (count in 10,000s) and analysis of drug proportions, presenting (i) drug types and user populations, (ii) drug-use proportions, and (iii) law-enforcement outcomes. (**B**) Time trend model results, summarizing (i) drug-user counts, (ii) the proportion of traditional drugs, (iii) the proportion of new synthetic drugs, and (iv) the proportion of new psychoactive substances. (**C**) Correlation heatmap between law enforcement-related actions and the number of drug users, (**D**) Time series comparison visualization of law enforcement-related actions, with (i) showing the dual-axis trends based on the full dataset and (ii) showing the corresponding trends restricted to 2015–2023 after temporal filtering and re-imputation. (**E**) Cross-sectional analysis results of law enforcement-related actions with (i) showing the contemporaneous correlation structure from the full dataset and (ii) the corresponding structure from data filtered to 2015–2023 with median imputation.

Regional Clustering Analysis

As shown in Table 3 and Figure 3B, provincial variations in the proportions of traditional, synthetic, and NPS use. Clustering robustness was assessed using alternative linkage methods and distance metrics. Both average linkage with Manhattan distance and AgglomerativeClustering (Ward linkage, Euclidean distance) produced perfect agreement with the original Ward–Euclidean clustering (ARI = 1.000), confirming that provincial clustering patterns are highly robust.

Traditional drug use was highest in Yunnan (69.51%) and Inner Mongolia (79.49%), while synthetic drug use was particularly elevated in Anhui (52.49%), Jiangxi (81.02%), and Henan (41.64%). NPS use is most prevalent in Beijing

