

# Poisoning by toxic plants in Hong Kong: a 15-year review

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## ABSTRACT

**Introduction:** Hong Kong has a great diversity of plants, many of which are toxic to humans. The aim of this study was to identify the plant species most commonly involved in cases of plant poisoning in Hong Kong and to provide clinicians with a reference tool for the diagnosis and management of plant poisoning.

**Methods:** We retrospectively reviewed all plant poisoning cases referred to the Hospital Authority Toxicology Reference Laboratory from 1 January 2003 to 31 December 2017. Demographics, clinical presentation, laboratory findings, treatment and outcomes of patients, as well as morphological identification and analytical testing of the plant specimens, were investigated.

**Results:** A total of 62 cases involving 26 poisonous plant species were identified, among which *Alocasia macrorrhizos* (Giant Alocasia), *Gelsemium elegans* (Graceful Jessamine), and *Rhododendron* (Azalea) species were the three most commonly encountered. Gastrointestinal toxicity (n=30, 48%), neurological toxicity (n=22, 35%), and hepatotoxicity (n=6, 10%) were the three most common clinical problems. Forty-nine (79%) and eight (13%) patients had mild and moderate toxicity, respectively; they all recovered shortly with supportive treatment. The remaining five (8%) patients experienced severe toxicity requiring intensive care support. Most

patients (n=61, 98%) used the plants intentionally: as a medicinal herb (n=31), as food (n=29), and for attempting suicide (n=1). Reasons for using the poisonous plants included misidentification (n=34, 55%), unawareness of the toxicity (n=20, 32%), and contamination (n=6, 10%).

**Conclusions:** Although most plant exposure resulted in a self-limiting disease, severe poisonings were encountered. Epidemiology of plant poisonings is geographically specific. Clinicians should be aware of local poisonous plants and their toxicities.

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### New knowledge added by this study

- The three most common plants causing poisoning in Hong Kong were *Alocasia macrorrhizos*, *Gelsemium elegans*, and *Rhododendron* species.
- Plants causing severe and potentially fatal poisonings in Hong Kong were *Abrus precatorius*, *Gelsemium elegans*, *Rhododendron* species, and *Emilia sonchifolia*.

### Implications for clinical practice or policy

- Plant poisoning is uncommon but can be severe.
- Raising public awareness minimises unintentional poisoning.
- This study provided useful reference for the local clinicians to diagnose and manage plant poisonings.

## Introduction

Many plants are poisonous to humans. Surveys of various toxicology centres in Australia,<sup>1</sup> Germany,<sup>2,3</sup> Morocco,<sup>4</sup> New Zealand,<sup>5</sup> Sweden,<sup>6</sup> Thailand,<sup>7</sup> the United Kingdom,<sup>8</sup> and the United States<sup>9,10</sup> showed that plant exposure was responsible for 1.8% to 8% of all inquiries. Most plant exposures did not result in significant toxicity, but severe and life-threatening

poisonings have been reported. As reported by the Moroccan Poison Control Centre from 1980 to 2011, plants were the cause of approximately 5% of all fatal cases of intoxication encountered.<sup>4</sup> Consumption of wild plants as “medicinal herbs” or food is not an uncommon practice in Hong Kong, and severe plant poisoning cases have been reported.<sup>11–19</sup> However, local epidemiology data on plant poisoning are

sparse and limited.

Owing to the variable clinical features and rare occurrence of plant poisonings, diagnosing and treating these patients remain a challenge to our frontline clinicians. Although history of plant exposure is important, it is often insufficient to pinpoint the incriminating toxic plant. Misidentification of plant is a common cause of poisoning in the first place. Morphological identification of a poisonous plant and biochemical confirmation are generally not available to guide immediate clinical management. Therefore, clinical features are critical for initiating supportive treatment, which is a common strategy for treating poisonings of an uncertain nature.

Classifications of clinically significant plant toxins have been proposed in order to aid rapid recognition and management of these patients.<sup>20,21</sup> Plant toxins can be broadly classified into four groups: (1) cardiotoxic toxins, such as cardiac glycosides; (2) neurotoxic toxins, such as gelsemium alkaloids, grayanotoxins, solanaceous tropane (anticholinergic) alkaloids, strychnine, and brucine; (3) cytotoxic toxins, such as colchicine, mimosine, plumbagin, toxalbumins; vinblastine, and vincristine; and (4) gastrointestinal-hepatotoxic toxins, such as amaryllidaceous alkaloids, calcium oxalate raphide, cycasin, pentacyclic triterpenoids, phorbol esters, phytolaccatoxins, plumericin, pyrrolizidine alkaloids, saponins, steroidal alkaloids, tetrahydropalmatine, and teucvin.

The Hospital Authority Toxicology Reference Laboratory (HATRL), the only tertiary clinical toxicology laboratory in Hong Kong, provides support to all local hospitals in managing patients with complex poisoning problem, including cases of plant poisonings. Besides plant identification, HATRL provides specialised toxicology testing for certain plant toxins, especially for those with significant clinical toxicity and management impact.<sup>16,22</sup> The aim of the present study was to identify the plant species most commonly involved in cases of plant poisoning in Hong Kong, in order to promote awareness among local clinicians and to provide a reference for diagnosing and managing plant poisonings.

