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Abstract

Understanding the clinical profiles of patients with substance abuse (drug abusers) and their corresponding utilisation of the public healthcare system in Hong Kong is important to evaluate and plan for the service needs of this population.

This study included a cohort of 8,423 patients with a diagnosis of substance abuse presenting to Accident and Emergency (A&E) departments in Hong Kong public hospitals, between 2004 and 2016, identified from the Hong Kong Hospital Authority electronic databases. Using big data methods, their medical conditions, trends of A&E attendances and hospitalisations were analysed and a comparison of healthcare resource utilisation between patients with and without substance abuse was conducted. Patients were matched on a 1:1 ratio, according to sex, age, recent (≤365 days before the index date) healthcare resource utilisation and concurrent medical conditions.

Among the identified A&E cases, the substances most frequently abused were opioids (2,395 cases, 27.1%), followed by ketamine (2,177, 24.6%), barbiturate/hypnotics (656, 7.4%), amphetamines (592, 6.7%) and cocaine (181, 2.0%). Opioids and ketamine are the two main substances that contribute to patients with substance abuse re-attending A&E departments. The most common concurrent medical condition of patients with substance abuse is a diagnosis of mental disorder (n=3,635, 43.2%). After matching, patients with substance abuse had a higher mean number of A&E attendances (7.49 versus 3.07, P <0.001) and hospitalisations (3.32 versus 1.29, P <0.001), and lengthier hospitalisations (27.62 days versus 8.46 days, P <0.001) from the first substance abuse-related A&E attendance during the study period until death or the end of 2016, compared to non-substance abusers.

Attendances to A&E and hospitalisations impact considerably on the healthcare burden in Hong Kong and have important implications for resource allocation in the public health system. Intervention to support and manage patients with substance abuse may reduce A&E department attendances and hospitalisations in this vulnerable patient group.

Declaration

The following work has been completed by the research team at the Centre for Safe Medication Practice and Research (CSMPR), the University of Hong Kong, as the final research report for Beat Drugs Fund 160052 under the Principal Investigator Dr. Esther W Chan.

Ethics approval was obtained from the Institutional Review Board of the University of Hong Kong/ Hospital Authority Hong Kong West Cluster (IRB Reference Number UW 17–107).

We hereby declare that the research report represents our own work and that, to the best of our knowledge, it contains no material that has been previously published or written by other persons nor submitted to Beat Drugs Fund or to any other institution, except where due acknowledgement has been made in the text.

Table of Contents

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Definitions

According to the World Health Organization (1), substance abuse refers to the harmful or hazardous use of psychoactive substances, including alcohol and illicit drugs. It can lead to dependence syndrome - a cluster of behavioural, cognitive, and physiological phenomena that develop after repeated substance use. Typically, this includes a strong desire to take the drug, difficulties in controlling use, persistent use despite harmful consequences, priority given to drug use over other activities and obligations, increased tolerance, and sometimes physical withdrawal.

Drug abuse refers to the use of illegal drugs or inappropriate use of legal drugs. This includes the repeated use of drugs (including prescription drugs in ways other than prescribed) to induce pleasure, and alleviate stress.

According to the Diagnostic and Statistical Manual of Mental Disorders (DSM-V) (2), the standard classification of mental disorders used for clinical, research, policy, and reimbursement purposes in the US and internationally, substance use disorder (SUD) is defined as a problematic pattern of substance use leading to clinically significant impairment or distress as manifested by at least two of the following criteria occurring in a 12-month period:

1. Use in larger amounts or longer than intended
2. Desire or unsuccessful effort to cut down
3. Great deal of time using or recovering
4. Craving or strong urge to use
5. Role obligation failure
6. Continued use despite social/interpersonal problems
7. Sacrificing activities to use or because of use
8. Use in situations where it is hazardous
9. Continued use despite knowledge of physical or psychological problems caused or exacerbated by use
10. Tolerance
11. Withdrawal

The Severity of each Substance-use-disorder is based on:

- 2-3 criteria: Mild Substance Use Disorder
- 4-5 criteria: Moderate Substance Use Disorder
- 6 or more criteria: Severe Substance Use Disorder

Substance use disorders occur in a broad range of severity, from mild to severe. Severity is based on the number of aforementioned criteria presented by self-reporting, reports by knowledgeable others, clinician observations, and biological testing.

For this study, the term "substance abuse" is used to characterise patients who use cannabis, barbiturates, benzodiazepines, cocaine, opioids and some substituted amphetamines. These patients are included in this study and they are described as "substance abusers". Patients with alcohol and tobacco abuse are excluded from this study because we define substance abuse in a similar manner to the Central Registry of Drug Abuse in Hong Kong, which excludes alcohol and tobacco in their definition of substance abuse.

List of tables

List of figures

List of abbreviations

A&E	Accident and Emergency
AMAS	American Society of Addiction Medicine
CDARS	Clinical Data Analysis and Reporting System
CMS	Clinical Management System
CRDA	Central Registry of Drug Abuse
DAWN	Drug Abuse Warning Network
DSM	Diagnostic and Statistical Manual of Mental Disorders
ED	Emergency Department
EPR	Electronic Patient Records
HA	Hospital Authority
HKPIC	Hong Kong Poison Information Centre
ICD-9-CM	International Classification of Diseases Ninth Edition-Clinical Modification
NA	Not Applicable
PICMS	Poison Information and Clinical Management System
PPV	Positive Predictive Value
SD	Standard Deviation
SES	Socioeconomic Status
UNODC	United Nations Office on Drugs and Crime
WDR	World Drug Report
WHO	World Health Organization

Chapter 1 Introduction

Substance abuse refers to the compulsive seeking and escalated intake of substances, including drugs without medical advice or prescription, or the illegal use of dangerous drugs involving psychotropic substances for non-treatment purposes (3). It is a global health issue that affects individuals, families, and societies. The commonly abused drugs have a profound negative impact on the nervous system, particularly on the brain. Frequent and prolonged use of substances of abuse in high doses is likely to distort an individual's perception of and response to their environment. Frequently, several substances are abused at the same time (4). Complex molecular interactions can occur among various types of administered substances, thus increasing the risk for harmful or fatal outcomes such as intoxication and psychosis.

The United Nations Office on Drugs and Crime (UNODC) estimated that 246 million people worldwide aged 15 to 64 used an illicit drug in 2013 (5). The number of individuals estimated to use substances showed a steady increase from 2008-2013, with cannabis and opioids being the most common substances abused globally (5). Substance abuse is commonly associated with crime, violence, imprisonment, unemployment, and child abuse (6-9).

Apart from social consequences, substance abuse can have serious effects on individual health. According to the latest World Drug Report (WDR), opioids were the most harmful drug type, accounting for 70% of the negative health impact associated with substance use disorders (10). Ketamine, methamphetamine, and cocaine users are at an increased risk of cardiovascular events (11), infectious diseases (12), mental disorders (13) and death by overdose. The impact of substance abuse may cause permanent changes to users' physiology (14, 15). Due to the increased risk of overdose, substance abusers frequently seek emergency medical care, thus increasing the burden to healthcare facilities (16). As accident and emergency (A&E) departments (also known as emergency departments (ED) in the US and Europe) are the front line responders to substance abusers experiencing

acute adverse consequences, they can offer valuable insight into the patterns of substance use (17).

According to the Drug Abuse Warning Network (DAWN), a public health surveillance system in the US that monitors substance-related visits and deaths via A&E departments (18), there were about 2.1 million A&E visits due to substance abuse in 2010. Of these cases, 21% involved illicit substances (cocaine, marijuana, and heroin). In 2004 and 2009, teenagers (aged 20 or younger) made 116,644 and 169,589 visits to A&E departments due to substance abuse respectively, showing a substantial increase of 45.5%. Almost half of these A&E visits were related to adverse reactions including illicit drug adverse reactions, side effects, and drug-drug interactions due to substance abuse. Moreover, 25% of A&E visits due to substance abuse required hospital admission. Overall, the data indicates that both adults and teenagers seek emergency medical care due to complications from substance abuse, detoxification, or treatment services.

1.1 Substance Abuse Issues in Hong Kong

In Hong Kong, official government data about substance abusers are recorded in the Central Registry of Drug Abuse (CRDA), a database maintained by the Narcotics Division of the Security Bureau. According to the CRDA, the most frequently abused drugs included methamphetamines, ketamine, triazolam/midazolam/zopiclone and cocaine in 2016 (19). Due to consistent anti-drug efforts from multiple stakeholders, such as government, law enforcement agencies, schools, and healthcare organizations, the number of reported substance abusers has generally declined since 2009 in both males and females as well as among individuals under 21 years of age (19).

Although the number of substance abusers has been declining, the length of time that substances are abused by newly reported abusers has increased every year from 1.7 years to 5.2 years between 2007 and 2014 (20). These numbers may reflect the hidden nature of substance abuse (20), in that it is difficult to identify substance abusers and offer early intervention. It is concerning that in recent years,

psychotropic substance abuse has been increasing and first-time usage is occurring at an earlier age (9). Ketamine was the psychotropic substance most commonly abused from 2007 to 2014 (19). Recreational use of ketamine comes with additional risks, ranging from bladder and renal complications to psychotropic behaviour and memory deficit (21). Concurrently, the number of methamphetamine abusers also increased from 2011 to 2016. Since 2015, methamphetamine has surpassed ketamine to become the most popular psychotropic substance abused (19). Among reported substance abusers under the age of 21 in Hong Kong, methamphetamine was the most popular type of substance abused and was taken by 44% of them in 2016. Apart from psychotropic effects such as paranoia and hallucinations, methamphetamine abuse is also a risk factor for cardiovascular problems. A recent study in the US showed that patients exposed to methamphetamine have a higher prevalence of heart failure compared to general ED patients with no prior exposure (22). Acute heart failure requires immediate treatment and results in A&E visits as well as hospital admission.

Cardiovascular-related problems are not exclusive to methamphetamine abuse. Cocaine abusers have a higher likelihood of myocardial infarction and stroke (23, 24). For patients visiting A&E for cocaine abuse, 56.2% experienced cardiopulmonary related complaints such as chest pain, and 39.1% exhibited neurologic events such as seizures (25, 26). Understanding the health impact of current trends of substance abuse will enable the Government of the Hong Kong SAR to focus resources on specific prevention education programs and healthcare assistance for substance abusers.

1.2 Rationale

Substance abuse remains a concern in Hong Kong with considerable knowledge gaps. The CRDA provides data on the baseline characteristics of substance abusers in Hong Kong, allowing the exploration of substance abuse trends among users. However, the CRDA is limited in that it is a voluntary reporting system. Information on substance abusers who have been voluntarily reported by agencies, including law enforcement, treatment and welfare agencies, tertiary institutions,

hospitals, and clinics are included in the CRDA (19). Those not reported by these agencies are excluded. Therefore, CRDA does not capture the precise extent of the substance abuse population and the nature of substance abuse in Hong Kong.

Moreover, current management of substance abusers moving through the public healthcare system in Hong Kong has not been fully examined. Previous studies of healthcare management for substance abusers were limited in the number of sites and recruited participants, and thus lacked generalizability (27).

In addition, the demographics and clinical profiles of substance abusers and their corresponding burden on the public healthcare system have not been systematically investigated. The clinical profiles of substance abusers in the CRDA are incomplete. Addressing this knowledge gap will be beneficial to society, especially decision makers. Many stakeholders in Hong Kong have strong interests in reducing substance abuse (28). Identifying the current health status of substance abusers will provide insight into understanding the medical conditions that affect substance abusers.

Healthcare characteristics of substance abusers are commonly reported to surveillance networks such as DAWN in the US, as mentioned above (18). However, Hong Kong does not have an established surveillance system for screening substance abuse-related A&E visits, perhaps because substance abuse in Hong Kong is not as prevalent as in the US, China and other countries (10, 19, 29). Regardless, the prevalence, pattern, and outcome of substance abuse-related accidents leading to A&E visits in Hong Kong are poorly understood. In this study, we expect our public health database to show trends in A&E attendances similar to those in the US and other countries. The study findings are expected to improve the management of substance abusers within the public healthcare system and guide the development of evidence-based interventions in Hong Kong.

This study aimed to examine the clinical characteristics of substance abusers in Hong Kong and the trends of healthcare resource utilisation in public hospitals. This

is a Hong Kong-wide population-based study of substance abusers seeking medical attention at A&E departments, some of whom will require hospital admission. We chose to focus on A&E attendance records as they represent individuals with emergency health conditions and capture the majority of medical records involving substance abuse in Hong Kong public hospitals.

In general, the overall goal of this study is to identify, describe and understand substance abusers in order to characterise and improve the key downstream clinical pathways within this group, such as follow-up hospital admission and re-attendance at A&E departments.

Chapter 2 Objectives

2.1 Overall goals and objectives

When substance abusers experience illicit substance-related illness, they may be first present for acute medical care. Describing and understanding the characteristics of substance abusers from a healthcare perspective may help identify a suitable time and place for drug-rehabilitation intervention. The long-term objective of this study is to use the big data platform derived from public health databases and clinical health service information to provide insights to the government to guide the development of evidence-based interventions for substance abusers.

2.2 Specific objectives

The overall objective of this study is to describe the current health of substance abusers in Hong Kong requiring medical care in A&E departments. Specifically, it aims to:

1. Characterise substance abusers by age group, gender, substance type and with attention to special groups such as school-aged individuals (<21 years old), elderly population (≥65 years old), individuals with mental disorders, pregnant women, and ethnic minorities. Describe the medical comorbidities at the time of A&E attendance and the geographical distribution of A&E attendance.