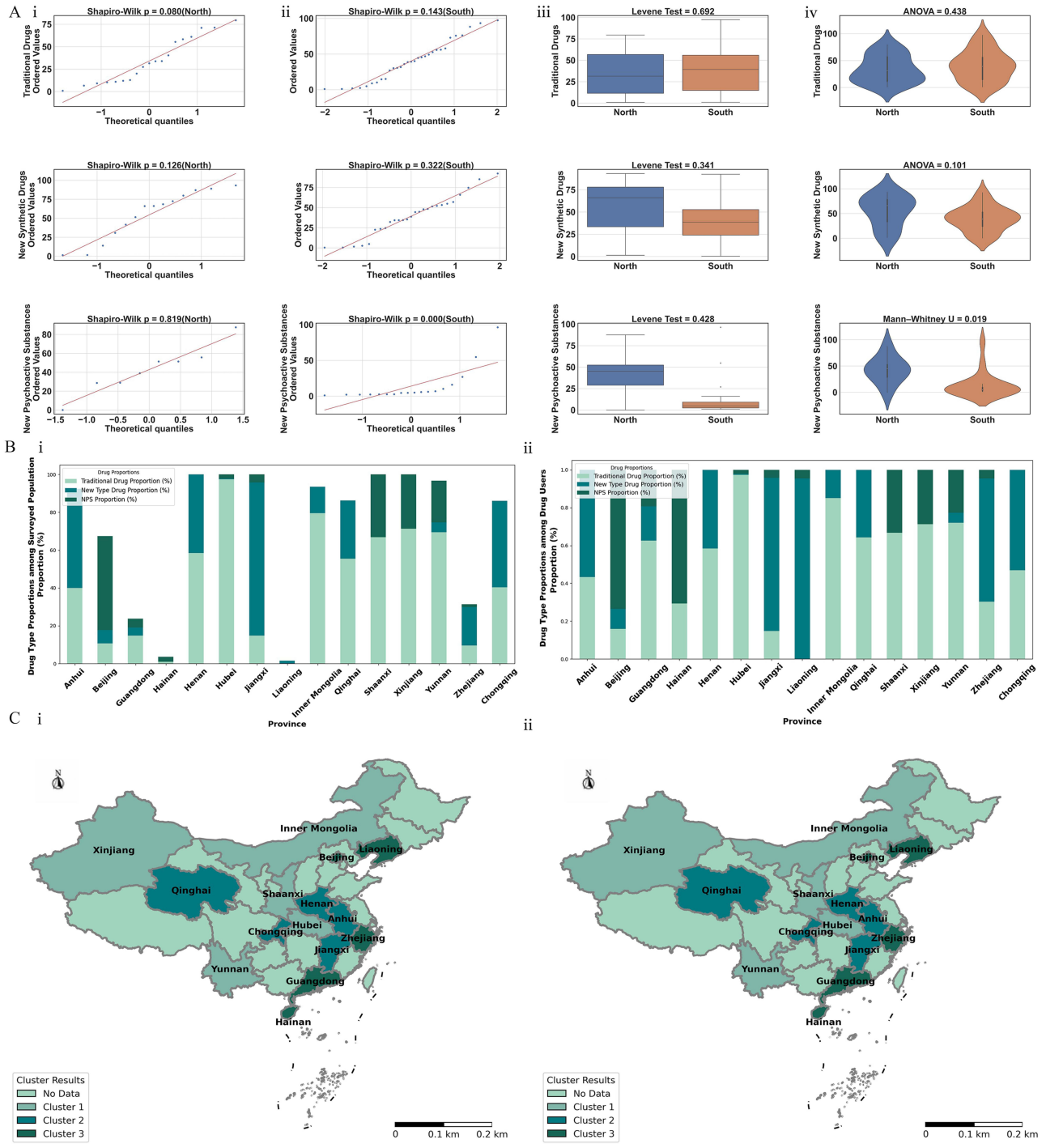

Figure 3 Continued.

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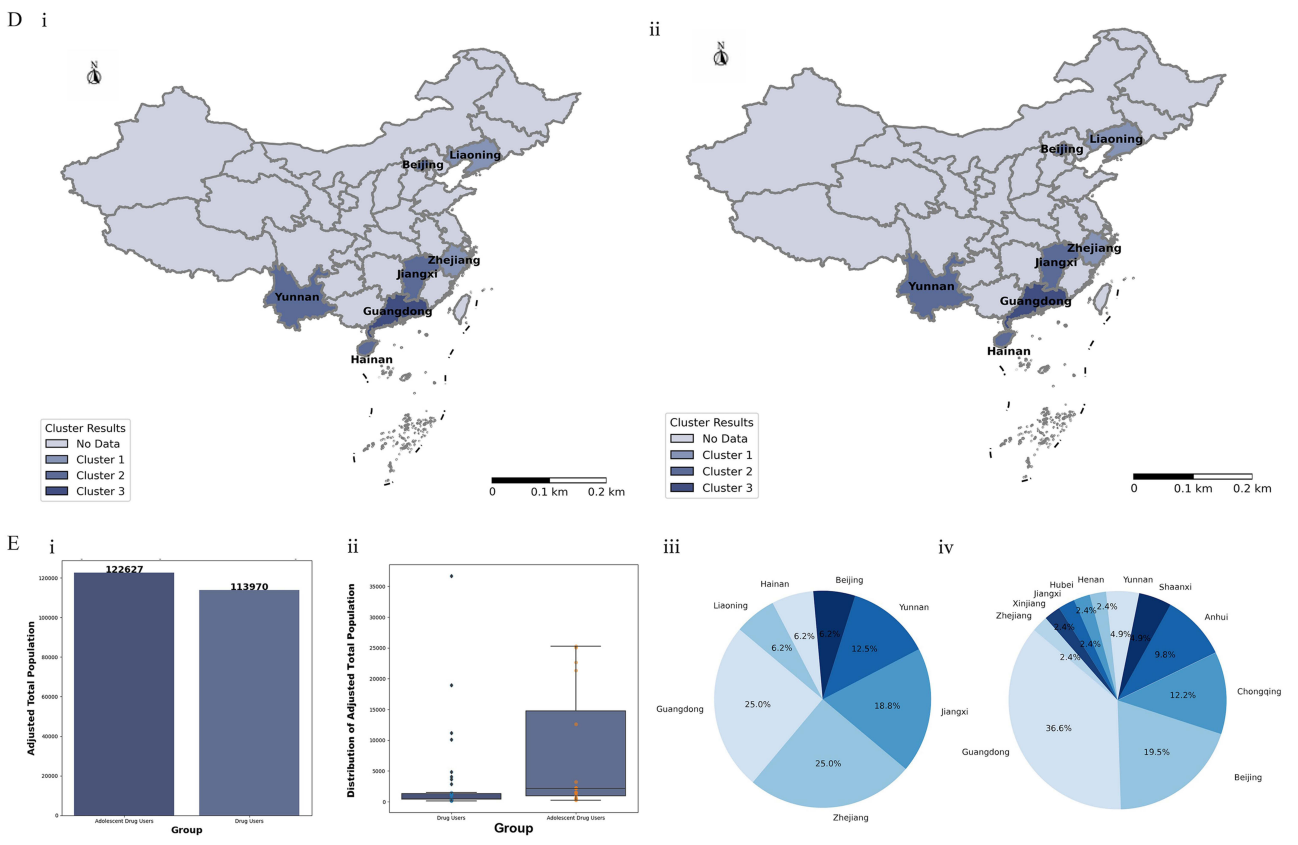