## Methods

All cases of suspected plant-related poisoning referred to the HATRL from January 2003 to December 2017 were retrospectively reviewed. Clinical data were collected by reviewing the laboratory database and patient medical records. Demographic characteristics, clinical presentation, drug history, laboratory and toxicological findings, progress, and outcomes of these patients were reviewed. The causal relationships between the clinical presentation and plant use were evaluated

## 香港植物中毒個案：十五年病例回顧

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引言：香港擁有豐富的植物資源，在我們數以千計的植物品種當中，部分含有毒性。本研究旨在探討香港常見之植物中毒案例，並為日後的相關中毒個案提供臨床診斷及治療方向。

方法：這項回顧性研究分析2003年1月1日至2017年12月31日期間轉介至醫院管理局毒理學參考化驗室有關植物中毒的案例，並整合患者的人口統計學資料、臨床症狀和相關植物標本的化驗結果及分析其毒性成份。

結果：研究期間共確診62病例，牽涉26種有毒植物，其中最常見的為海芋、鈎吻和杜鵑。中毒徵狀主要為腸胃毒性30例（48%）、神經系統毒性22例（35%）及肝毒性6例（10%）。其中49例（79%）和8例（13%）分別屬於輕微和中度中毒，患者接受症狀治療後完全康復；其餘5例（8%）為嚴重中毒個案，患者需接受深切治療。患者使用有關植物作藥材佔31例，食材佔29例，並有一例用作自殺。有關藥材/食材引致中毒的原因源於誤認植物品種34例（55%）、不了解植物毒性20例（32%）及進食被毒素污染的植物6例（10%）。

結論：在香港發生的植物中毒個案大多為輕微中毒，嚴重中毒病例亦偶有發生。本研究綜合本化驗室過去十五年間處理本地植物中毒的經驗，可作為醫生臨床診斷及治療的參考工具。

based on known adverse effects of the specified plant or toxins, the temporal sequence, exclusion of other underlying or concurrent diseases which could otherwise account for the clinical presentation, and progress after discontinuation of plant use. Severity of the poisoning cases was graded according to an established poisoning severity score as follows<sup>23</sup>: mild, transient, and spontaneously resolving symptoms (mild); pronounced or prolonged symptoms (moderate); severe or life-threatening symptoms (severe); and fatal poisoning (fatal). Descriptive statistics were used to present the results.

In collaboration with the Hong Kong Herbarium, Agriculture, Fisheries and Conservation Department, available plant specimens were sent for morphological identification. Mass spectrometry-based and microscopy-based tests for specific plant toxin(s) were developed, and performed on selected cases, guided by clinical presentation of the patients and types of the toxic plant(s) exposed. Mass spectrometry-based analytical platforms can identify the majority of the clinically significant plant toxins affecting the cardiovascular, neurological, gastrointestinal, hepatological, and renal systems in plant and biological specimens. The poisonous plants commonly encountered in Hong Kong and the corresponding plant toxins are summarised in Table 1.<sup>24</sup>

The ethics committee exempted the study group from obtaining patient consent because the presented data were anonymised, and the risk of identification was low. The STROBE guidelines were used to ensure the reporting of this study.<sup>25</sup>

TABLE I. Mechanism of toxicity and poisoning features of common plant toxins, and the corresponding poisonous plants in Hong Kong<sup>24</sup>