2. Describe the trends of substance abusers having A&E re-attendance due to substance abuse, the number of deaths among substance abusers, and the number of deaths among substance abusers who attended A&E or had hospital admission due to substance abuse.

3. Compare the length of hospitalisations, the number of hospital admissions and A&E attendance due to any causes between substance abusers and non-substance abusers.

Chapter 3 Methodology

3.1 Patient cohort

We retrospectively studied a cohort of 8,423 substance abusers who sought A&E services in Hong Kong public hospitals between 1 Jan 2004 and 31 Dec 2016. These individuals were identified based on A&E attendance with an International Classification of Diseases Ninth Edition-Clinical Modification (ICD-9-CM) diagnosis code for substance abuse (including but not limited to ICD-9-CM codes in Table 1 for drug dependence, non-dependent abuse of drugs, and drug withdrawal).

Table 1. ICD-9-CM codes indicating substance abuse for data retrieval from CDARS

Diagnosis code description	ICD-9-CM codes
Drug withdrawal [a]	292.0
Drug dependence [b]	304
Nondependent abuse of drugs [c]	305 (0)
Cannabis Abuse [d] *(Example: marijuana)*	305.2
Hallucinogen abuse [e] *(Examples: psilocybin, lysergic acid diethylamide [LSD])*	305.3
Barbiturate and similarly acting sedative or hypnotic abuse [f] *(Example: benzodiazepines, nonbenzodiazepine receptor agonists – zolpidem, zopiclone, melatonin receptor agonist)*	305.4
Opioid abuse [g] *(Examples: heroin, morphine, codeine, oxycodone, buprenorphine, hydrocodone)*	305.5
Cocaine abuse [h]	305.6
Amphetamine or related acting sympathomimetic abuse [i] *(Examples: amphetamine, methamphetamine, 3,4-methylenedioxymethamphetamine/ MDMA)*	305.7
Antidepressant type abuse	305.8
Others, mixed, or unspecified substance abuse [j] *(Examples: ketamine, phencyclidine, caffeine, inhalants such as thinner, glue, paint)*	305.9
Drug dependence complicating pregnancy, childbirth, or the puerperium	648.3

Source: Clinical Data Analysis and Reporting System (CDARS); ICD-9-CM: International Classification of Diseases Ninth Edition-Clinical Modification.

[a] Drug withdrawal includes approximate synonyms such as withdrawal of amphetamine, cocaine, nicotine, opioid, psychostimulant, sedative, hypnotic, anxiolytic, and stimulant withdrawal.

[b] Drug dependence is defined as a state, psychic and sometimes also physical, resulting from the interaction between a living organism and a drug, characterised by behavioural and other responses that always include a compulsion to take the drug on a continuous or periodic basis in order to experience its psychic effects, and sometimes to avoid the discomfort of its absence. Tolerance may or may not be present. A person may be dependent on more than one drug.

[c] Nondependent abuse of drugs is defined as excessive use of drugs or chemicals with associated psychological symptoms and impairment in social or occupational functioning and excessive use of habit-forming medications.

[d] Cannabis is a psychoactive drug made from the *Cannabis* plant intended for medical or recreational use.

[e] A psychoactive agent which can cause hallucinations, perceptual anomalies, and other substantial subjective changes in thoughts, emotion, and consciousness.

[f] Barbiturate is a central nervous system depressant, and can, therefore, produce a wide spectrum of effects from mild sedation to total anaesthesia. Hypnotics are psychoactive drugs whose primary function is to induce sleep and to be used in the treatment of insomnia or surgical anaesthesia.

[g] Opioids are drugs that act on the nervous system to relieve pain. They act on opioid receptors to produce morphine-like effects.

[h] Cocaine is a stimulant drug made from the leaves of the coca plant.

[i] Amphetamine is a potent central nervous system (CNS) stimulant. It is the parent compound of its own structural class, substituted amphetamines, which includes prominent substances such as MDMA and methamphetamine.

[j] Others or unspecified substance abuse may include other unspecified substance that are not included above, non-prescribed use of drugs or patent medicines, or inhalation of vapors from volatile chemical substances (such as aerosol sprays, solvents, and anesthetics) in order to produce mind-altering effects.

3.1.1 Substance abusers versus non-substance abusers on healthcare utilisation

In this study, healthcare utilisation by substance abusers was compared with similar individuals without a known history or diagnosis of substance abuse.

As above, substance abusers were defined as patients who had attended A&E with ICD-9-CM codes for substance abuse (Table 1). To select patients without substance abuse, we identified a random sample from the entire population who had ever used the services of the Hong Kong Hospital Authority (HA) based on random reference key numbers generated from CDARS. Individuals with a diagnosis of substance abuse were excluded and the remaining patients in the random sample were classified as non-substance abusers in this study.

The identification of both substance abusers and non-substance abusers with matching is shown in Appendix 1.

3.2 Data Source

In this study, two databases were utilised and analysed. They are the Clinical Data Analysis and Reporting System (CDARS) of the HA and the Poison Information and Clinical Management System (PICMS) of the Hong Kong Poison Information Centre (HKPIC). Thirteen years of data (2004-2016) were collected regarding the medical attendance and clinical outcomes of substance abusers in the public healthcare system, with special attention to vulnerable groups such as school-aged youth, individuals with mental disorders, pregnant women, elderly and ethnic minorities. These databases provided relatively complete and generalizable data on healthcare and substance abusers who sought medical care through A&E attendance and HA hospital admission.

3.2.1 Clinical Data Analysis and Reporting System

This study used data retrieved from the electronic medical records of the Clinical Data Analysis and Reporting System (CDARS) of the HA, a publicly-funded healthcare provider (30). The HA uses the Clinical Management System (CMS), an internal electronic medical record, to record key clinical information such as treatment, diagnoses, prescriptions, laboratory results, procedure information, and to write consultation and discharge summaries. It also allows clinicians and healthcare specialists to review care in daily practice (31). The HA also uses Electronic Patient Records (EPR), which include patient data on demographics, date of consultation, date of hospital admission and discharge, diagnoses, procedures, drug prescriptions, and laboratory test results transferred from CMS to CDARS for auditing and research proposes. Examples of other types of databases in different countries are the Clinical Practice Research Datalink (32), Taiwan National Health Insurance Research Database (33), Taiwan Stroke Registry (33), Danish National Prescription Registry (34) and the Danish Register of Causes of Death (35).

CDARS has been used to conduct several high-quality epidemiological studies in Hong Kong (36-41) and multinational pharmacovigilance studies (42, 43). The accuracy of case ascertainment for conducting epidemiological studies using

CDARS is high. Validation from previous studies demonstrated a high positive predictive value of clinical events including gastrointestinal bleeding (100%), intracranial haemorrhage (95%), history of peptic ulcer/ gastrointestinal bleeding (90%) and ischaemic stroke (90%) (36, 41).

3.2.2 Study period and data structure (CDARS)

Data from CDARS were collected between 1 Jan 2004 and 31 Dec 2016. These included:

- Demographics, comorbidities (including but not limited to a diagnosis of cardiovascular and endocrine diseases, neuropsychiatric illnesses, and infectious diseases), use of commonly prescribed medications, date of registered death.
- Use of hospital resources: total length of hospital stay, number of A&E attendances and number of hospitalisations.
- Geographical location of service use and patient locations.

3.2.3 Poison Information and Clinical Management System

Hong Kong Poison Information Centre (HKPIC) is an organization that provides 24-hour telephone consultation on poison information and clinical toxicology management to healthcare professionals in Hong Kong. HKPIC also provides an inpatient and outpatient toxicology service at its location in the United Christian Hospital. The Poison Information and Clinical Management System (PICMS) from HKPIC acts as a reporting centre for all poisoning cases from A&E under the HA.

The PICMS from the HKPIC includes information of patients who have used drugs. The substance is identified based on results from two bedside urine tests. HKPIC is notified of the majority of patients with poisoning through consultation and reporting (44). Consultation is defined as a patient with poisoning consulting a healthcare professional for information on poison and management advice. Reporting is defined as patients with poisoning reported to the HA, where the majority of cases are from A&E departments. All patients with poisoning are recorded in PICMS.

Details of each patient with poisoning was recorded in PICMS according to the information obtained from consulting health care professionals, electronic patient records, medical records, and other relevant sources.

3.2.4 Study period and data structure (PICMS)

Data from PICMS were collected between 1 Jul 2008 and 31 Dec 2016. These include the patient's demographic data and poison data (namely, poison type, route, and approximate time of exposure).

3.3 Data collection procedure

In the HA, the health records in the CMS recorded by clinicians or other healthcare professionals are routinely transferred to CDARS (45). Data on cause of death are also available through the internal linkage to the regional death registry from the Immigration Department. To protect patient confidentiality, a unique identifier is assigned to each patient to enable linkage between the patient and his/her data.

3.4 Data validation

Medical records from the EPR/CMS are studied to verify the validity of the data records in CDARS. Co-investigators Dr. M.L. Tse and Dr. A.T.Y. Chow from the HKPIC reviewed the records and performed case validation. Criteria for validating medical records were based on the following:

DSM-IV Criteria for Substance Dependence and Substance Abuse Recurrent use in physically hazardous situations (occurs at least once every 12 months)
AND one or more of the following:

1. Documentation as a substance abuser at the A&E episode by the clinician/ nurse
2. Documentation as a substance abuser in the electronic patient record prior to the A&E attendance episode
3. Whether the presentation of that A&E attendance episode was related to substance abuse

In total, 11,602 A&E attendance cases were related to substance abuse in this study. Three hundred cases (A&E records due to substance abuse from all hospitals in this sample) were extracted and randomised for data validation.

3.5 Statistical analysis

Descriptive analyses were conducted to characterise the sample of substance abusers that require medical attention through A&E attendance and hospital admission. Total numbers, percentages, means, and median were used to describe substance abusers by demographic characteristics including age, gender, and drug type. T-test or Wilcoxon test were used to determine whether the length of hospitalisations, number of A&E attendances, and hospital admissions differed in the group of substance abusers with the group of non-substance abusers. A significance level of 0.05 was used in all statistical analyses.

For patients with substance abuse, the index date was defined as the date of the first A&E attendance due to substance abuse between 1 Jan 2004 and 31 Dec 2016, while for the random sample without substance abuse, a random date between 1 Jan 2004 or the date of birth (whichever came later) and 31 Dec 2016 or date of death (whichever came first) was assigned to each patient as the index date. The follow-up for each patient commenced from the index date to death or end of study period (31 Dec 2016), whichever came first. Propensity score matching, a commonly used method to reduce potential bias due to treatment allocation or heath conditions was performed to control for confounders between patients with substance abusers and the random sample without substance abuse. Patients from two groups were matched at a 1:1 ratio on sex, age, recent (≤365 days before the index date) healthcare utilisation and concurrent medical conditions. Standardized mean difference was used to assess the difference between two groups of which a value of less than 0.1 was considered negligible.

Chapter 4 Results

4.1 Results of data validation

For validation, 272 of 300 cases were classified as substance abuse cases by clinical experts, and the remaining cases were classified as non-substance abuse cases. The positive predictive value (PPV) was 90.7% (95% confidence interval 87.4%-94.0%), demonstrating a high number of true positive substance abuse cases.

4.2 Results of Objective 1

From the CDARS dataset, there were 11,602 cases of attendance at A&E departments in all Hong Kong public hospitals due to substance abuse in the study period, with 8,423 patients meeting the definition of substance abuse in this study.

From the PICMS dataset, there were 2,298 recorded cases of substance abuse from both public and private settings, where 1,850 substance abusers were identified as having more than one recorded substance abuse case.

An increasing trend of substance abusers seeking medical care in A&E settings was observed from 2004 to 2012, followed by a decreasing trend from 2012 to 2016 (Figure 1). The number of cases dropped in 2009 but rebounded in 2010.

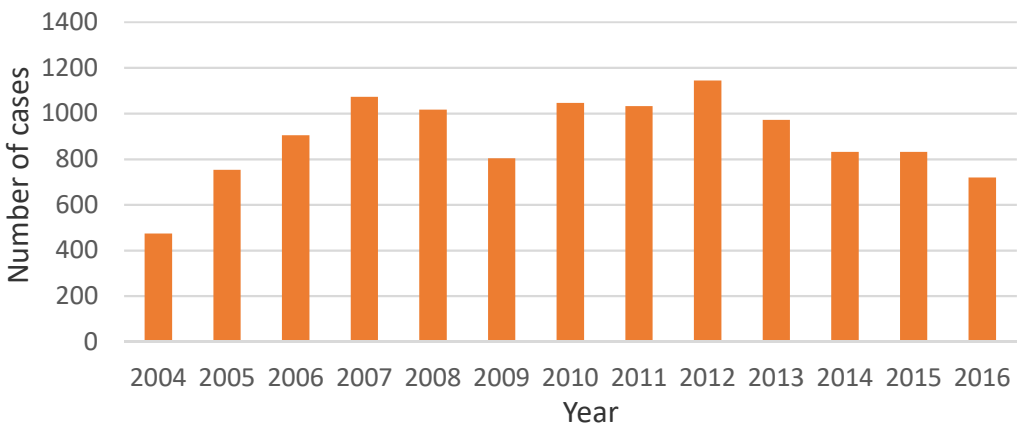

Figure 1. Number of A&E cases due to substance abuse during 2004-2016, CDARS [a] data. [a] Clinical Data Analysis and Reporting System

4.2.1 Age groups

A total of 8,301 substance abusers (122 out of 8,423 substance abusers had a missing date of birth) attending A&E were identified by age in the study period (Figure 2); 48.0% were aged 21-35, 28.1% aged 36-50, 11.5% aged 51-64, and 9.9% aged under 21. The mean (SD) age of all substance abusers attending A&E was 35.7 (13.1) years. PICMS data of 1,835 substance abusers (15 out of 1,850 substance abusers had a missing date of birth) showed similar patterns where 63.5% were aged 21-35, 18.7% aged 36-50, 2.1% aged 51-64, and 15.6% aged under 21. The mean (SD) age of PICMS reported substance abusers was 28.7 (8.9) years.