Figure 3 Provincial Clustering and Special Population Analysis Results. (**A**) Univariate analysis: QQ plots of northern (i) and southern (ii) regions; (iii) variance homogeneity test; (iv) univariate test results. (**B**) Proportions of three drug types by province: (i) in the total surveyed population, and (ii) in the drug-using population. (**C**) (i) Heatmap of clustering results for drug use quantities by province in China (from the literature); (ii) Spatial clustering analysis of drug type proportions by province in China. (**D**) (i) Spatial clustering analysis for adolescent drug users, and (ii) for all drug users by province. (**E**) Overall data characteristics of drug users and adolescents shown in bar and pie charts, with (i) bar charts displaying adjusted population counts, (ii) boxplots illustrating distributional patterns, (iii) a pie chart showing the provincial distribution of Adolescent Drug Users, and (iv) a pie chart showing the provincial distribution of Drug Users.

(49.58%), Shaanxi (33.21%), and Xinjiang (28.72%). It is important to note that data from certain provinces, such as Liaoning and Hainan, may have limited representation due to smaller sample sizes, which could affect affecting the completeness of findings.

Provinces are grouped into three clusters based on survey population data (Figure 3C): Cluster 1, with fewer studies, includes Xinjiang, Inner Mongolia, Qinghai, Henan, and Shaanxi. Cluster 2, which has more extensive studies, includes Beijing, Hubei, Yunnan, Zhejiang, and coastal areas. Cluster 3 is Guangdong, with the largest sample size.

Clustering by drug type proportions (Figure 3C) reveals that: Cluster 1 (Yunnan, Inner Mongolia, Xinjiang, Hubei, Shaanxi) shows high traditional drug use (>50%) and lower synthetic and NPS use. Cluster 2 (Anhui, Jiangxi, Henan, Chongqing, Qinghai) has high synthetic drug use (>40%) and lower traditional and NPS use. Cluster 3 (Beijing, Guangdong, Zhejiang, Hainan, Liaoning) has higher NPS use (>20%) and lower traditional and synthetic drug use. These clusters illustrate significant regional patterns in drug usage types across China.

Analysis of Specific Populations

The specific population analysis for drug users (~113,970 individuals) and adolescents (~122,627 individuals) (Figure 3D and E) reveals marked demographic differences in drug use. Detailed data can be found in Table 4.

Drug users are geographically dispersed, primarily concentrated in Guangdong, Beijing, and Chongqing. Adolescent drug issues are more concentrated in provinces such as Guangdong, Zhejiang, and Jiangxi, with fewer affected areas overall.

Table 3 Summary of Drug Data by Province in China

City	Total Survey Population	Traditional Drugs (%)	New Drugs (%)	NPS (%)	Cluster
Anhui	20201	39.93	52.49	0	Cluster 1
Beijing	12964	10.66	7.16	49.58	Cluster 1
Guangdong	119858	14.84	4.3	4.56	Cluster 3
Hainan	2270	1.06	0	2.56	Cluster 2
Henan	329	58.36	41.64	0	Cluster 2
Hubei	36706	97.41	0.44	2.14	Cluster 1
Jiangxi	2708	14.73	81.02	4.25	Cluster 2
Liaoning	12598	0	1.46	0.07	Cluster 1
Inner Mongolia	2019	79.49	14.02	0	Cluster 2
Qinghai	5059	55.39	30.74	0	Cluster 2
Shaanxi	277	66.79	0	33.21	Cluster 2
Xinjiang	491	71.28	0	28.72	Cluster 2
Yunnan	13120	69.51	5.2	21.91	Cluster 1
Zhejiang	13075	9.48	20.43	1.44	Cluster 1
Chongqing	2000	40.3	45.7	0	Cluster 2

Table 4 Provincial Drug Use Composition and Clustering (Adjusted)