Plant toxins	Mechanism of toxicity	Poisoning features reported in the literature	Genera/species	Common name(s) in Chinese
<b>Cardiotoxic</b>				
Cardiac glycosides*	Inhibit Na <sup>+</sup> /K <sup>+</sup> -ATPase of the myocardium, increase its excitability and may lead to arrhythmia	Mimics digoxin toxicity, nausea, vomiting, abdominal pain, arrhythmias, confusion, convulsion	<i>Adenium obesum</i> <i>Asclepias curassavica</i> <i>Calotropis gigantea</i> <i>Catunaregam spinosa</i> <i>Cerbera manghas</i> <i>Convallaria majalis</i> <i>Nerium oleander</i> <i>Strophanthus divaricatus</i> <i>Thevetia peruviana</i>	天寶花 馬利筋 牛角瓜 山石榴 海芒果 鈴蘭 夾竹桃 羊角拗 黃花夾竹桃
<b>Neurotoxic</b>				
Gelsemium alkaloids*	Antagonise acetylcholine receptors	Dry mouth, dizziness, sweating, blurred vision, weakness, hyperthermia, mydriasis, convulsion, respiratory and central nervous system depression	<i>Gelsemium elegans</i> <i>Gelsemium sempervirens</i>	鈎吻 / 斷腸草 金鈎吻
Grayanotoxins*	Prevent inactivation and lead to persistent opening of voltage-gated sodium channels	Nausea, vomiting, sweating, dizziness, blurred vision, confusion, arrhythmias, respiratory failure	<i>Rhododendron</i> species	杜鵑
Solanaceous tropane alkaloids*	Competitive blockage of cholinergic muscarinic receptors	Anticholinergic toxidrome, including dry mouth, dry skin, flushing, hyperthermia, tachycardia, hypertension, urinary retention, decreased bowel sounds, mydriasis, confusion	<i>Solandra nitida</i> <i>Datura metel</i>	金盃藤 洋金花 / 白花曼陀羅
Strychnine and brucine*	Act as glycine receptor antagonist result in hyperexcitability of spinal nerves	Opisthotonos, respiratory paralysis, hyperthermia, rhabdomyolysis, lactic acidosis, renal failure	<i>Strychnos angustiflora</i>	牛眼馬錢
<b>Cytotoxic</b>				
Colchicine* and related toxins	Prevent assembly of microtubules, resulting in failure of mitosis	Nausea, vomiting, diarrhoea, abdominal pain, bone marrow suppression, multi-organ failure	<i>Hemerocallis citrina</i> <i>Gloriosa superba</i>	黃花草 / 金針菜 嘉蘭
Mimosine*	Inhibit the initiation of DNA replication	Delayed growth, hair loss, and cataract in animal models	<i>Mimosa pudica</i> <i>Leucaena leucocephala</i>	含羞草 銀合歡
Plumbagin	Increase the formation of reaction oxygen species in cells, leading to DNA strand breakage and base damage	Skin contact: contact dermatitis, stinging pain, blistering Ingestion: vomiting, diarrhoea, miscarriage	<i>Plumbago zeylanica</i>	白花丹
Toxalbumins (eg, abrin*, ricin, curcin)	Inactivate ribosome and inhibit protein synthesis	Nausea, vomiting, diarrhoea, abdominal pain, gastrointestinal bleeding, tachycardia, drowsiness, weakness, hallucination, convulsion, multi-organ failure	<i>Abrus precatorius</i> <i>Ricinus communis</i>	相思子 蓖麻
Vinblastine and vincristine*	Prevent assembly of microtubules, resulting in failure of mitosis	Paraesthesia, stomatitis, paralytic ileus, myalgia, fever, bone marrow suppression, organ failure	<i>Catharanthus roseus</i>	長春花
<b>Gastrointestinal hepatotoxic</b>				
Amaryllidaceous alkaloids	Irritate gastrointestinal tract and hypotensive effect	Skin contact: contact dermatitis. Ingestion: nausea, vomiting, diarrhoea, perioral numbness dizziness, blurred vision, hypotension, convulsion	<i>Hymenocallis littoralis</i> <i>Lycoris aurea</i> <i>Narcissus tazetta</i> var. <i>chinensis</i>	水鬼蕉 忽地笑 水仙
Calcium oxalate raphide*	Raphides stored in cells are released when subjected to mechanical pressure such as ingestion and pressure, causing tissue irritation and inflammation	Skin contact: itchiness Eye contact: irritation, blindness Ingestion: burning sensation of the oral cavities, salivation, nausea, vomiting, diarrhoea, dysphagia, dysphonia	<i>Alocasia macrorrhizos</i> <i>Alocasia cucullata</i> <i>Arisaema erubescens</i> <i>Dieffenbachia seguine</i> <i>Monstera deliciosa</i> <i>Typhonium blumei</i> <i>Zantedeschia aethiopicum</i> <i>Hyacinthus orientalis</i> <i>Narcissus tazetta</i> var. <i>chinensis</i>	海芋 尖尾芋 一把傘南星 花葉萬年青 龜背竹 犁頭尖 馬蹄蓮 風信子 水仙

\* Specific toxicological investigation available in The Hospital Authority Toxicology Reference Laboratory

TABLE I. (cont'd)

Plant toxins	Mechanism of toxicity	Poisoning features reported in the literature	Genera/species	Common name(s) in Chinese
Cycasin	Irritate gastrointestinal tract	Nausea, vomiting, diarrhoea, abdominal pain, headache, dizziness	<i>Cycas revoluta</i>	蘇鐵
Pentacyclic triterpenoids	May be hepatotoxic and cause intrahepatic cholestasis	Vomiting, diarrhoea, abdominal pain, respiratory depression and liver impairment	<i>Lantana camara</i>	馬纓丹
Phorbol esters	Irritate gastrointestinal tract	Nausea, vomiting, diarrhoea, abdominal pain	<i>Aleurites moluccana</i> <i>Croton tiglium</i> <i>Vernicia montana</i>	石栗 巴豆 木油樹
Phytolaccatoxins*	Irritants to mucosal surface and have haemolytic effect	Weakness, nausea, vomiting, diarrhoea, abdominal pain	<i>Phytolacca americana</i>	美洲商陸
Plumericin	Irritate gastrointestinal tract	Skin contact: rash, contact dermatitis Ingestion: vomiting, diarrhoea, abdominal pain, dehydration	<i>Allamanda cathartica</i> <i>Allamanda schottii</i>	軟枝黃蟬 黃蟬
Pyrrolizidine alkaloids*	Convert to highly reactive metabolites by liver, which bind to cellular components causing acute and chronic toxicities	Acute: abdominal pain, hepatomegaly, ascites, liver necrosis, death Chronic: hepatomegaly, recurrent ascites, hepatic vein occlusion, cirrhosis, hepatocellular carcinoma, pulmonary hypertension, death	<i>Crotalaria pallida</i> var. <i>obovata</i> <i>Crotalaria retusa</i> <i>Emilia sonchifolia</i> <i>Farfugium japonicum</i> <i>Gynura divaricata</i> <i>Heliotropium indicum</i> <i>Senecio scandens</i>	豬屎豆 吊裙草 一點紅 大吳風草 白子菜 大尾搖 千里光
Saponins	Irritate gastrointestinal tract	Vomiting, diarrhoea, abdominal pain	<i>Albizia lebbek</i> <i>Aleurites moluccana</i> <i>Cardiospermum halicacabum</i> <i>Costus speciosus</i>	大葉合歡 石栗 倒地鈴 閉鞘薑
Steroidal alkaloids*	Bind to sterols, disrupt cell membrane integrity and cause tissue damage	Nausea, vomiting, diarrhoea, abdominal pain, dizziness, delirium, slurring of speech, ataxia	<i>Solanum americanum</i> <i>Solanum capsicoides</i> <i>Solanum mammosum</i>	少花龍葵 牛茄子 乳茄 / 五代同堂茄
Tetrahydro-palmitine*	Cause apoptosis of hepatocytes	Fever, nausea, vomiting, diarrhoea, abdominal pain, jaundice, hepatomegaly, liver impairment, drowsiness, weakness and central nervous system depression	<i>Stephania sinica</i>	汝蘭
Teucvin	Share similar structure with the hepatotoxin teucrin A, which can cause hepatitis through direct toxicity and secondary immune-mediated injury	Nausea, vomiting, jaundice, hepatitis	<i>Teucrium viscidum</i>	血見愁 / 山藿香