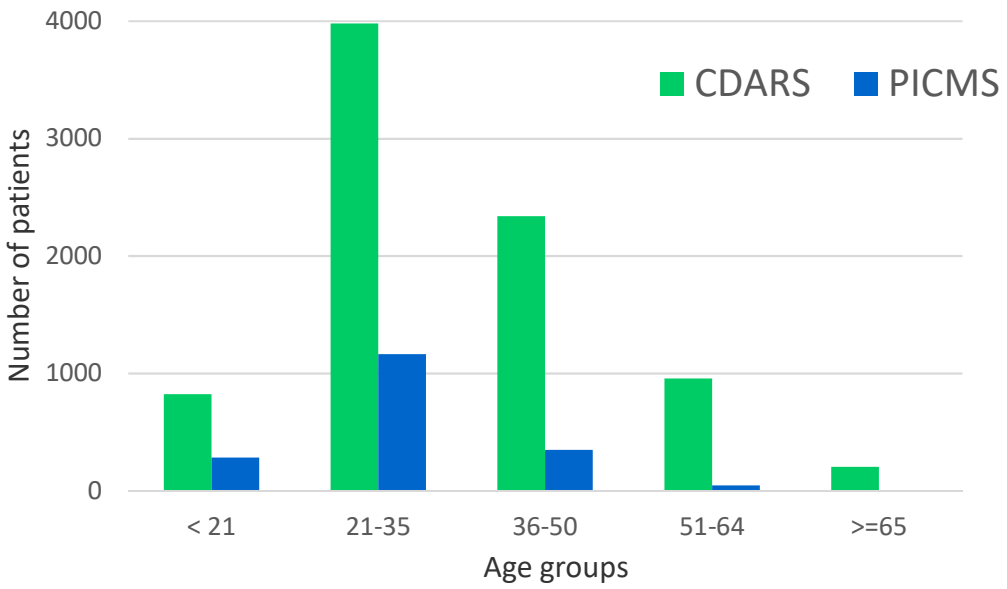

Figure 2. Number of patients [a] by age group, CDARS data and PICMS [b] data. [a] In CDARS data, 122 patients were excluded due to a missing date of birth. In PICMS data, 15 patients were excluded due to missing date of birth.[b] Poison Information and Clinical Management System

The five age groups had a similar increasing and decreasing trend of A&E attendance relating to substance abuse (Figure 3). Individuals in age group 21-35 had the highest number of A&E substance abuse-related cases in the whole study period compared to other groups.

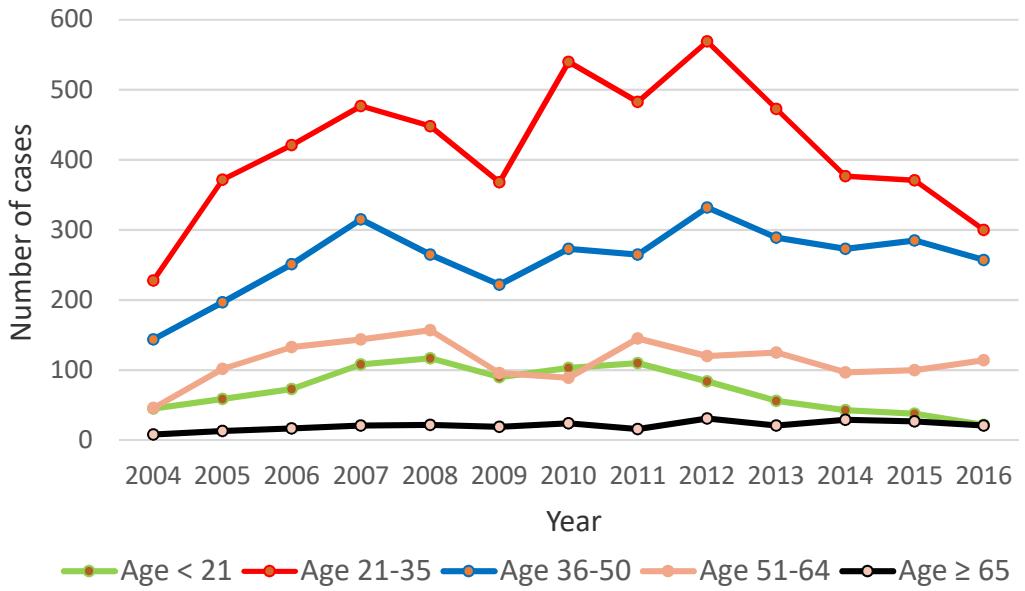

Figure 3. Number of A&E substance abuse cases each year by age group during 2004-2016, CDARS data

4.2.2 Gender

In the CDARS data set, 6,045 (71.8%) people were males and in the PICMS data set, 1,344 (72.6%) people were males.

The reported average age of male substance abusers was 36.7 years. Female substance abusers tend to be younger than the male substance abusers, with an average age of 33.2 years. The proportion of females below age 40 was 74.0% while the corresponding proportion of males was only 64.7%.

There were more males than females attending A&E due to substance abuse in 2004-2016 (Figure 4). The number of male substance abusers increased from 356 in 2004 to 847 in 2007. Thereafter, the number went down continuously, with a short rebound of 24% to 780 in 2010. In 2016, the number was 551, which was 12% lower than in 2015.

The number of female substance abusers increased from 118 in 2004, with a sudden drop in 2009, and back to 345 in 2012. After that, the number dropped continuously to 168 in 2016.

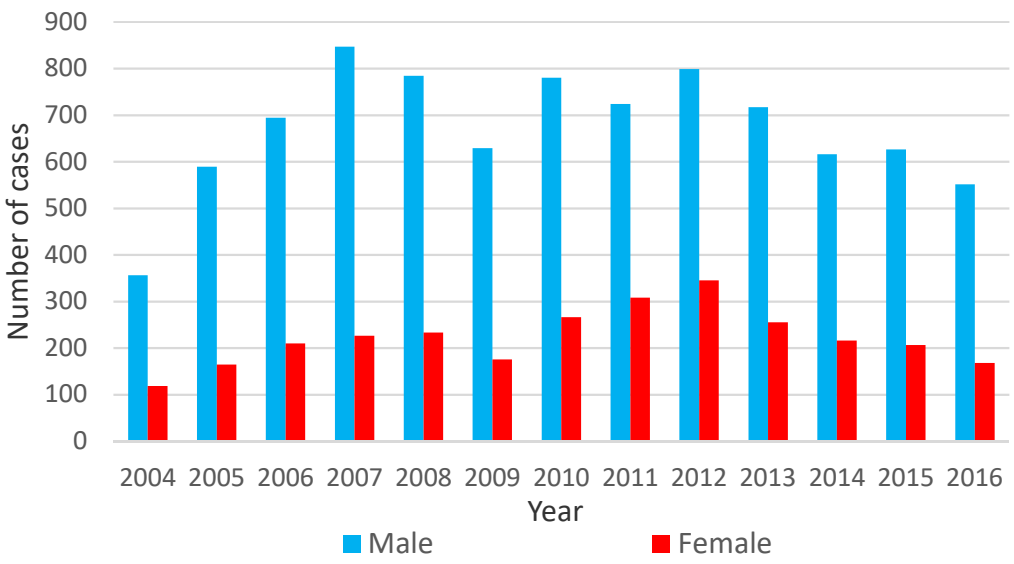

Figure 4. Number of male and female substance abuse A&E cases by year during 2004-2016, CDARS data

4.2.3 Substance types

In 2004-2016, the most frequently abused substance related to A&E cases and recorded in CDARS were opioids (27.1%), followed by barbiturate/hypnotics (7.4%), amphetamines (6.7%) and cocaine (2.0%). Over half (54.5%) of substance abusers reported concurrent abuse of other substances, with 2,177 cases (24.6%) classified as ketamine abuse based on clinician diagnosis or comments (Table 2).

Table 2. Number of A&E cases in each substance abuse category, CDARS data

Substance abused	**A&E cases**	
	N	**(%)**
Cannabis	**104**	**(1.2)**
Hallucinogen	**93**	**(1.1)**
Barbiturate or hypnotic	**656**	**(7.4)**
Subcategory [a]:		
Hypnotics (including zopiclone/zolpidem)	98	(1.1)
Unspecified [b]	558	(6.3)
Opioid	**2,395**	**(27.1)**
Cocaine	**181**	**(2.0)**
Amphetamine or related acting sympathomimetic	**592**	**(6.7)**
Antidepressant type [c]	**1**	**(0.01)**
Other, Mixed, Or unspecified drug	**4,816**	**(54.5)**
Subcategory [b]:		
Ketamine	2,177	(24.6)
Methamphetamine	211	(2.4)
Inhalant	45	(0.5)
MDMA	8	(0.1)
Cough mixture	7	(0.1)
Midazolam	7	(0.1)
Ecstasy	3	(0.1)
Unspecified [a]	2,358	(25.9)
Total number	**8,838**	

[a] Subcategory was based on the diagnosis comments of that specific A&E case recorded manually by the clinicians in CDARS records. Recording of diagnosis comment was not mandatory.

[b] All A&E cases in subcategory without diagnosis comments were marked as unspecified in the table.

[c] The antidepressant is reported as dothiepin in the diagnosis comment. MDMA: 3,4-Methylenedioxymethamphetamine.

Among PICMS reported substance abuse cases, the most abused drug was ketamine (61.1%), followed by methamphetamine/amphetamine (30.5%), cannabis (3.1%), cocaine (2.3%) and MDMA (2.0%) (Table 3).

Table 3. Types of drugs abused (Urine test positive/ self-reporting) in PICMS data

Types of drugs abused	Number of cases	
	N	(%)
Ketamine	1,404	(61.1)
Amphetamine/Methamphetamine	702	(30.5)
Cannabis	72	(3.1)
Cocaine	53	(2.3)
MDMA	47	(2.0)
Others/Unknown [a]	20	(1.0)
Total number	2,298	

[a] Others/Unknown included ecstasy, hash, tetrahydrocannabinol, methoxphenidine, foxy, LSD, and unknown substances.

MDMA: 3,4-Methylenedioxymethamphetamine

The trend in the use of major types of substances during 2004 and 2016 was shown in Figure 5. In recent years, the most commonly abused types of substances were amphetamines, opioids, and ketamine. Ketamine was the most commonly abused substance between 2009 and 2015. Since 2015, opioids surpassed ketamine to become the most commonly abused substance. Amphetamine has surpassed barbiturates/hypnotics since 2014, and also surpassed ketamine to become the second most used substance in 2016. Cocaine and cannabis came in fifth and sixth, respectively, after ketamine and barbiturates/hypnotics.

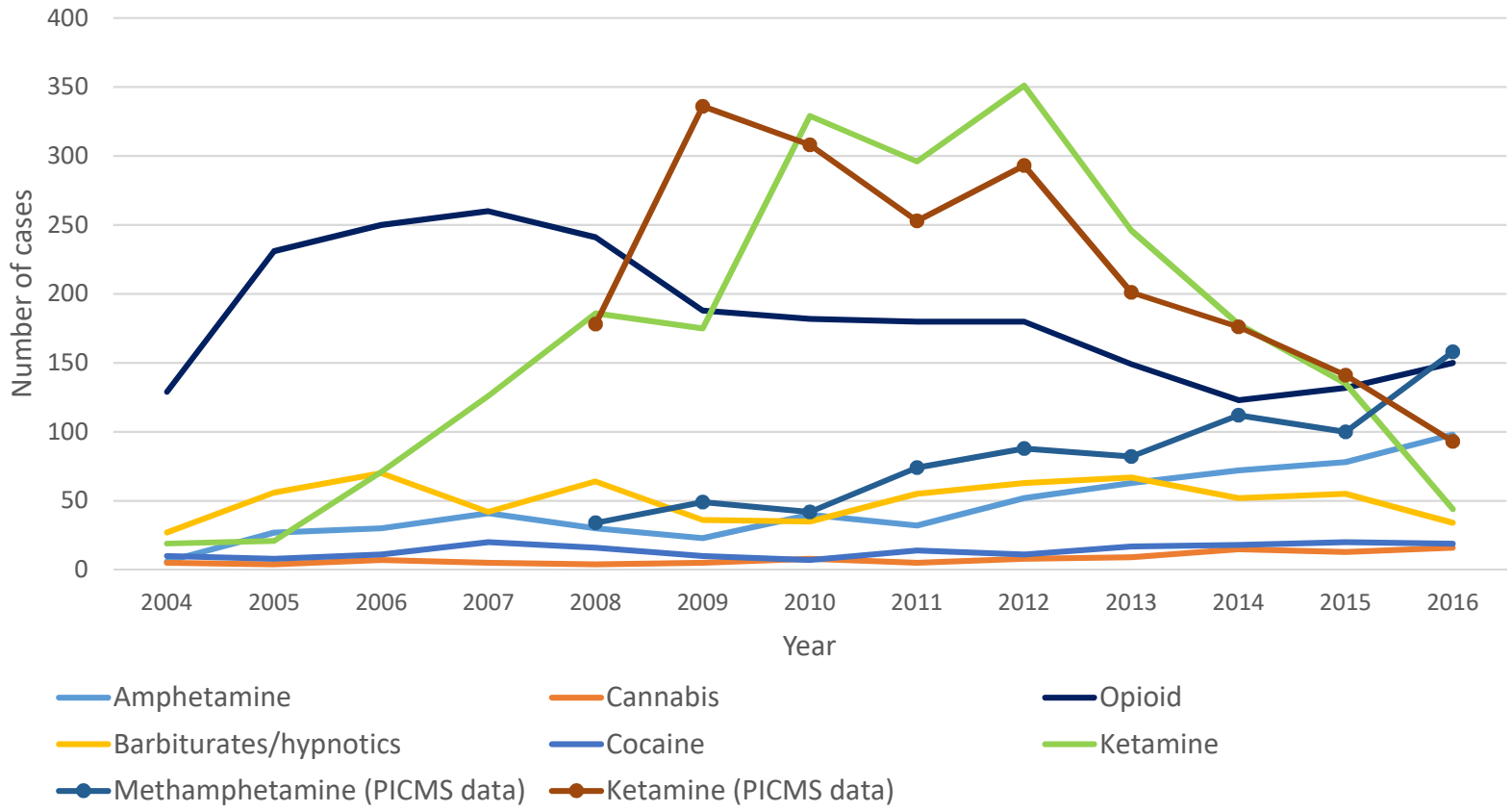

Figure 5. Major types of substances used by substance abusers during 2004-2016, CDARS and PICMS data. Note: The two most commonly reported substances were ketamine and methamphetamine.