Population	Province	Traditional Drugs (%)	New Drugs (%)	NPS (%)	Cluster
Drug users					
	Beijing	11.11%	7.41%	47.85%	Cluster3
	Inner Mongolia	79.49%	14.02%	0.00%	Cluster2
	Anhui	39.93%	52.49%	0.00%	Cluster1
	Jiangxi	12.62%	87.38%	0.00%	Cluster1
	Zhejiang	30.65%	66.02%	0.00%	Cluster1
	Guangdong	69.83%	20.18%	2.10%	Cluster2
	Henan	58.36%	41.64%	0.00%	Cluster1
	Hubei	98.13%	0.38%	1.49%	Cluster2
	Qinghai	59.18%	32.84%	0.00%	Cluster1
	Shaanxi	50.41%	0.00%	49.59%	Cluster3
	Xinjiang	71.28%	0.00%	28.72%	Cluster3
	Yunnan	86.32%	6.72%	6.96%	Cluster2
	Chongqing	40.30%	45.70%	0.00%	Cluster1
Adolescents					
	Liaoning	0.00%	1.46%	0.07%	Cluster2
	Beijing	0.44%	0.53%	52.39%	Cluster1
	Jiangxi	5.59%	94.41%	0.00%	Cluster3
	Zhejiang	0.00%	0.00%	1.97%	Cluster2
	Guangdong	0.00%	0.00%	5.20%	Cluster2
	Hainan	1.15%	0.00%	12.56%	Cluster2
	Yunnan	1.35%	2.94%	57.88%	Cluster1

In terms of drug types (Figure 3D), all three drug categories are present among the general drug user population. However, NPS use is significantly more prevalent among adolescents, while traditional drug use is notably lower. This trend raises concerns about adolescents' vulnerability to emerging drugs.

Geographical clustering analysis (Figure 3D) further highlights the distinct regional patterns of drug use. Drug use issues among the general population are particularly severe in eastern coastal, central, southwestern, and some western regions (eg, Xinjiang, Yunnan). In contrast, adolescent drug use is more pronounced in eastern and central regions.

Discussion

Comprehensive Discussion

This multilevel analysis synthesizes fragmented data to provide an integrated picture of drug use data in China, revealing the complexity, regional differences, and usage patterns of various populations.

Trends in Drug Use Patterns

Our analysis corroborates and visually delineates the widely recognized shift in drug use patterns in China. The proportion of traditional drug use is declining, with new synthetic drugs becoming more prevalent, and NPS are on the rise. Although NPS usage remains relatively low on average, it has exhibited substantial volatility, with its peak proportion potentially reaching 11.83%. The trend aligns with UNODC and national surveillance, and our study adds value through multilevel visualization.[15,54] The rapid growth of NPS use indicates a more complex and diverse drug problem in China, influenced by delayed legal regulation, changing market demands, the impact of the internet and social media, and globalization.[55] Critically, it is important to acknowledge that this observed increase may be partially attributable to enhanced detection capabilities and reporting systems over the study period.

This shift presents new challenges for drug control, as NPS and synthetic drugs are often difficult to detect and regulate.[56–58] Moreover, our study reveals a strong negative correlation between law enforcement and drug use (correlation coefficient −0.89 to −0.92), suggesting that stronger enforcement could effectively reduce drug use over time. This emphasizes the need for continued law enforcement efforts[59] and the development of advanced detection and control technologies.[60]

Regional Differences in Drug Use

Our analysis identified significant regional disparities in drug use patterns across China. While no major differences were observed between northern and southern regions for traditional or synthetic drugs, NPS use differed significantly (U = 114.0, p = 0.019). Cluster analysis further suggested distinct geographic patterns: provinces in the northwest and central regions (eg, Yunnan, Inner Mongolia, Xinjiang) tended to be associated with a higher proportion of traditional drug use. This pattern is consistent with the hypothesis that economic underdevelopment and geographic isolation may perpetuate the prominence of traditional drugs. Conversely, clusters comprising coastal eastern regions and major municipalities (eg, Beijing, Guangdong, Zhejiang) were characterized by higher usage rates of new synthetic drugs and NPS. It is plausible that factors such as economic development, cross-border trade, and high population mobility contribute to these regions serving as entry points and hubs for newer substances.[61,62]

Additionally, several inland provinces (eg, Anhui, Jiangxi, Henan) appear to represent transitional zones, showing a mix of traditional and new synthetic drug use.[63] It is important to note that these provincial-level findings are generated from secondary data of varying quality and completeness; thus, they should be considered as informative hypotheses that highlight areas for future targeted research rather than definitive representations of provincial-level realities. This trend suggests that economically developed areas face more complex drug issues,[64,65] with a higher proportion of NPS use.[66] Collectively, the observed clustering implies that drug issues may manifest differently along a socioeconomic developmental gradient, which underscores the potential value of developing region-specific drug control strategies.