## Results

A total of 62 cases of confirmed plant poisoning, involving 26 plant species, were identified within the study period. The patients were referred from 14 local hospitals administered by the Hospital Authority. Almost all patients (n=60, 97%) were Chinese, 29 (47%) were male, and 33 (53%) were female. The median age was 50 years (range, 1 month to 83 years), including three children (range, 1-23 months) and four adolescents (range, 15-18 years). The route of exposure was oral in 60 (97%) patients and topical in two (3%) patients. The majority of the patients (n=55, 89%) developed acute toxic symptoms after a single use of the plants, while the remaining patients (n=7, 11%) reported a history of prolonged exposure. Details of the plant poisoning cases, including the involved plant species and toxins, clinical presentation and outcome of these patients are summarised in Table 2.

Gastrointestinal toxicity was the most

common clinical presentation (n=30, 48%). Of these 30 patients, 17 developed oromucosal irritation after ingestion of calcium oxalate raphide-containing plants. The other 13 patients presented with gastroenteritis-like symptoms, such as nausea, vomiting, abdominal pain and diarrhoea, after ingestion of plant containing gastrointestinal irritants (n=11) or cytotoxic toxins (n=2). Neurological toxicity was the second most common presenting symptoms (n=22, 35%), mainly caused by gelsemium alkaloids (n=12), Solanaceous tropane alkaloids (n=4), and grayanotoxins (n=3). Hepatotoxicity was encountered in six (10%) patients. Five patients had abnormal liver function test results owing to the use of teucvin (n=1), pyrrolizidine alkaloids (n=1), and other unknown hepatotoxin(s) (n=3); one patient developed cholestasis after exposure to pentacyclic triterpenoids. Cases of nephrotoxicity (n=2, 3%), cardiotoxicity (n=1, 2%), and dermatological toxicity (n=1, 2%) were also recorded.

TABLE 2. Summary of plant poisoning cases encountered from 2003 to 2017, details and severity of poisonings, presentation signs and symptoms, treatment, and outcome of the patients