4.2.4 Special groups

A comparison of the baseline characteristics of substance abusers by special patient group is shown in Table 4. Substance abusers with mental disorders were found to have the highest mean number of A&E attendances due to substance abuse, followed by school-aged individuals, ethnic minorities, pregnant women and elderly.

Table 4. Characteristics by special patient groups in A&E attendance due to substance abuse during 2004-2016, CDARS data

Special patient groups (N=number of patients)	School-aged individuals [a] (N=823)	Elderly [b] (N=203)	Pre-pregnant/Pregnant/Post-delivery women [c] (N=119)	Individuals with mental disorder (N=3,635)	Ethnic minorities (N=401)
Mean age ± SD	17.7 ± 3.5	73.2 ± 7.2	26.8 ± 6.2	37.5 ± 12.3	34 ± 9.7
Median age (IQR)	18.5 (3.1)	71.5 (10.6)	25.6 (8.6)	35.7 (17.1)	32.7 (13.6)
Age Range	0.6-21.0	65.0-97.7	15.9-43.9	7.2-97.7	2.1-65.5
Sex ratio M/F	1.24	2.76	NA	2.09	3.71
Mean number of A&E attendances due to substance abuse	1.32	1.17	1.19	1.58	1.19
Race/Ethnicity					
Chinese (%)	744 (90.4)	198 (97.5)	115 (95.8)	2472 (95.2)	NA
Non-Chinese (%)	79 (9.6)	5 (2.5)	4 (4.2)	126 (4.8)	401 (100)

Table 4. (Continued)

Special patient groups (N=number of patients)	School-aged individuals [a] (N=823)	Elderly [b] (N=203)	Pre-pregnant/Pregnant/Post-delivery women [c] (N=119)	Individuals with mental disorder (N=3,635)	Ethnic minorities (N=401)
Geographic location of A&E attendance [d]					
Hong Kong East Cluster (%)	114 (13.9)	25 (12.3)	16 (13.4)	475 (13.1)	95 (23.7)
Hong Kong West Cluster (%)	43 (5.2)	14 (6.9)	2 (1.7)	204 (5.6)	50 (12.4)
Kowloon Central Cluster (%)	126 (15.3)	52 (25.6)	23 (19.3)	884 (24.3)	85 (21.2)
Kowloon East Cluster (%)	176 (21.4)	30 (14.8)	16 (13.4)	514 (14.14)	14 (3.5)
Kowloon West Cluster (%)	90 (10.9)	53 (26.1)	17 (14.3)	585 (16.1)	89 (22.2)
New Territories East Cluster (%)	129 (15.7)	10 (4.9)	17 (14.3)	393 (10.8)	20 (5.0)
New Territories West Cluster (%)	145 (17.6)	19 (9.4)	28 (23.5)	580 (16.0)	48 (12.0)

[a] Age <21 years on index A&E attendance.

[b] Age ≥65 years on index A&E attendance.

[c] Defined as female patients who attended A&E due to substance abuse before pregnancy (within 1 year before the start of pregnancy), during the gestation period, and in post-delivery period (within 1 year after delivery).

[d] Hong Kong is served by seven clusters of public hospitals and institutions governed by the Hospital Authority (Appendix 2).

Abbreviations: IQR, interquartile range; SD, standard deviation

A comparison of substance type used by different special groups is shown in Table 5. This table is characterised by the A&E cases related to ICD-9-CM code 305 "Non-dependent abuse of substance", and differs from Table 4, which is characterised by substance abusers. (Therefore, the number N will be different in Table 4 and 5.) This shows that ketamine was more commonly abused by school-aged individuals (44.5%) compared to other substances (Table 5). Among the elderly, more than half (54.1%) reported A&E attendance due to opioid abuse.

Table 5. Characteristics of A&E cases due to substance abuse by special patient groups in 2004-2016 [a], CDARS data

Special patient groups (N=number of cases)	School aged individuals [b] (N=845)	Elderly [c] (N=205)	Pre-pregnant/Pregnant/Post-delivery women [d] (N=104)	Individuals with mental disorder (N=5,301)	Ethnic minorities (N=317)
Primary substance					
Cannabis (%)	30 (3.6)	0	1 (1.0)	25 (0.5)	17 (5.4)
Hallucinogen (%)	13 (1.5)	1 (0.5)	1 (1.0)	54 (1.0)	3 (0.9)
Barbiturate, sedative, hypnotics (%)	29 (3.4)	26 (12.7)	8 (7.7)	426 (8.0)	20 (6.3)
Opioids (%)	18 (2.1)	111 (54.1)	8 (7.7)	1,678 (31.7)	92 (29.0)
Amphetamine or related acting sympathomimetic (%)	78 (9.3)	0	7 (6.7)	350 (6.6)	29 (9.2)
Ketamine (%)	377 (44.6)	0	36 (34.6)	1,184 (22.3)	15 (4.7)
Other/unspecified (%)	301 (35.6)	67 (32.7)	45 (43.3)	1,548 (29.2)	141 (44.5)

[a] This result table is analysed based on the A&E cases related to ICD-9-CM code 305 "Non-dependent abuse of substance", not including alcohol and tobacco.

[b] Age <21 years on index A&E attendance.

[c] Age ≥65 years on index A&E attendance.

[d] Defined as female patients who attended A&E due to substance abuse before pregnancy (within 1 year before the start of pregnancy), during the gestation period, and in post-delivery period (within 1 year after delivery).

School-aged individuals (youth) under age 21 who sought medical care for substance abuse from A&E (Figure 6) increased by 1.72 times from 43 in 2004 to 117 in 2008. Despite a sudden drop in 2009, the number rebounded to 110 in 2011. The number of cases dropped dramatically to 22 in 2016, reporting an 80% decrease from 2011.

Overall, substance abusers seeking A&E attention before 2011 were younger, with the proportion aged under 21 rising from 7.8% in 2005 to about 11.5% in 2008, and higher than 10% in 2011 despite some fluctuation. However, this number has since decreased to 3.1% in 2016.

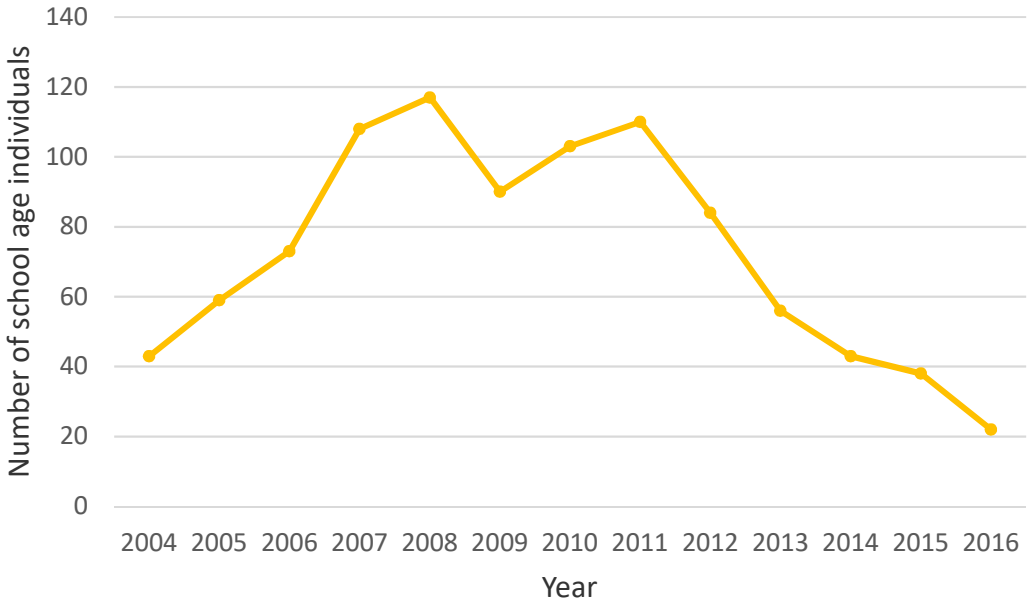

Figure 6. Number of school-aged individuals in A&E substance abuse-related cases by year during 2004-2016, CDARS data

Of 2,378 females in CDARS data, 489 had at least one maternity episode recorded in in-patient obstetrics and gynaecology department records (Table 6). The proportion of pregnant women who sought medical care for substance abuse from A&E during the gestation, pre-pregnancy or post-delivery period was 24.3%.

Table 6. Patterns of substance abuse amongst pregnant women during 2004-2016, CDARS data

Time period	Number of women with maternity episode (N = 489)	(%)
Substance abuse during gestation period/pre-pregnancy period/post-delivery period	**119**	**(24.3)**
Substance abuse during the gestation period [a]	29	(5.9)
Pregnant adults with substance abuse [b]	25	(5.1)
Pregnant school-aged individuals with substance abuse [c]	4	(0.8)
Substance abuse in the pre-pregnancy period [d]	65	(13.3)
Substance abuse in the post-delivery period [e]	34	(6.9)
Substance abuse <u>not in</u> gestation period/pre-pregnancy period/post-delivery period	**370**	**(75.5)**

[a] Females having attended A&E due to substance abuse during gestation period are counted

[b] Age ≥21 years

[c] Age <21 years

[d] 1 year period before the start of pregnancy

[e] 1 year period after delivery of the baby

Based on the CDARS race description, 7,366 (87.45%) patients were recorded as of Chinese ethnicity (Table 7). The remaining cases were recorded as one of 26 racial groups or had missing race information. Amongst non-Chinese ethnicities, the Vietnamese group had the highest number of substance abusers 105 (1.25%).

Table 7. Number of patients in each race group in CDARS data set

Race description [a]	**Number of patients (N = 8,423)**	**(%)**
Chinese	7,366	(87.45)
Non-Chinese:		
Vietnamese	105	(1.25)
Nepalese	80	(0.95)
British	48	(0.57)
Indian	32	(0.38)
Pakistani	30	(0.36)
Thai	20	(0.24)
Filipino	19	(0.23)
Australian	13	(0.15)
Indonesian	12	(0.14)
American	11	(0.13)
Canadian	6	(0.07)
Korean	4	(0.05)
Colombian	3	(0.04)
French	2	(0.02)
Japanese	2	(0.02)
Malaysian	2	(0.02)
Russian	2	(0.02)
Spanish	2	(0.02)
Swiss	2	(0.02)
Chilean	1	(0.01)
Italian	1	(0.01)
Pole	1	(0.01)
Singaporean	1	(0.01)
Swede	1	(0.01)
Venezuelan	1	(0.01)
Missing/Unknown	656	(7.79)

[a] Race description recorded in CDARS is actually based on the patient's country of origin from their identity documents provided.

4.2.5 Concurrent Medical Conditions

Of 8,423 substance abusers, 2,936 (34.9%) were without any concurrent comorbidities/medical presentations/symptoms in either Table 8 or Table 9.

Table 8. Common concurrent chronic medical conditions of substance abusers before A&E attendance in CDARS data

Chronic medical conditions [a]	**Number of patients (N = 8,423)**	**(%)**
Mental disorders:	3,635	(43.2)
Depressive disorder	678	(8.0)
Adjustment disorder	591	(7.0)
Schizophrenic disorder	418	(5.0)
Anxiety/ dissociative/ somatoform disorder	377	(4.5)
Personality disorder	325	(3.9)
Bipolar disorder	76	(0.9)
Attention deficit hyperactivity disorder	14	(0.2)
Suicidal attempt and self-inflicted injury	1,721	(20.4)
Cardiovascular diseases:	575	(6.8)
Deep vein thrombosis	313	(3.7)
Hypertension	179	(2.1)
Ischaemic stroke	101	(1.1)
Atrial fibrillation	31	(0.4)
Congestive heart failure	28	(0.3)
Myocardial infarction	21	(0.2)
Gastrointestinal diseases:	313	(3.7)
Gastric/ duodenal/ peptic/ gastrojejunal ulcer	181	(2.1)
Constipation	138	(1.6)
Respiratory diseases:	354	(4.2)
Chronic obstructive pulmonary disease	111	(1.3)
Asthma	268	(3.2)
Renal diseases:	94	(1.1)
Acute renal failure	66	(0.8)
Chronic renal failure	35	(0.4)
Anaemia	196	(2.3)
Diabetes mellitus	126	(1.5)
Epilepsy/ seizure	165	(2.0)
Liver disease	239	(2.8)
Hepatitis B	74	(0.9)
Hepatitis C	214	(2.5)
Human immunodeficiency virus (HIV)	14	(0.2)
Malignant Neoplasm	113	(1.3)

[a] This table was categorised by ICD-9-CM codes (Appendix 4). Some patients may present with one or more comorbidities.