Drug Use in Specific Populations

This study also examines drug use among adolescents and the general drug-using population. It found that NPS use is significantly higher among adolescents compared to drug users overall, while traditional drug use is notably lower. Among drug users, new synthetic drugs are more prevalent. Geographically, adolescent drug use is concentrated in the eastern and central regions, which may be associated with higher population mobility, economic development, and better access to transportation and external exchanges. However, regional disparities in reporting and enforcement intensity could also contribute to this observed pattern. The evolving chemical structure of NPS allows them to temporarily evade legal controls, and adolescents may be more likely to experiment with these new, seemingly "legal" substances.[67] The widespread use of the internet and social media may also accelerate NPS distribution, further influenced by international drug trends through cross-border trade and cultural exchanges. These findings are consistent with international research[68–70]and highlight the need for tailored prevention and intervention strategies, particularly for adolescents.

Synthetic drugs and NPS have shown a marked upward trend in East Asian and Western countries, and China's rising use of these substances corresponds to this broader regional and global pattern.[67,69,70]

The rapid growth of NPS use, especially among adolescents, poses serious societal risks.[71] First, the toxicity and long-term effects of NPS are not fully understood,[72] potentially creating significant public health concerns. Traditional addiction treatments may be ineffective for NPS, underscoring the necessity to develop new therapeutic approaches. Additionally, the fast-evolving nature of NPS makes law enforcement and detection more challenging.[73] NPS misuse can also lead to broader social issues, such as rising crime rates and reduced productivity, thus increasing societal costs.[74] As such, prevention, treatment, and regulatory strategies for NPS must be continuously evaluated and updated to address these emerging challenges.

Study Limitations

This study has several limitations. First, the data were sourced from literature, and the "Drug Situation Report" may limit comparability due to inconsistent data collection methods and standards across different time periods and provinces. A key limitation is the inability to distinguish between an actual increase in NPS use and improved detection capabilities. Additionally, as a retrospective study, reliance on historical data may result in missing or inaccurate records, which are influenced the evolving state of research and shifting public and institutional attention at the time. The findings from provinces with small sample sizes should be interpreted as preliminary and hypothesis-generating. Furthermore, the observed strong correlations, particularly between law enforcement and drug use, cannot be interpreted as causal due to potential confounding factors (eg, socioeconomic changes, major events like the pandemic) and the ecological nature of the data. Finally, the long duration of the study means that policy and environmental changes may have significantly impacted drug use patterns, yet these effects may not be fully captured or disentangled in the historical data.

Future Research Directions

Future research should build upon the findings and limitations of this study. First, prospective cohort studies or surveys employing standardized methodologies are needed to verify the subnational patterns identified here and establish causal relationships, moving beyond the correlational associations of this analysis. Specifically, mixed-methods research that integrates quantitative data with qualitative insights is crucial to understand the mechanisms behind the observed regional disparities and the rapid rise of NPS. Such approaches could also help disentangle the effects of major disruptions, such as the COVID-19 pandemic, from long-term trends. Additionally, focused research on NPS, particularly among adolescents, is essential to understand the drivers of initiation and patterns of use. Long-term tracking studies using high-frequency data would also provide a deeper understanding of the dynamics of drug use patterns and the long-term impact of interventions. These efforts will contribute to more targeted and effective drug control strategies in China.

Conclusion

This study provides a descriptive overview of recent drug use patterns in China, showing a continued decline in traditional substances and a growing presence of new synthetic drugs and NPS, consistent with broader global observations.[18,52,53] Clear regional variation was observed, with western and central provinces showing higher proportions of traditional drugs, while eastern coastal regions exhibited greater representation of emerging substances.[58–62]

Adolescents displayed a higher proportion of NPS use compared with the general drug-using population, aligning with international reports documenting the prominence of newer substances among younger groups.[64–67] Although overall NPS prevalence remains lower, their rapid evolution and limited toxicological understanding—frequently noted in prior studies—underscore the need for ongoing surveillance and updated detection approaches.[68–71]

These patterns also align with the epidemiological model,[11,12] suggesting that in rapidly developing regions with high information flow, susceptible adolescent "hosts" are more likely to encounter new "agents" such as NPS. In addition, the observed relationship between strong enforcement and lower traditional drug use, coupled with continued NPS growth, supports supply–demand theory,[3,13] indicating that while strict enforcement effectively suppresses traditional drug supply, it may unintentionally foster the emergence of more evasive NPS to satisfy persistent demand. Together, these findings highlight the importance of improving data completeness, enhancing regional comparability, and strengthening

population-specific monitoring. Continued high-quality, longitudinal data collection will be essential for tracking China's evolving drug landscape and informing evidence-based public health responses.

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Disclosure

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