Poisonous plant involved	Plant toxin(s)	Details of poisoning	Presenting signs and symptoms and severity of poisoning	Treatment and outcome of the patient(s)
<b>Gastrointestinal toxicity (n=30)</b>				
<i>Alocasia macrorrhizos</i> , <i>Alocasia cucullata</i> , and other raphide-containing plants (n=17)	Calcium oxalate raphide	<ul style="list-style-type: none"> <li>Ingested root of the plant due to misidentification as wild taro (n=9)</li> <li>Ingested other parts of the plants due to misidentification as edible vegetable (n=7)</li> <li>Accidentally bit on a leaf of unknown plant species (n=1)*</li> </ul>	Mild toxicity (n=17): lip and tongue swelling (n=11), burning sensation and pain in oral cavity (n=11), tongue numbness (n=6), sore throat (n=1)	All recovered within a day with supportive management
<i>Vernicia montana</i> (n=3)	Phorbol esters	<ul style="list-style-type: none"> <li>Took kernels of its fruit due to misidentification as edible nuts (n=3, in a cluster)</li> </ul>	Mild toxicity (n=3): vomiting (n=3), abdominal pain (n=3)	All recovered within a day with supportive management
<i>Justicia gendarussa</i> (n=2)	Unknown gastrointestinal irritant	<ul style="list-style-type: none"> <li>Took herbal broth prepared with the plant for medicinal purpose (n=1)</li> <li>Took herbal broth prepared with the plant due to misidentification as medicinal plant (n=1)</li> </ul>	Mild toxicity (n=2): dizziness (n=2), vomiting (n=2), diarrhoea (n=1)	All recovered within a day with supportive management
<i>Sauropus spatulifolius</i> (n=2)	Unknown gastrointestinal irritant	<ul style="list-style-type: none"> <li>Took soup prepared with leaves or root of the plant (n=2)</li> </ul>	Mild toxicity (n=2): vomiting (n=2), diarrhoea (n=2), abdominal pain (n=1)	All recovered within a day with supportive management
<i>Phytolacca americana</i> (n=1)	Phytolaccatoxins	<ul style="list-style-type: none"> <li>Took herbal broth prepared with root of the plant due to misidentification as "fresh ginseng"</li> </ul>	Mild toxicity (n=1): nausea, repeated vomiting	Recovered within a day with supportive management
<i>Solanum americanum</i> (n=1)	Steroidal alkaloid	<ul style="list-style-type: none"> <li>Took the leaves and fruits of the plant as wild vegetable</li> </ul>	Mild toxicity (n=1): nausea, dizziness, repeated vomiting	Recovered within a day with supportive management
<i>Vernonia amygdalina</i> (n=1)	Unknown gastrointestinal irritant	<ul style="list-style-type: none"> <li>Took fresh leaves of the plant for medicinal purposes</li> </ul>	Mild toxicity (n=1): vomiting, dizziness	Recovered within a day with supportive management
<i>Cycas revoluta</i> (n=1)	Cycasin	<ul style="list-style-type: none"> <li>Took fruits of the plant as edible fruit/nut</li> </ul>	Mild toxicity (n=1): abdominal pain, vomiting, dizziness, lip numbness, diarrhoea	Recovered within a day with supportive management
<i>Hemerocallis citrina</i> (n=1)	Colchicine	<ul style="list-style-type: none"> <li>Took cooked fresh flower of the plant as vegetable</li> </ul>	Mild toxicity (n=1): vomiting, diarrhoea	Recovered within a day with supportive management
<i>Abrus precatorius</i> (n=1)	Toxalbumins	<ul style="list-style-type: none"> <li>Took herbal broth prepared with stem, leaves and seed of the plant for 10 days due to misidentification as "touch-me-not"</li> </ul>	Severe toxicity (n=1): nausea, vomiting, acute renal failure	Required haemodialysis and intensive care support for several weeks
<b>Neurotoxicity (n=22)</b>				
<i>Gelsemium elegans</i> (n=12)	Gelsemium alkaloids	<ul style="list-style-type: none"> <li>Took herbal broth prepared with the plant due to misidentification as non-poisonous plant (n=4, in a cluster)</li> <li>Took herbal broth prepared with non-poisonous plant which was contaminated with gelsemium alkaloids (n=5, in two clusters)</li> <li>Took herbal broth prepared with the plant for suicidal attempt (n=1)</li> <li>Took herbal broth prepared with non-poisonous plant which was contaminated with <i>Gelsemium</i> species (n=1)</li> <li>Accidentally took herbal wine self-prepared with the plant which was intended for topical use (n=1)</li> </ul>	Mild toxicity (n=10): dizziness (n=10), blurred vision (n=5), weakness (n=3), vomiting (n=2)	All recovered within a day with supportive management
<i>Datura metel</i> and other solanaceous tropane alkaloid-containing plants (n=4)	Solanaceous tropane alkaloids	<ul style="list-style-type: none"> <li>Took herbal tea prepared with the plant due to misidentification as non-poisonous species (n=1)</li> <li>Took root of tropane alkaloid-containing plants as edible species (n=3, in a cluster)</li> </ul>	Mild toxicity (n=4): confusion (n=4), dizziness (n=3), nausea (n=3), vomiting (n=3)	All recovered within a day with supportive management

Abbreviations: IV = intravenous; IVF = intravenous fluid; LFT = liver function test

\* Cases involving children aged <10 years

TABLE 2. (cont'd)

Poisonous plant involved	Plant toxin(s)	Details of poisoning	Presenting signs and symptoms and severity of poisoning	Treatment and outcome of the patient(s)
<i>Rhododendron</i> species (n=3)	Grayanotoxins	• Took pieces of petals of its flower for medicinal purpose (n=1)	Mild toxicity (n=1): facial numbness, blurred vision	Recovered within a day with supportive management
		• Took 10 flowers due to misidentification as non-poisonous species (n=1)	Moderate toxicity (n=1): nausea, vomiting, blurred vision, muscle cramps, bradycardia, hypotension	Required IV atropine and IVF, recovered with supportive treatment in few days
		• Took herbal broth prepared with the flower due to misidentification as non-poisonous species (n=1*)	Severe toxicity (n=1): excessive salivation, vomiting, cyanosis, limb twitching, bradycardia, respiratory depression	Required intubation and intensive care support for days, fully recovered and discharged after 1 week
<i>Mirabilis jalapa</i> (n=1)	Unknown neurotoxin	• Took herbal soup prepared with root of the plant for medicinal purpose	Mild toxicity (n=1): dizziness, headache, muscle weakness	Recovered within a day with supportive management
<i>Anredera cordifolia</i> (n=1)	Unknown neurotoxin	• Took herbal tea prepared with leaves of the plant due to misidentification as medicinal plant	Mild toxicity (n=1): weakness, limb numbness	Recovered within a day with supportive management
<i>Basella alba</i> (n=1)	Unknown neurotoxin	• Took raw stem and fruits of the plant as vegetable	Mild toxicity (n=1): vomiting, limb numbness, palpitation	Recovered within a day with supportive management
<b>Hepatotoxicity (n=6)</b>				
<i>Teucrium viscidum</i> (n=1)	Teucvin	• Took herbal broth prepared with the plant for medicinal use for 1 week	Moderate toxicity (n=1): liver derangement	LFT normalised in few weeks after discontinuation of the plant use
<i>Lantana camara</i> (n=1)	Pentacyclic triterpenoids	• Took herbal broth prepared with the plant for medicinal purpose for few weeks	Moderate toxicity (n=1): liver derangement	LFT normalised in few weeks after discontinuation of the plant use
<i>Juniperus</i> species (n=1)	Unknown hepatotoxin	• Took herbal tea prepared with "pine needles" for medicinal purpose for 3 weeks	Moderate toxicity (n=1): liver derangement	LFT normalised in few weeks after discontinuation of the plant use
<i>Blumea balsamifera</i> (n=1)	Unknown hepatotoxin	• Took herbal tea prepared with the plant for medicinal purpose for 1 month	Moderate toxicity (n=1): liver derangement	LFT normalised in few weeks after discontinuation of the plant use
<i>Emilia sonchifolia</i> (n=1)	Pyrrrolizidine alkaloids	• Took herbal broth prepared with the plant for medicinal purpose for 6 months*	Severe toxicity (n=1): liver impairment with hepatic vein thrombosis	Budd-Chiari syndrome with ascites, pleural effusion and hepatomegaly requiring weeks of intensive care unit support. Resolved in few months after discontinuation of the plant use
<i>Mimosa pudica</i> (n=1)	Mimosine	• Took herbal broth prepared with the plant for medicinal purpose for 1 day	Moderate toxicity (n=1): liver derangement	LFT normalised in few weeks after discontinuation of the plant use
<b>Nephrotoxicity (n=2)</b>				
<i>Mimosa pudica</i> (n=1)	Mimosine	• Took herbal broth prepared with the plant for medicinal purpose on-and-off for 1 year	Moderate toxicity (n=1): renal impairment, haematuria, tubulonephritis confirmed by renal biopsy	Residual mild renal impairment after discontinuation of the plant use
<i>Alternanthera</i> species (n=1)	Unknown nephrotoxin	• Took herbal broth prepared with the plant for medicinal purpose for 1 month	Moderate toxicity (n=1): acute kidney injury	Progressed to chronic kidney disease despite discontinuation of the plant use
<b>Cardiotoxicity (n=1)</b>				
<i>Strophanthus divaricatus</i> (n=1)	Cardiac glycosides	• Topical use of herbal wine prepared with the skin of the fruit of the plant for medicinal purpose	Mild toxicity (n=1): palpitation, dizziness	Recovered within a day with supportive management
<b>Dermatological toxicity (n=1)</b>				
<i>Plumbago zeylanica</i> (n=1)	Plumbagin	• Topical use of herbal paste prepared with the plant due to misidentification as a medicinal plant	Mild toxicity (n=1): stinging pain, skin discoloration	Recovered with supportive management