Table 9. Common acute medical presentations/symptoms of substance abusers before A&E attendance in CDARS data

Acute medical presentation/ symptoms [a]	Number of patients (N = 8,423)	(%)
Poisoning		
Accidental poisoning by drugs, medicinal substances and biologicals [b]	773	(9.2)
Accidental poisoning by other solid and liquid substances, gases, and vapours [c]	69	(0.8)
Alcohol abuse/ dependence	449	(5.3)
Pain		
Abdominal pain	1,822	(21.6)
Chest pain	477	(5.7)
Accidental fall	960	(11.4)
Dizziness and giddiness	652	(7.7)
Syncope and collapse	414	(4.9)
Intracranial injury [d]	1,129	(13.4)
Assault	804	(9.5)
Infections		
Cellulitis and abscess [e]	1,042	(12.4)
Pneumonia	424	(5.0)
Gastritis and gastroduodenitis	559	(6.6)
Urinary tract infection	395	(4.7)
Non-infectious gastroenteritis	886	(10.5)

[a] This table was categorised by ICD-9-CM codes (Appendix 5). Some patients may present with one or more conditions.

[b] Including analgesics, antipyretics, barbiturates, sedatives, hypnotics, psychotropic agents, tranquilizers, antibiotics, and anti-infectives.

[c] Including alcohol, paints, varnishes, organic solvents, poisonous plants, gas distributed by pipeline, and carbon monoxide.

[d] Including concussion, cerebral laceration, and contusion, haemorrhage following injury / excluding those with skull fractures.

[e] Including body parts such as arm, leg, face, neck, and foot.

4.2.6 Geographical location

The HA currently manages 42 public hospitals and institutions. These 42 hospitals are organized into seven clusters (Appendix 2). The highest number of A&E attendance due to substance abuse is in the Kowloon Central Cluster with 2,609 cases. Queen Elizabeth Hospital and Kwong Wah Hospital provides A&E service in this cluster (Table 10).

Table 10. Number of A&E substance abuse-related cases in each HA cluster during 2004-2016, CDARS data

Cluster	Number of cases (N=11,602)	(%)
Hong Kong East Cluster	1,801	(15.5)
Hong Kong West Cluster	624	(5.4)
Kowloon Central Cluster	2,609	(22.5)
Kowloon East Cluster	1,717	(14.8)
Kowloon West Cluster	1,733	(14.9)
New Territories East Cluster	1,248	(10.8)
New Territories West Cluster	1,870	(16.1)

4.3 Results of Objective 2

4.3.1 Accident and Emergency department re-attendance

Of 8,423 substance abusers, 1,642 had at least one substance abuse-related A&E re-attendance. 654 re-attended A&E at least twice. The mean A&E re-attendance rate of substance abusers in 2004-2016 was 1.93. The number of A&E re-attendance cases due to substance abuse within 1 year, 90 days and 30 days after previous attendance showed similar trends (Figure 7).

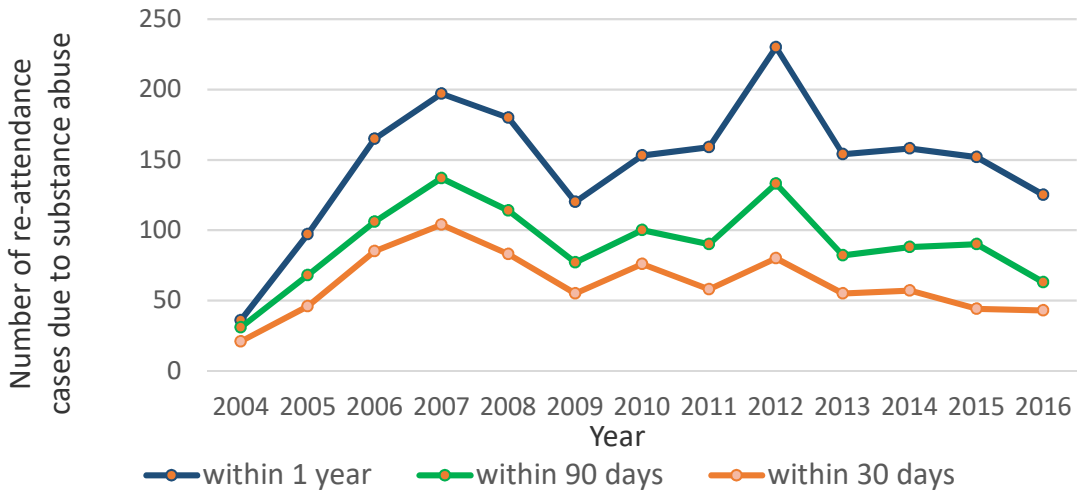

Figure 7. Annual number of A&E re-attendances due to substance abuse during 2004-2016, CDARS data

Substance abusers who took opioids and ketamine were found to have a higher frequency of A&E re-attendance (Table 11).

Table 11. Number of A&E re-attendances by substance type during 2004-2016, CDARS data

Primary substance (N=Total number of patients having A&E attendance)	Number of patients having at least one A&E re-attendance (%)	Number of patients having at least two A&E re-attendance (%)
Cannabis (N=101)	2 (2.0)	1 (1.0)
Hallucinogen (N=89)	4 (4.5)	0
Barbiturate, sedative, hypnotics (N=617)	27 (4.4)	7 (1.1)
Opioid (N=1,653)	351 (21.2)	149 (9.0)
Cocaine (N=167)	13 (7.8)	1 (0.6)
Amphetamine or related acting sympathomimetic (N=523)	49 (9.4)	10 (1.9)
Ketamine (N=1,617)	320 (19.8)	120 (7.4)

4.3.2 Death

Of the study population, there were 1,064 patient deaths during the study period. The mean (SD) and median (IQR) age of death was 49.1 (15.3) and 48.9 (22.9) years respectively. The cause of death of 188 (17.7%) were due to poisoning from heroin, other opioids or other substances (Table 12).

Table 12. Number of deaths among substance abusers by cause of death, CDARS data

ICD-10-CM [a] Death cause category	Number of patients (N=1064) [b]	(%)
Toxicity	228	(21.4)
Poison due to heroin	96	(9.0)
Poison due to other opioids	51	(4.8)
Poison due to other/unspecified substances [c]	41	(3.9)
Toxic effect, carbon monoxide	20	(1.9)
Asphyxiation	20	(1.9)
Lower respiratory disease [d]	129	(12.1)
Unspecified multiple injuries	88	(8.3)
Cancer [e]	86	(8.1)
Cardiovascular diseases [f]	79	(7.4)
Sepsis – specified/unspecified	31	(2.9)
Liver diseases [g]	17	(1.6)
Others [h]	60	(5.6)
Unspecified [b]	44	(4.2)
Missing death cause	302	(28.4)

[a] ICD-10-CM: International Classification of Diseases Tenth Edition-Clinical Modification

[b] 302 patients did not have cause of death recorded in CDARS and this number will be included in the "Unspecified" category, in addition to those recorded as "non-specified cause of mortality"

[c] Including poison – benzodiazepines, other psychotropic substances, poison - others/nonspecified drug/medicine/biological substances, toxic effect – organophosphate/carbamate insecticides, toxic effect – unspecified

[d] Including pneumonia, bronchopneumonia, COPD. Among them, 85 cases died due to pneumonia

[e] Including cancer of liver, nasopharynx, stomach, pancreas, colon, larynx, nasopharynx, cervix uteri, mesothelioma, sec cancer - brain/cerebral meninges

[f] Including myocardial infarction, pulmonary embolism, acute/subacute infect endocarditis, cardiac arrest – unspecified, cerebrovascular accident due to intracerebral haemorrhage, cerebrovascular accident due to stroke

[g] Including hepatic failure, unspecified liver cirrhosis, toxic liver disease

[h] Including cholangitis, anoxic brain damage, pancreatitis, uncertain behaviour tumour brain, focal brain injury, injury of femoral artery, open wound abdomen, chronic viral hepatitis

Following A&E attendance due to substance abuse, 40 patients died during hospital admission and lower respiratory diseases were the predominant causes of death (Table 13).

Table 13. Cause of death in patients admitted to hospital following A&E attendance due to substance abuse, CDARS data

ICD-10-CM [a] Cause of death during hospital admission with substance abuse	Number of patients (N = 40) [b]	(%)
Toxicity [c]	7	(17.5)
Cancer [d]	7	(17.5)
Lower respiratory diseases [e]	12	(30.0)
Cardiovascular diseases [f]	5	(12.5)
Sepsis – unspecified	3	(7.5)
Disorder of muscle – unspecified	1	(2.5)

[a] ICD-10-CM: International Classification of Diseases Tenth Edition-Clinical Modification

[b] 5 patients did not have cause of death recorded in CDARS

[c] Including toxic liver disease - cholestasis, poison - other psychotropic substances, poison - others/nonspecified drug/medicine/biological substances, toxic effect –

organophosphate/ carbamate insecticides, toxic effect – unspecified

[d] Including liver cell carcinoma, cancer of liver – unspecified, cancer of nasopharynx – unspecified, cancer of cervix uteri, mesothelioma, sec cancer - brain/cerebral meninges

[e] Including pneumonia – unspecified, bronchopneumonia – unspecified, chronic obstructive pulmonary disease – unspecified, pneumonitis – food and vomit, respiratory disorder – unspecified

[f] Including acute/subacute infect endocarditis, cardiac arrest – unspecified, cerebrovascular accident due to intracerebral haemorrhage, cerebrovascular accident due to stroke

4.4 Results of Objective 3

In Appendix 1, we randomly extracted the healthcare records for 94,239 patients in CDARS using random reference key numbers as the unique identification of patients. The random sample identified 90,300 patients without substance abuse. A random date was assigned to each patient as the index date. From our study population of 8,423 patients with substance abuse, 8,301 had complete demographic information and were included into the propensity score matching with the random sample without substance abuse. Finally, 13,254 patients were identified after matching on sex, age, recent (≤365 days before the index date) healthcare utilisation and concurrent medical conditions, of which 6,627 were patients with substance abuse and 6,627 were patients without substance abuse.

The characteristics of patients with and without substance abuse before matching are shown in Table 14. Patients with substance abuse had a significantly higher prevalence of mental disorders, suicidal attempts, deep vein thrombosis, hypertension and hepatitis C, compared to patients without substance abuse.

Table 14. Characteristics of patients with and without substance abuse before propensity score matching, CDARS data

Variables	With Substance abuse (n=8,301)	Without Substance abuse (n=90,300)	Standardized mean difference (95% confidence interval) [a]	
Sex (M %)	5,936 (71.5)	42,879 (47.5)	0.505	(0.482, 0.527)
Mean age ± SD (years)	35.7 ± 13.1	41.3 ± 24.2	0.290	(0.268, 0.313)
Recent (≤365 days before the index date) healthcare utilisation				
Number of A&E attendance ± SD	1.9 ± 4.1	0.3 ± 1.2	0.511	(0.488, 0.533)
Number of hospitalisation ± SD	0.7 ± 1.9	0.2 ± 1.8	0.285	(0.262, 0.307)

Table 14. (Continued)

Variables	With Substance abuse (n=8,301)	Without Substance abuse (n=90,300)	Standardized mean difference (95% confidence interval) [a]	
Concurrent medical conditions: [b]				
Mental disorders: (%)	3635 (43.8)	5991 (6.6)	0.947	(0.924, 0.97)
Depressive disorder (%)	678 (8.2)	1141 (1.3)	0.330	(0.308, 0.353)
Adjustment disorder (%)	591 (7.1)	664 (0.7)	0.333	(0.311, 0.356)
Schizophrenic disorder (%)	418 (5.0)	713 (0.8)	0.255	(0.232, 0.277)
Anxiety/ dissociative/ somatoform disorder (%)	377 (4.5)	1044 (1.2)	0.205	(0.182, 0.227)
Personality disorder (%)	325 (3.9)	111 (0.1)	0.272	(0.250, 0.295)
Bipolar disorder (%)	76 (0.9)	151 (0.2)	0.102	(0.080, 0.125)
Attention deficit hyperactivity disorder	14 (0.2)	138 (0.2)	0.004	(-0.019, 0.026)
Suicidal attempt and self-inflicted injury (%)	1721 (20.7)	595 (0.7)	0.687	(0.664, 0.709)
Cardiovascular diseases: (%)	575 (6.9)	8054 (8.9)	0.074	(0.051, 0.096)
Deep vein thrombosis (%)	313 (3.8)	206 (0.2)	0.255	(0.233, 0.278)
Hypertension (%)	179 (2.2)	6006 (6.7)	0.220	(0.198, 0.243)
Ischaemic stroke (%)	101 (1.2)	2175 (2.4)	0.089	(0.067, 0.112)
Atrial fibrillation (%)	31 (0.4)	1335 (1.5)	0.116	(0.093, 0.138)
Congestive heart failure (%)	28 (0.3)	1587 (1.8)	0.140	(0.117, 0.162)
Myocardial infarction (%)	21 (0.3)	899 (1.0)	0.094	(0.072, 0.117)
Gastrointestinal diseases: (%)	313 (3.8)	2633 (2.9)	0.048	(0.025, 0.070)
Gastric/ duodenal/ peptic/ gastrojejunal ulcer (%)	181 (2.2)	1661 (1.8)	0.024	(0.002, 0.047)
Constipation (%)	138 (1.7)	1073 (1.2)	0.040	(0.018, 0.062)
Respiratory diseases (%)	354 (4.3)	2235 (2.5)	0.099	(0.077, 0.122)
Chronic obstructive pulmonary disease (%)	111 (1.3)	1002 (1.1)	0.021	(-0.002, 0.043)
Asthma (%)	268 (3.2)	1420 (1.6)	0.108	(0.086, 0.131)
Renal diseases (%)	94 (1.1)	1266 (1.4)	0.024	(0.002, 0.047)
Acute renal failure (%)	66 (0.8)	418 (0.5)	0.042	(0.020, 0.065)
Chronic renal failure (%)	35 (0.4)	964 (1.1)	0.075	(0.053, 0.098)
Anaemia (%)	196 (2.4)	1767 (2.0)	0.028	(0.005, 0.050)
Diabetes mellitus (%)	126 (1.5)	3374 (3.7)	0.139	(0.117, 0.162)
Epilepsy/ seizure (%)	165 (2.0)	623 (0.7)	0.113	(0.091, 0.136)
Liver disease (%)	239 (2.9)	1225 (1.4)	0.106	(0.083, 0.128)
Hepatitis B (%)	74 (0.9)	639 (0.7)	0.021	(-0.002, 0.043)
Hepatitis C (%)	214 (2.6)	69 (0.1)	0.220	(0.197, 0.242)

[a] Standardized mean difference indicates difference in mean or proportion of covariates in substance abusers vs non-substance abusers divided by the pooled standard deviation. A standardized difference of less than 0.2 indicates a negligible difference in covariates between treatment groups.