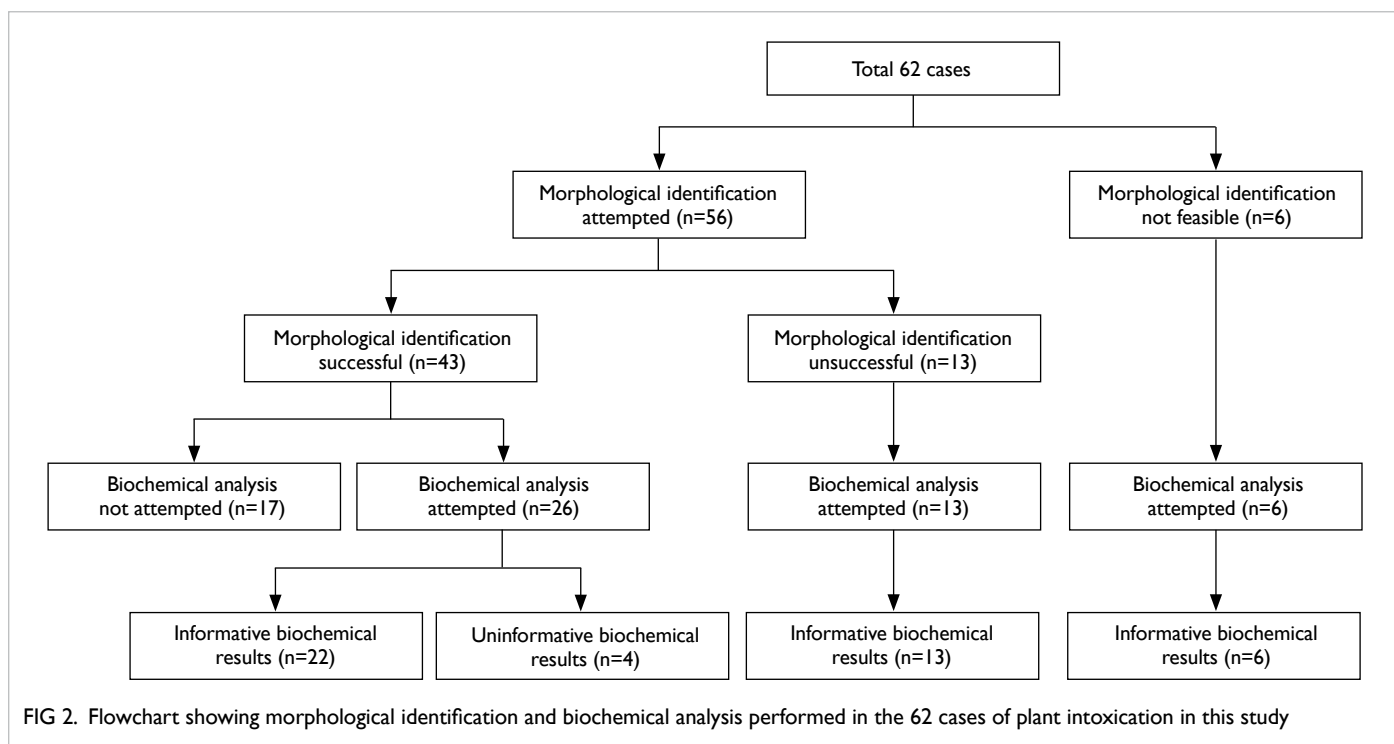


FIG 1. The four types of poisonous plants causing severe toxicity in our patients (reproduced from reference 24 with permission)

Most of the patients experienced mild (n=49, 79%) or moderate toxicity (n=8, 13%). Of them, 55 patients recovered within days with supportive treatment. The other two patients with nephrotoxicity had residual renal impairment after discontinuation of plant use; in one of them a renal biopsy study showed tubulonephritic changes. The remaining five patients (8%) experienced severe toxicity after the use of *Abrus precatorius* (n=1), *Gelsemium elegans* (n=2), *Rhododendron* species (n=1), and *Emilia sonchifolia* (n=1), and all five required intensive care support.

The morphological identification and biochemical analysis process followed to identify the plants involved in the 62 cases of intoxication is shown in Figure 2. Most patients provided fresh plant specimens (n=53, 85%) or photograph of the plant (n=3, 5%) they had consumed. Among these specimens received by our laboratory, 43 could be identified morphologically with the aid of the Hong Kong Herbarium, Agriculture, Fisheries and Conservation Department. Biochemical analysis for specific plant toxin(s) were attempted in the plant or the biological specimens in 45 (73%) cases, with 41 yielding diagnostic information, including six cases with no plant specimens for identification and 13 cases with unsuccessful identification. There were 22 (35%) cases with both informative morphological identification and biochemical results. Among these 22 cases, the morphological identification and biochemical results were coherent in 20. For the remaining two cases with clinical gelsemium poisoning, gelsemium alkaloids were detected in both the urine and plant specimens. However, the plant specimen was morphologically identified as *Cassytha filiformis*. *Cassytha filiformis* is a non-toxic plant that has been shown to parasitise *Gelsemium elegans* and absorb gelsemium alkaloids, leading to poisoning.<sup>18</sup> Patient accuracy in identification of plants was low. Although 56 (90%) patients had given common names of the plants they consumed, only 19 of them were correct.

Patients consumed the plants as medicinal herbs (n=31, 50%), as food (n=29, 47%), in an attempted suicide (n=1, 2%), or accidentally, in one paediatric patient (n=1, 2%). Causes of poisoning in patients using the plants as medicinal herbs or food included plant misidentification (n=34), unawareness/underestimation of the potential toxicity (n=20), or contamination of non-toxic plants with poisonous ones (n=6). The sources of the poisonous plants used included self-collecting from parks or the countryside (n=37, 60%), obtaining from friends or relatives (n=20, 32%), growing at home (n=3, 5%), and buying from wet markets (n=2, 3%). The plants were obtained in Hong Kong (n=49, 79%) or mainland China (n=12, 19%), with one (2%) case collected from the Philippines.



## Discussion

The 62 cases reported herein represent the largest series of plant poisoning cases in Hong Kong confirmed by either morphological identification or biochemical confirmation. Comparing our results with those of studies from other regions, the pattern of plant poisoning is considerably different. Plant poisonings reported in Western countries are predominantly accidental exposure in children,<sup>3,7,10</sup> whereas in the present study, most patients were adults poisoned after intentional use of wild plants. The highly urbanised and industrialised nature of Hong Kong explains the low incidence of paediatric accidental poisoning. The relatively high rate of adult poisoning may be related to the long-standing tradition and Chinese culture of using wild plant as “medicinal herbs” and “vegetables”. Recreational abuse of toxic plants, such as *Datura* species,<sup>26,27</sup> which are responsible for a significant number of poisoning cases reported in other regions, was not observed locally.

The most common type of poisoning in the current study was the use of raphide-containing plants, such as *Alocasia macrorrhizos*, accounting for more than 25% of cases. The roots of these plants are frequently mistaken as edible taro.<sup>28</sup> Although all cases in this study were mild, severe outcomes including oropharyngeal oedema, upper airway obstruction, or systemic toxicity are possible.<sup>29,30</sup>

Similar to previous reports of plant poisoning,<sup>3,5,7</sup> most patients in the present study developed mild transient symptoms and recovered with supportive management and discontinuation of exposure. However, there were five cases of severe poisoning requiring intensive care support, involving the use of *Gelsemium elegans*, *Rhododendron* species, *Abrus precatorius*, and *Emilia sonchifolia* (Fig 1).

*Gelsemium elegans* is one of the most notorious poisonous plants in Hong Kong and South-East Asian countries and has been used for homicidal and suicidal purposes.<sup>31,32</sup> Severe gelsemium toxicity can result in respiratory depression and even death. In our case series, two clusters of “hidden” gelsemium poisoning were identified where the patients consumed non-toxic parasitic *Cassytha filiformis* which absorbed gelsemium alkaloids from *Gelsemium elegans* on which it grew.<sup>18</sup> Similar cases of hidden gelsemium poisoning from contaminated dried herbs *Ficus hirta* have been reported in Hong Kong.<sup>16</sup>

*Rhododendron* species and other plants in the *Ericaceae* family contain grayanotoxins.<sup>33</sup> Severe grayanotoxin poisoning may result in respiratory depression and arrhythmias.<sup>34</sup> “Mad honey” containing nectar of *Ericaceae* plants is known to be a source of exposure in Hong Kong,<sup>35</sup> but poisonings due to direct consumption of *Rhododendron* flowers are not uncommon.<sup>12</sup>



The seed of *Abrus precatorius* contains the protein abrin, an extremely poisonous toxin similar to ricin that can result in multi-organ failure.<sup>36,37</sup> These seeds are sometimes used in beaded jewellery, in addition to being collected, providing another potential source of exposure.<sup>37</sup> Cases of abrin poisoning due to suicidal attempt or accidental ingestion have been reported worldwide,<sup>38-40</sup> but such poisoning is rare in Hong Kong.