[b] Concurrent medical conditions were categorised by ICD-9-CM codes (Appendix 4). Some patients may present with one or more comorbidities.

After propensity score matching, all baseline characteristics had standardized mean differences of less than 0.1 (Table 15), indicating that patients with or without substance abuse were well-balanced regarding the observed potential confounders.

Table 15. Characteristics of patients with and without substance abuse after propensity score matching, CDARS data

Variables	With Substance abuse (n=6,627)	Without Substance abuse (n=6,627)	Standardized mean difference (95% confidence interval) [a]	
Sex (M %)	4851 (73.2)	4643 (70.1)	0.070	(0.036, 0.104)
Mean age ±SD (years)	36.0 ± 21.5	35.3 ± 13.3	0.043	(0.009, 0.077)
Recent (≤365 days before the index date) healthcare utilisation				
Number of A&E attendance	1.0 ± 3.6	1.1 ± 3.2	0.043	(0.009, 0.077)
Number of hospitalisation	0.3 ± 1.2	0.4 ± 1.3	0.038	(0.004, 0.072)
Concurrent medical conditions: [b]				
Mental disorders: (%)	2038 (30.8)	2036 (30.7)	0.001	(-0.033, 0.035)
Depressive disorder (%)	349 (5.3)	366 (5.5)	0.011	(-0.023, 0.045)
Adjustment disorder (%)	276 (4.2)	296 (4.5)	0.015	(-0.019, 0.049)
Schizophrenic disorder (%)	255 (3.8)	225 (3.4)	0.024	(-0.010, 0.058)
Anxiety/ dissociative/ somatoform disorder (%)	319 (4.8)	213 (3.2)	0.082	(0.047, 0.116)
Personality disorder (%)	59 (0.9)	137 (2.1)	0.098	(0.064, 0.132)
Bipolar disorder (%)	64 (1.0)	44 (0.7)	0.034	(0, 0.068)
Attention deficit hyperactivity disorder	10 (0.2)	54 (0.8)	0.096	(0.062, 0.130)
Suicidal attempt and self-inflicted injury (%)	466 (7.0)	526 (7.9)	0.034	(0, 0.068)
Cardiovascular diseases: (%)	271 (4.1)	285 (4.3)	0.011	(-0.024, 0.045)
Deep vein thrombosis (%)	75 (1.1)	81 (1.2)	0.008	(-0.026, 0.042)
Hypertension (%)	136 (2.1)	147 (2.2)	0.011	(-0.023, 0.046)
Ischaemic stroke (%)	60 (0.9)	65 (1.0)	0.008	(-0.026, 0.042)
Atrial fibrillation (%)	25 (0.4)	22 (0.3)	0.008	(-0.026, 0.042)
Congestive heart failure (%)	24 (0.4)	21 (0.3)	0.008	(-0.026, 0.042)
Myocardial infarction (%)	14 (0.2)	15 (0.2)	0.003	(-0.031, 0.037)
Gastrointestinal diseases: (%)	209 (3.2)	208 (3.1)	0.001	(-0.033, 0.035)
Gastric/ duodenal/ peptic/ gastrojejunal ulcer (%)	117 (1.8)	117 (1.8)	<0.001	(-0.034, 0.034)
Constipation (%)	95 (1.4)	96 (1.4)	0.001	(-0.033, 0.035)
Respiratory diseases (%)	240 (3.6)	215 (3.2)	0.021	(-0.013, 0.055)
Chronic obstructive pulmonary disease (%)	67 (1.0)	66 (1.0)	0.002	(-0.033, 0.036)
Asthma (%)	186 (2.8)	161 (2.4)	0.024	(-0.010, 0.058)

Table 15. (Continued)

Variables	With Substance abuse (n=6,627)	Without Substance abuse (n=6,627)	Standardized mean difference (95% confidence interval) [a]	
Concurrent medical conditions: [b]				
Renal diseases (%)	44 (0.7)	44 (0.7)	<0.001	(-0.034, 0.034)
Acute renal failure (%)	27 (0.4)	26 (0.4)	0.002	(-0.032, 0.036)
Chronic renal failure (%)	21 (0.3)	22 (0.3)	0.003	(-0.031, 0.037)
Anaemia (%)	103 (1.6)	116 (1.8)	0.015	(-0.019, 0.049)
Diabetes mellitus (%)	88 (1.3)	91 (1.4)	0.004	(-0.03, 0.038)
Epilepsy/ seizure (%)	90 (1.4)	87 (1.3)	0.004	(-0.03, 0.038)
Liver disease (%)	120 (1.8)	126 (1.9)	0.007	(-0.027, 0.041)
Hepatitis B (%)	59 (0.9)	47 (0.7)	0.02	(-0.014, 0.054)
Hepatitis C (%)	38 (0.6)	47 (0.7)	0.017	(-0.017, 0.051)

[a] Standardized mean difference indicates difference in mean or proportion of covariates in substance abusers vs non-substance abusers divided by the pooled standard deviation. A standardized difference of less than 0.2 indicates a negligible difference in covariates between treatment groups.

[b] Concurrent medical conditions were categorised by ICD-9-CM codes (Appendix 4). Some patients may present with one or more comorbidities.

A&E attendances and hospitalisations of patients with and without substance abuse are shown in Table 16. Both the crude outcomes before matching and the adjusted outcomes after matching were statistically significant. The adjusted mean number of A&E attendances was significantly higher for patients with substance abuse, compared with those without substance abuse (7.49 versus 3.07, P <0.001). In addition, the adjusted mean number of hospitalisations was 3.32 for patients with substance abuse, which was higher than 1.29 for those without substance abuse (P <0.001). The adjusted length of hospitalisations of patients with substance abuse was also significantly higher than those without substance abuse (27.62 versus 8.46, P <0.001).

Table 16. Number of A&E attendances, hospitalisations and length of hospitalisations among patients with and without substance abuse after the index date in CDARS data

Outcomes	**Before matching**			**After matching**		
	Without Substance abuse (n=90,300)	With Substance abuse (n=8,301)	P-value [a]	Without Substance abuse (n=6,627)	With Substance abuse (n=6,627)	P-value
Number of A&E attendance (SD) [b]	0.34 (1.24)	1.87 (4.07)	<0.001	3.07 (13.46)	7.49 (19.804)	<0.001
Number of hospitalisations (SD) [c]	0.22 (1.76)	0.74 (1.87)	<0.001	1.29 (4.65)	3.32 (6.327)	<0.001
Length of hospitalisations (days) (SD) [d]	1.10 (14.99)	5.44 (21.71)	<0.001	8.46 (63.94)	27.62 (100.787)	<0.001

[a] T-test or Wilcoxon test

[b] Number of A&E attendances were counted from the index date to the end of 2016

[c] Number of hospitalisations were counted from the index date to the end of 2016

[d] Length of hospitalisations was calculated based on mean of all hospitalisations per patients

A&E: Accident and Emergency

Chapter 5 Discussion

5.1 Interpretation of study results

5.1.1 Substance abuse trends

Analysis of CDARS data found that substance abusers seeking medical care in A&E accounted for 11,602 cases from 2004 to 2016 and the burden of these attendances/admissions fell largely on the public hospitals in the Kowloon Central Cluster and New Territories West Cluster (Table 10).

The overall trend of substance abusers between the CRDA and CDARS is similar at the beginning of the study period. Both had a rising trend of substance abusers from 2004 to 2008. According to the CRDA, the total number of substance abusers increased from 13,593 in 2007 to 14,241 in 2008. Thereafter, the number went down to 8,077 in 2016, 8% lower than 8,767 in 2015 (19). Similarly, the number of A&E attendance cases due to substance abuse from CDARS dropped in 2009 (Figure 1). This decrease may be due to the effect of the Hong Kong Government's continuous anti-drug efforts. One of the anti-drug schemes used was the Trial Scheme on School Drug Testing in Tai Po District (School Year 2009/10), proposed in early 2009 to prevent drug dispersal in schools and to provide assistance to students who abused drugs (46). The anti-drug activities included preventive education for students, early identification of at-risk students, in collaboration with community partners (such as Caritas-Hong Kong and Tung Wah Group of Hospitals), timely guidance, and treatment (47). The launch of this scheme may have motivated more school-aged individuals to quit substance abuse. This is reflected in the decreasing trend of young substance abusers during 2009 (Figure 6).

Based on our total number of A&E substance abuse-related cases, there was an increasing trend from 2010 until 2012. In contrast, the CRDA data shows that the total number of reported substance abusers and young substance abusers continued

to decline. These discrepancies of the CRDA and CDARS suggest that there might be "hidden" substance abusers who are difficult to identify unless they seek medical care. This is an existing problem that the Hong Kong Government is facing (48). Another explanation might be the introduction of the immunoassay of ketamine bed-side urine test by the HA from 2010. Before 2010, immediate urine bed test of ketamine was not available and A&E clinicians would submit patient urine samples to the central laboratory for drug testing specifically, as required. Therefore, following the introduction of bed-side urine tests, increased ketamine-positive cases would be detected which may increase the substance abuse trend. This is supported by both CDARS and PICMS data, which showed the highest ketamine-abuse cases among other substances from 2009 to 2015.

For every substance type, substance abusers were predominantly male (Figure 4). This finding is consistent with worldwide data which shows that men represent a higher proportion of substance abusers (49). Nevertheless, the substance abuse trend for women in our study is similar to men, showing a rising trend during 2004 to 2012 and dropping since 2012 (Figure 4). Likewise, women are just as likely as men to become addicted (50). The American Society of Addiction Medicine defines addiction as a chronic brain disease that affects the brain's reward, pleasure, memory, and motivation. The addiction cycle includes key stages of craving and relapse (51). Several studies also showed that women may be more susceptible to craving (52) and relapse (53), suggesting they are more likely to be addicted than men. Therefore, the government officials and community collaborators should also focus assistance on female as well as male substance abusers.

5.1.2 Substance types

The proportion of substance abuse in A&E attendance cases was calculated based on the Principal Diagnosis Code with ICD-9-CM code 305 "Non-dependent abuse of substance" (Table 1, 2). The highest proportion of cases belonged to the "Other, Mixed, Unspecified substance abuse" subgroup, with ketamine having the highest number of cases. These are identified by the diagnosis comments of the specific "Other, Mixed, Unspecified substance abuse" case recorded in CDARS manually

by clinicians. For instance, there were cases recorded as “ketamine abuse” or “ketamine intoxication” in the diagnosis comments. Therefore, taking these into consideration, there were 2,177 (24.6%) ketamine-related substance abuse A&E cases during 2004 to 2016 (Table 2).

From 2004 to 2016, the proportion of opioids, ketamine, barbiturates/hypnotics, and amphetamines-related A&E cases were 27.1%, 24.6%, 7.4%, 6.7% respectively (Table 2). Opioids had the highest proportion. In 2010, a study was published in a multi-criteria decision analysis to rank the harmfulness of different drugs (54). Results showed that heroin, methamphetamine, and crack cocaine were the most harmful drugs to users (54). Heroin ranked higher in mortality risk while crack cocaine, a freebase form of cocaine that can be smoked, posed a much higher risk of mental impairment. Our results also reflect this finding, where adverse events from heroin and amphetamines resulted in an increase in A&E visits.

Both CDARS and PICMS data in this study showed a rising trend of methamphetamine-related A&E attendance cases from 2009 to 2016 (Figure 5). The number of amphetamine-related A&E visits surpassed ketamine and hypnotics/barbiturates in recent years, illustrating growing methamphetamine use in Hong Kong. This trend is also seen in other countries such as the US (55), Canada (56), and Australia (57). Widespread methamphetamine abuse may be the result of the worldwide cost reduction of crystal methamphetamine (58). The United Nations reported that Hong Kong was involved in the growing trade of illegal narcotics throughout the Southeast Asia region (59), possibly making methamphetamine more easily accessible to substance abusers. The report also discussed that seizures of crystal methamphetamine across Asia had exponentially increased fourfold from 11 tons in 2008 to 42 tons in 2013. The market price of cocaine per gram costs two times more than methamphetamine and the effects might only last a few nights. In comparison, the effect of one gram of methamphetamine can last for two to three weeks (60). This may explain why substance abusers in Hong Kong favour methamphetamine, resulting in a rising trend of methamphetamine-related A&E attendances in recent years.

5.1.3 Concurrent medical conditions

Substance abusers attending A&E commonly have concurrent mental disorders (61, 62), including schizophrenia, major depression, personality disorders and bipolar disorder. The brain regions involving drug addiction overlaps extensively with the functional regions and processes involved in essential cognitive functions, including learning, memory, attention, reasoning, and impulse control (63). Illicit drugs alter normal brain structure and function, impairing cognitive effect. In the US, it was estimated that over half of individuals had a concurrent mental and drug disorder (64). According to a US national survey in 2016, the prevalence of adults with substance abuse with major depressive episodes was almost twice as age-matched controls (65). Likewise, in our study, we characterised substance abusers attending A&E with concurrent mental disorders based on the ICD-9-CM codes 290-319, and 3,635 (43.2%) of 8,423 substance abusers also had a mental disorder (Table 4). Our results show comparable findings with the US survey, where 53% of people with drug disorders were found to have a mental disorder.

We also categorised the comorbidities of substance abusers based on ICD-9-CM codes (Table 8, 9) (66, 67) The most substantial category showed 1,721 substance abusers attending A&E with a previous suicidal attempt or self-injury. This number accounted for 20.4% of the total population and we believe this was attributable to substance abuse and mental disorder comorbidity. Substance abuse was found to be associated with suicide risk (68). Several studies showed that individuals being treating for substance use disorders have had prior suicidal thoughts and behaviours (69, 70). People with mental disorders were also at a higher risk of suicidal attempts (71). Furthermore, patients seeking A&E consultation related to self-injury would have a higher risk of future suicidal attempt (68). Given that 20.4% of substance abusers had previous suicidal attempts or self-harm behaviour, it is important they are identified during A&E attendance in order to provide early healthcare and assistance.

Apart from mental disorders and suicidal attempts, the third most common

comorbidity is cardiovascular disease. Abuse of certain substances will also cause hypertension and ischaemic stroke. Cocaine is a powerful vasoconstrictor related to hypertensive crises, strokes or myocardial infarctions (15, 72). Similarly, methamphetamine may lead to hypertension and contribute to long-term negative effects on health, such as stroke (73). Patients with ischaemic stroke are at high risk of neurologic and medical complications that may lead to a higher chance of attending A&E for immediate medical care.

Other common comorbidities of substance abusers attending A&E in this study included respiratory diseases (Table 8) and pneumonia (Table 9). Previous studies have investigated the relationship between substance abuse and the respiratory system. Exposure to substances of abuse through inhalation cause lung damage (14, 74). Mechanisms of the damage include production of reactive oxygen species, direct chemical reactivity, and inflammation triggered by activated alveolar macrophages. Moreover, "crack lung" may be a result of smoking crack or freebase cocaine, which is a pure crystalline form of cocaine (75). A survey conducted in Canada showed that about 95% of reported crack users have had at least one respiratory symptom in the past week and 68% experienced improvement in symptoms during abstinence (76). The destruction of alveolar tissues is permanent, which is the pathological pathway leading to COPD.

Studies of substance abusers have consistently shown that they were far more likely to have hepatitis B, C virus and Human Immunodeficiency Virus (HIV), especially in drug users using injections (77, 78). In this study, there were 74, 214 and 14 positive carriers of hepatitis B, hepatitis C, and HIV respectively. These viral infections could lead to serious complications such as liver impairment or increased risk of other illnesses due to a weakened immune system.

5.1.4 Geographical location

Hong Kong is geographically divided into 18 districts (Figure 9). According to the CRDA, the highest number of substance abusers reside in Sham Shui Po (12%), Kwun Tong (10%) and Yau Tsim Mong (10%) (19). In our analysis, the Kowloon

Central Cluster (KCC) was the region with the highest number of A&E attendance cases due to substance abuse (Table 10). Kowloon Central Cluster covered the Yau Tsim Mong district which suggests that the high number of A&E substance abuse-related attendance cases is consistent with the CRDA report. Similarly, the Kowloon West Cluster (KWC) reported 1,733 cases (14.9%) and this cluster includes the Sham Shui Po district. The consistency between the two datasets confirmed our hypothesis that substance abusers had an impact on the A&E attendance of these clusters.

We also observed that among the hospital clusters with a high number of substance abuse cases, the median monthly household incomes of those districts (Appendix 3) within the cluster were relatively lower than the others. For example, New Territories West Cluster also had a high number of cases. There were 1,870 (16.1%) A&E-related substance abuse cases (Table 10). This cluster included Yuen Long and Tuen Mun, two districts that reported low monthly household income (within the lowest 5 districts) in 2016 (79). Similarly, Shum Shui Po district in KWC reported the lowest monthly household income in Hong Kong. Conversely, Hong Kong West Cluster showed the lowest number of A&E attendance cases related to substance abuse. The two districts, Central & Western and Wan Chai, in this cluster reported the highest monthly household income in Hong Kong. Our findings are consistent with those in the literature that suggests lower household monthly income as a proxy for lower socioeconomic status (SES) and is associated with higher rates of substance abuse (80). Further work is needed to examine the association between SES and A&E substance abuse-related attendance.

5.1.5 A&E attendance

Substance abusers have several common characteristics. They tend to be sicker, use more health services, and have higher rates of mental illness (81). These individuals frequent the A&E department due to chest pain, drug-induced psychosis, depression, accidents (16, 82), consistent with current findings. In our findings, there were 1,642 substance abusers out of 8,423 with a substance abuse-related A&E re-attendance in the study period 2004-2016. The number of re-attendance

cases within 30 days, 90 days and 1 year rose respectively from 2004 to 2007 (Figure 7). In addition, substance abusers who took opioids and ketamine were found to have a higher proportion of A&E re-attendance (Table 11). The peak of re-attendance was in 2012 and started decreasing until 2016. Over half of these individuals with A&E re-attendance related to substance abuse had a history of mental health issues. This supports previous work that patients with an increased need for mental health and substance use treatment services have a higher frequency of access to A&E services (83).

The mean attendance rate due to substance abuse was 1.38 for our study population in 2004-2016. Among the special patient groups, mental disorder individuals had the highest A&E attendance rate of 1.58 (Table 4, total attendances are 5,743). Results have been replicated from previous studies that show mental disorders are associated with higher rates of A&E use (84, 85). Individuals with mental disorders usually visit A&E with psychosis, mood disorder with psychotic features, and hypomanic or manic episode (84). Substance abuse could induce or amplify psychosis events, making it necessary to seek medical care or medication.

5.1.6 Death causes

In this study, 1,064 patient deaths (Table 12) were identified. Among them, a high proportion reported the cause of death to be related to lower respiratory diseases such as pneumonia. Death due to poisoning substances such as heroin and other opioids were reported in 96 (9%) and 51 (4.8%) cases respectively. It is expected that substance abusers' deaths were commonly caused by fatal intoxication (86, 87). Other death causes reported cancer, cardiovascular diseases or unspecified multiple injuries. We also analysed the A&E substance abuse-related cases to see if any deaths were reported in that specific episode. Of 11,602 A&E substance abuse-related cases, 4,774 cases were admitted to the hospital. Forty of these cases were reported as deaths (Table 13). There were 12 (30%) cases reported with death cause related to lower respiratory diseases and 7 (17.5%) cases related to toxicity. In general, the mean and median age of these 1,064 patients are both around 49 years old. This number is much lower than Hong Kong's female (87.3 years) and male

(81.3 years) average life expectancy in 2016 (88). The systemic effects of substance abuse on the central nervous system, respiratory, and cardiovascular systems are well recognized.

5.1.7 Healthcare resources utilisation

Patients with substance abuse had a higher proportion of mental disorders, suicidal attempts, deep vein thrombosis, hypertension and hepatitis C than the random sample of non-substance abusers (Table 14). Some of these medical conditions such as mental disorders and suicidal attempts increased the likelihood of A&E attendance, and might be potential confounding factors (84, 85). After matching, the baseline characteristics of 6,627 substance abusers and 6,627 non-substance abusers were well-balanced. We followed up their general A&E attendances and hospitalisations after the index date. Substance abusers showed a higher number of A&E attendances compared to non-substance abusers (7.49 versus 3.07, P <0.001). Reasons for the higher number of attendances likely include substance abusers attending A&E with altered mental status, metabolizing their intoxication, need for administration of sedatives. Moreover, for follow-up observations by clinicians, substance abusers may need to be hospitalised following A&E treatment services, as reflected in our results of higher mean number of hospitalisations for substance abusers (3.32 versus 1.29, P <0.001). These frequent attendances and hospitalisations may increase the medical burden for A&E in caring for substance abusers and demand additional available resources (89, 90). The demand for resources, including A&E medical transport services such as ambulance, would increase since higher A&E attendances increases the need for hospital admission. Apart from A&E attendances, previous literature supports the high medical burden of substance abusers due to hospital admissions, with excessive duration of hospitalisations (91, 92). In general, our results showed that substance abusers put significant medical burden on A&E departments and hospitals in Hong Kong.

5.2 Clinical implications

This study affirms the needs of substance abusers for hospital and A&E medical

services in Hong Kong. Excessive healthcare resource utilisation as shown by A&E attendances and hospitalisations has resource implications for the public healthcare system in Hong Kong. Our results show that of the substances abused, opioids and ketamine impose more burden on A&E departments in terms of re-attendance rates as these are much higher in individuals taking these two substances than other substance groups (Table 11). In addition, our study population of patients with mental disorders (43.2%) and previous suicidal attempts (20.4%) seeking A&E substance abuse treatment services indicate a greater use of A&E services, as supported in previous literature (70, 84, 93).

In consideration of these characteristics, appropriate intervention is needed to reduce the frequency of substance abusers' A&E attendances and hospitalisations, which could reduce financial pressure on the HA and society. First, healthcare providers could develop screening tools for the early identification of substance abusers and intervention for health-related risk factors such as mental disorder. Based on current findings, A&E psychiatrists who treat patients with mental health disorders and suicidal attempts should also consider screening these patients for substance abuse and intervene accordingly. Second, coordination of integrated primary and behavioural healthcare in cost-effective out-patient clinics can provide regular health checks for substance abusers. This will place the needs of substance abusers as a higher priority to facilitate early treatment and care. Early effective treatment for substance abuse could reduce the morbidities for all groups of substance abusers, reducing the frequency of access to A&E medical services.

Designing and implementing education programs could be accomplished with collaboration between hospitals and non-government organizations. Workshops could be provided for patients following A&E attendances or hospitalisations. Emphasis on the harmful effects of specific substances like opioids and ketamine is a critical component to this approach, as these two substances place a high burden on A&E departments. These programs could contribute to a reduction in A&E re-attendance rates due to substance abuse.

In general, clinicians could support substance abusers in A&E departments and hospitals by providing substance use treatment, rehabilitation advice or referral before discharge (94). Effective treatment with early identification can improve outcomes for substance abusers and decrease the costs for the health care system in Hong Kong.

5.3 Strengths and limitations

Several limitations in this study warrant attention. First, the ICD-9-CM codes used in this study are for major types of substances. For example, the ICD-9-CM code 305.6 is for amphetamine and other psychostimulant abuse. However, there is no ICD-9-CM code specifically for methamphetamine. It is possible that this has led clinicians to assign methamphetamine-related A&E cases to amphetamine categories or other/ unspecified categories, therefore the number for other major types of substances is underestimated. Second, it cannot be assumed that it is the first substance abuse-related episode for patients attending A&E with an incidence of substance use. There may be a history of substance abuse before 2004, which would be reflected in the data validation or in the electronic patient record. Therefore, we were unable to report whether the first A&E attendance due to substance abuse is an indication of their first exposure to substance abuse.

Third, substance abusers visit A&E with various presentations and some may not disclose their history of substance abuse. Therefore, clinicians may overlook substance abuse problems and the associated complications. Moreover, when A&E clinicians realise the patient's substance abuse issue and input the clinical diagnostic code in the database, they often characterise this as others/unspecified due to uncertainty about the substance abuse, unless a blood/urine test confirms the diagnosis. In our study this resulted in a high number of A&E cases in the others/unspecified substance category. Although ketamine accounted for half of the cases in this category, the other half did not have a diagnostic description or comment. As a result, we are not able to identify the substance abused. This issue was not confined to this category; diagnostic comments were also missing from

other general categories such as opioid or hallucinogens, preventing us from identifying the specific substances in these categories (such as heroin versus codeine or psilocybin versus lysergic acid diethylamide).

In addition, PICMS was used to gather additional information concerning A&E attendance for substance abuse, including the specific substance category. However, PICMS may only contain a subset of the records from A&E. In general, CDARS contained more information than PICMS on the prevalence of A&E attendance due to substance abuse. Notably, the CDARS data source does not include data from private hospitals and health clinics. As a result, part of the substance abuse population is missing. However, we captured a representative sample, as approximately 80% of Hong Kong residents use public hospitals and healthcare services.