The toxic constituents in *Emilia sonchifolia* are pyrrolizidine alkaloids.<sup>41</sup> Massive acute ingestion can lead to hepatotoxicity and coagulopathy, while chronic low-dose exposure can result in liver cirrhosis and hepatic veno-occlusive disease.<sup>42-44</sup> Certain types of traditional Chinese medicine, such as *Flos farfarae* and *Herba senecionis scandentis*, are potential sources of pyrrolizidine alkaloids exposure in Hong Kong,<sup>45,46</sup> but toxicity due to wild plant consumption is relatively rare.<sup>14</sup>

Timely diagnosis of plant poisonings is very difficult. Local epidemiology data are scarce, and reports published in other parts of the world are of limited use because plant species are geographically specific. Patients might volunteer a history of plant exposure, but the information they provide may be uninformative, misleading, or incorrect. In our case series, among those who provided a common name of the plant, only 34% were correct.

Our results demonstrate the importance of adopting a complementary approach, incorporating clinical toxidrome, morphological identification of plant specimens, and biochemical analysis of plant toxins, in order to achieve maximal diagnostic efficacy. Clinical history may not be particularly informative. The presenting toxidrome is more objective and useful for identifying the plant responsible for the poisoning, and this diagnostic approach is well supported in the literature.<sup>20,21</sup>

Table 1 summarises and categorises commonly encountered local poisonous plants by toxidromes. This may serve as quick reference for clinicians to allow rapid identification of the plant and prompt management of the poisoning. However, clinicians should also be aware that the toxicity of some plants may not be well characterised, and that some plants may give rise to non-specific toxidrome, rendering this approach less useful in certain cases.

Specialised toxicological investigation may provide additional evidence to confirm or refute the provisional diagnosis. In most situations, morphological identification of the plant is sufficient to achieve a diagnosis, if a well-preserved plant specimen is provided. However, a plant specimen is not always available; even if available, it may not be representative of the plants consumed by the patient, or may have been deformed due to prior processing. An equally important tool is target testing for specific plant toxin(s) in the plant or biological specimens

based on clinical suspicion. This is a powerful tool for confirming the diagnosis, especially when plant specimen is not available; and for identifying cases of contamination with an unclear or hidden source.<sup>18</sup> However, these investigations cannot aid immediate management in the emergency room.

Diagnosis of plant poisoning requires a proactive rather than a reactive approach. A knowledge database comprising the clinical toxicity, morphology, and biochemical analysis of local toxic plants is an important tool to prepare clinicians and healthcare professionals, such as that provided by the Hospital Authority.<sup>24</sup> This public resource can also be used to educate the general public on the dangers of wild plants.

As a retrospective study, this study has several limitations. This study is subjected to selection bias as the data collection is a passive procedure depending on test or consultation requests by clinicians, and there might be incomplete or missing data. Moreover, for those with history of exposure or mild clinical symptoms, toxicology testing or consultation may not be requested, our data might therefore include only cases with more severe outcome in the overall continuum of plant poisoning. Inevitably, some plant exposures were not reported to our laboratory, and thus our findings may underestimate the actual number of cases.

## Conclusions

Diagnosing plant poisoning is challenging and the epidemiology of plant poisonings is geographically specific. Clinicians should consider a complementary approach with consideration of the clinical toxidromes, local epidemiological data, botanical and toxicological findings to help recognition of the plants involved in cases of intoxication. Plant specimens and biological specimens should be saved whenever possible for toxicological analysis. Clinicians should be aware of local poisonous plants and their toxicities. Although most plant exposure resulted in a self-limiting disease, severe poisonings were encountered. The public should be educated about the potential hazards of consuming plants obtained from the wild and discouraged from engaging in this practice.

## Author contributions

All authors had full access to the data, contributed to the study (including concept or design, acquisition of data, analysis or interpretation of data, drafting of the manuscript, and critical revision for important intellectual content), approved the final version for publication, and take responsibility for its accuracy and integrity.

## Conflicts of interest

All authors have disclosed no conflicts of interest.

## Declaration

Some of the cases have been published by the authors in electronic form<sup>24</sup> and in book form (Mak WL, Lam YH, Ching CK, Chan SS, Chong YK, Ng WY, editors. Atlas of Poisonous Plants in Hong Kong—A Clinical Toxicology Perspective. Hong Kong: Hospital Authority Toxicology Reference Laboratory; 2016), and presented at the Hospital Authority Toxicology Services Scientific Conference 2016 (“Poisonous plants in Hong Kong—a clinical perspective”). Some of the cases have been previously published as case reports by the authors and other units.<sup>12-19</sup>

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## Ethics approval

The study was approved by the Hong Kong Hospital Authority Kowloon West Cluster Research Ethics Committee (Ref. KW/EX-16-036[96-18(TCM)]).

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