To our knowledge, this is the first Hong Kong wide, population-based study using big data analytics to provide a real-world glimpse into the clinical profiles of substance abusers. Current findings have increased our understanding of common concurrent medical conditions and their A&E attendance trends in order to assess the burden at different hospital clusters. Although the annual number of reported substance abusers from CRDA is higher than the annual number of substance abusers attending A&E from our CDARS data (e.g. 14,241 versus 760 in 2008), this can be explained by the difference in the two recording systems. The CRDA is a voluntary reporting system recording the details of substance abusers provided by reporting agencies. These agencies are mainly non-governmental organizations that provide social assistance or educational awareness programs for substance abusers (95, 96). Through these activities, agencies would access their details to facilitate assistance. Their information will be recorded and voluntarily reported to the government. On the other hand, information on substance abusers reported in CDARS are from those seeking A&E medical care due to serious emergency health conditions such as poisoning or psychosis. This number is expectedly smaller in CDARS as some substance abusers without acute symptoms tend to present to outpatient clinics or are admitted to hospitals. As we have screened all A&E

attendance records in public hospitals from 2004 to 2016 and 8,423 patients were identified based on the diagnosis of substance abuse during A&E attendance, the sample in this study is highly representative of the health profiles of substance abusers with emergency health conditions who seek A&E medical services in Hong Kong. In addition, the ICD-9-CM codes for cohort identification are of high positive predictive values (90.7%), suggesting the codes are of high accuracy in this study. Finally, given the high proportion of comorbidities in substance abusers, which will act as confounders and increase the likelihood of seeking health services, propensity score matching was performed for the comparison of healthcare utilisation between substance abusers and non-substance abusers. After matching, patients from two groups were well balanced regarding sex, age, recent (≤365 days before the index date) healthcare utilisation and concurrent medical conditions, and 6,627 (78.7%) out of 8,423 substance abusers were included in the outcome analysis. The large sample size and high proportion of matched patients generated results with good representation and generalization.

Chapter 6 Conclusion

By understanding the pattern of A&E attendance of patients with substance abuse, this study highlights their healthcare characteristics and alerts clinicians to the potential diagnostic difficulties. Screening tools are needed for early identification of these patients and to provide early intervention. Patients with substance abuse have a higher likelihood of A&E attendance and hospitalisation, thus placing increasing pressure on public healthcare resources. Sustainable, accessible and effective management for substance abuse should be provided for early care and treatment to reduce downstream resource utilisation. Ketamine and opioids are the main causes of A&E re-attendances. Interventions that aim at reduction or cessation of the use of these two substances should be a key priority in order to prevent readmissions following hospital discharge.

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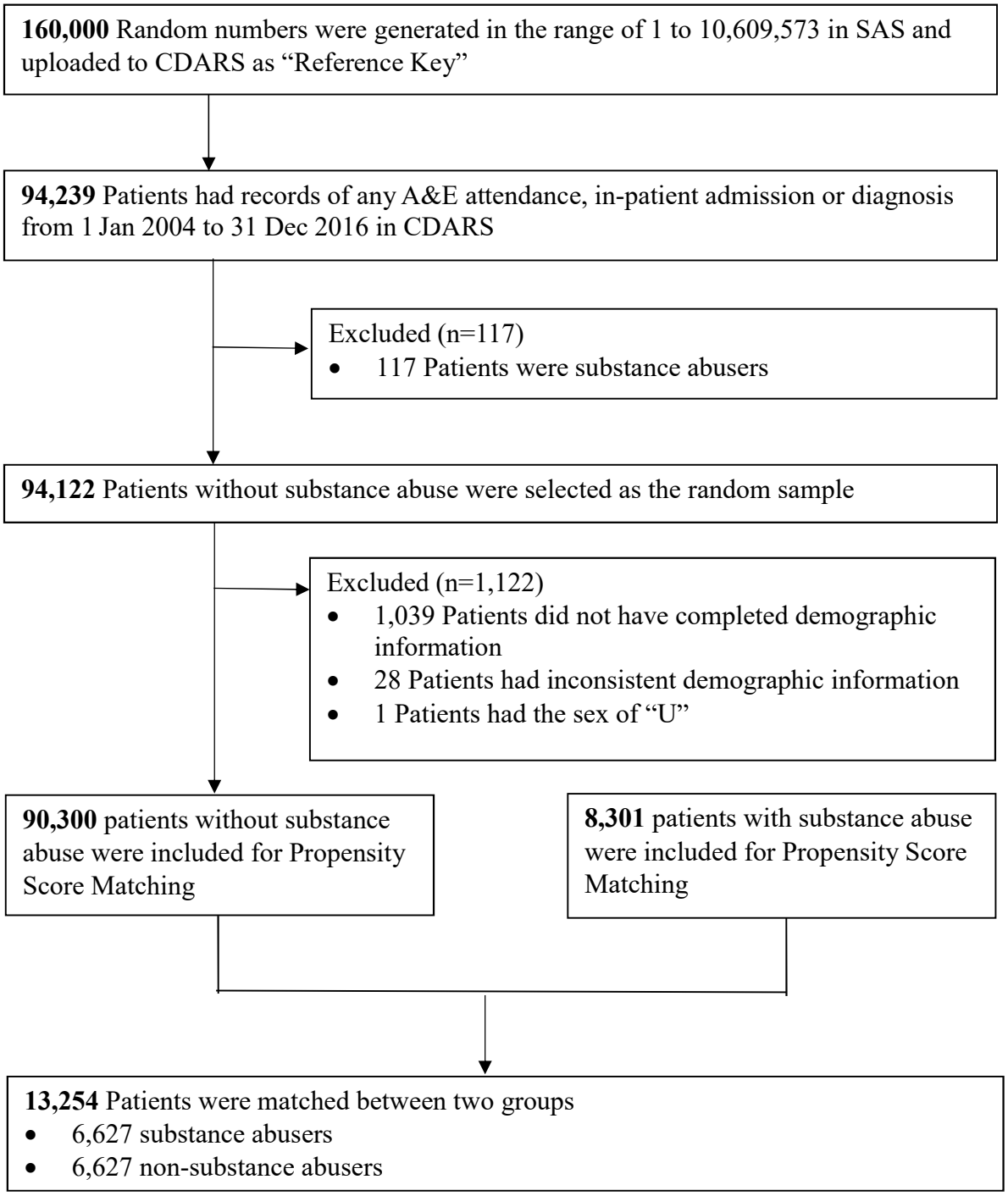
Appendices

Appendix 1. Selection of substance abusers and non-substance abusers for Objective 3 analysis



Appendix 2. Hong Kong Hospital Authority clusters

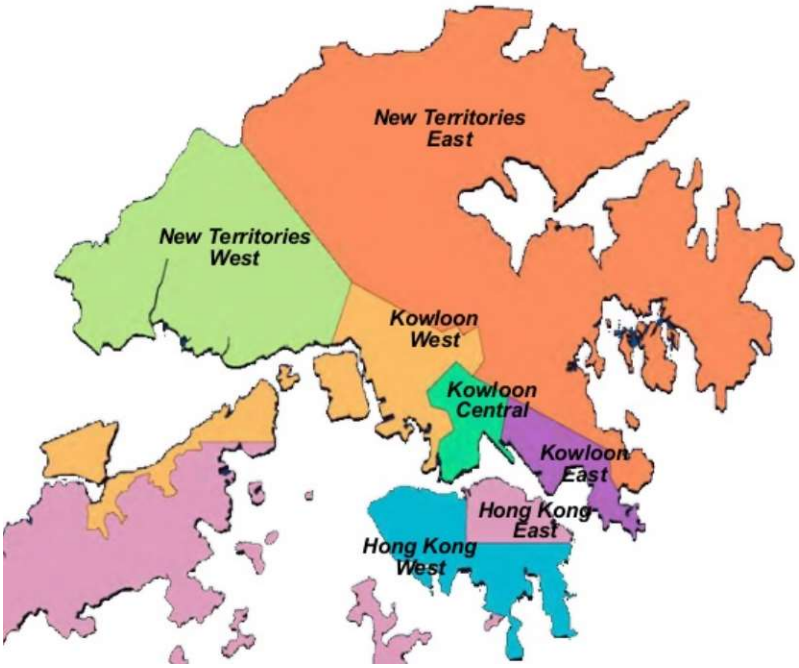


Figure 8. Geographical map of Hong Kong with hospital clusters. Source: https://www.slideshare.net/HINZ/0915-cheung-health-informatics-transforming-healthcare-delivery-in-hong-kong

Hospitals with A&E departments in Hong Kong East cluster included: Pamela Youde Nethersole Eastern Hospital (PYNEH), Ruttonjee Hospital (RH), St. John Hospital (SJH)

Hospitals with A&E departments in Hong Kong West cluster included: Queen Mary Hospital (QMH)

Hospitals with A&E departments in Kowloon Central cluster included: Kwong Wah Hospital (KWH), Queen Elizabeth Hospital (QEH)

Hospitals with A&E departments in Kowloon East cluster included: United Christian Hospital (UCH), Tseung Kwan O Hospital (TKOH)

Hospitals with A&E departments in Kowloon West cluster included: Caritas Medical Centre (CMC), North Lantau Hospital (NLTH), Princess Margaret Hospital (PMH), Yan Chai Hospital (YCH)

Hospitals with A&E departments in New Territories East cluster included: Alice Ho Miu Ling Nethersole Hospital (AHNH), North District Hospital (NDH), Prince of Wales Hospital (PWH)

Hospitals with A&E departments in New Territories West cluster included: Pok Oi Hospital (POH), Tuen Mun Hospital (TMH)

Appendix 3. Districts of Hong Kong

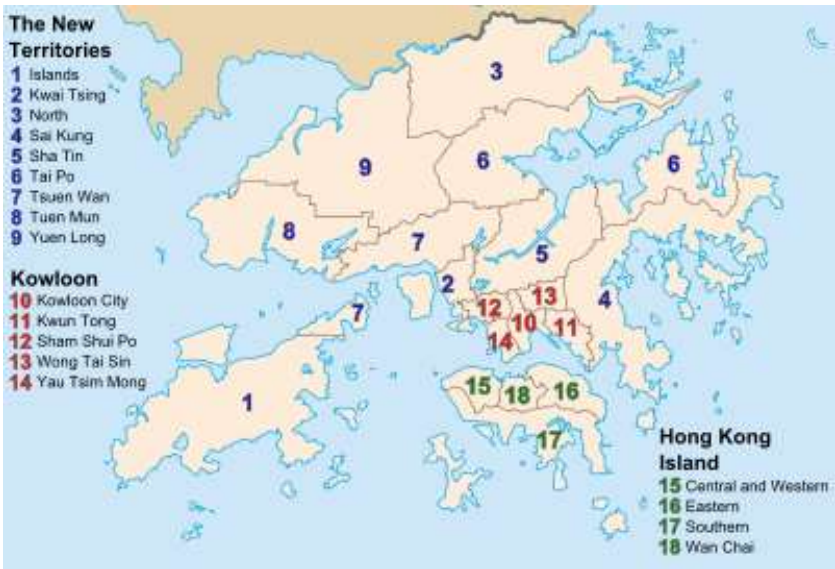


Figure 9. Map of Hong Kong showing the 18 geopolitical districts. Source: https://en.wikipedia.org/wiki/Hong_Kong

Appendix 4. List of chronic medical conditions with ICD-9-CM codes

Medical conditions	ICD-9-CM Codes
Mental disorder	290-319
Depressive disorder	296.2, 296.3, 311
Adjustment disorder	309
Schizophrenic disorder	295
Anxiety/ dissociative/ somatoform disorder	300
Personality disorder	301
Bipolar disorder (%)	296.0, 296.4-296.8
Attention deficit hyperactivity disorder	314
Suicidal attempt and self-inflicted injury	E950-E959
Cardiovascular diseases	
Deep vein thrombosis	453.8
Hypertension	401-405, 437.2
Ischaemic stroke	433.01, 433.11, 433.21, 433.31, 433.81, 433.91, 434, 436, 437.0, 437.1, 435, 444, 445
Atrial fibrillation	427.3
Congestive heart failure	398.91, 402.01, 402.11, 404.01, 404.03, 404.11, 404.13, 404.91, 404.93, 428
Myocardial infarction	410, 412
Gastrointestinal diseases	
Gastric/ duodenal/ peptic/ gastrojejunal ulcer	531-534
Constipation	564.0
Respiratory diseases	
Chronic obstructive pulmonary disease	492, 496
Asthma	493
Renal diseases	
Acute renal failure	584
Chronic renal failure	582, 583.0-583.4, 583.6, 585, 586, 588
Anaemia	285
Diabetes mellitus	250
Epilepsy/ seizure	780.33, 780.39, 333.2, 345
Liver disease	570, 571, 572, 573
Hepatitis B	070.2, 070.3
Hepatitis C	070.5
Human immunodeficiency virus (HIV)	042, 043, 044
Malignant Neoplasm	140-200, 230-234

Appendix 5. List of acute medical presentations/symptoms with ICD-9-CM codes

Medical presentations/symptoms	ICD-9-CM Codes
Accidental poisoning by drugs, medicinal substances and biologicals	E850-E858
Accidental poisoning by other solid and liquid substances, gases, and vapours	E860-E869
Alcohol abuse/ dependence	305.0, 303
Abdominal pain	789.0
Chest pain	786.50
Accidental fall	E880-E888
Dizziness and giddiness	780.4
Syncope and collapse	780.2
Intracranial injury	850-854
Assault	E960-E969
Cellulitis and abscess	682
Pneumonia	480-486, 487.0
Gastritis and gastroduodenitis	535
Urinary tract infection	599.0
Non-infectious gastroenteritis	558