

Review Paper: The Features and Processes of Poisoning Registries: A Scoping Review



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Citation Sabahi A, Asadi F, Shadnia S, Rabiei R, Hosseini AS. The Features and Processes of Poisoning Registries: A Scoping Review. International Journal of Medical Toxicology and Forensic Medicine. 2021; 11(3):34286. <https://doi.org/10.32598/ijmtfm.v11i3.34286>



<https://doi.org/10.32598/ijmtfm.v11i3.34286>



ABSTRACT

Article info:

Received: 5 Mar 2021

First Revision: 14 Mar 2021

Accepted: 5 Apr 2021

Published: 25 Aug 2021

Keywords:

Registry, Data management, Poisons, Information management

Background: Poisoning is a common condition worldwide that requires precise evaluation of the quality and rapid management. Registry plays an essential role in the management of toxins. This study aimed to examine the features and processes of poisoning registries.

Methods: This review study was conducted in 2020. Several searches were conducted in the following scientific databases: PubMed, Scopus, Embase, and Web of Science using a combination of keywords, such as “data management, registry, poison, and toxic”. The review of titles, abstracts, and full-text of the selected articles was independently performed by two researchers. Besides, the obtained data were analyzed based on the research objectives by the content analysis method.

Results: Some critical features of registries were considered the confidentiality of patients' information, i.e., equipped with various technologies, such as Geographical Information System (GIS), warning systems, searches, and text retrieval tools. The most common sources of case findings were self-reported contacts by individuals and healthcare professionals to poison control centers. Moreover, the main tool for data collection was electronic forms. The major indices of data quality were the accuracy, completeness, and consistency of the data. Phone calls were usually made at follow-ups.

Conclusion: The registry's features and processes are an essential and fundamental step to achieve the registry goals, as well as designing and developing these systems. It is recommended that the registries be equipped with various technologies to better manage the exposure cases. It is recommended to use educational, incentive, competitive, participatory, and motivational mechanisms among all organizations and individuals involved in poisoning registry programs.

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1. Introduction

Poisoning refers to an injury that results from an exogenous substance, which causes cellular injury or death [1]. The World Health Organization (WHO) believes that poisoning is a global threat to public health [2]. Moreover, its prevalence is constantly increasing due to the changes in lifestyle and social behaviors [3]. Poisoning or overdose can be clinically acute, sub-acute, chronic, or sub-chronic [4]. Acute intoxication is a frequent condition in the emergency department worldwide, requiring accurate and rapid evaluations [5, 6]. Additionally, acute poisoning plays a significant economic effect on health services in countries [7, 8]; the total medical poisoning costs in the United States are estimated to be \$3 billion annually. Besides, on average, \$925 is spent on each poisoning case [9]. The most prevalent route of intentional poisoning is consuming high doses of drugs [10, 11]. The most common cause of unintentional poisoning is pesticides, exposure to household and occupational chemicals, and environmental pollution [12]. Based on the WHO, approximately one million individuals die annually due to suicide; with chemicals accounting for a significant proportion of deaths [13].

The WHO report in 2016 also reflected that over 100000 subjects died by unintentional poisoning worldwide [14]; 84% of which occurred in low- and middle-income countries [15]. The poisoning-induced death rate in these countries is 4 times higher than that in high-income countries [16]. In developing countries, incomplete laws and regulations on drugs and pharmaceutical chemicals, poor supervision systems, and easy access to various drugs and chemicals have increased the poisoning rate [17]. The poisoning cases can generally vary from region to region concerning demographic characteristics, the cause of poisoning, and frequency [18]. Differences in poisoning patterns are related to cultural, social, economic, environmental factors as well as industrial and agricultural activities [19].

The knowledge of general poisoning patterns in a particular area helps to identify risk factors, early diagnosis, and management, ultimately reducing disease and mortality [20]. Therefore, to identify, manage, and improve disease control, it is essential to develop an integrated information system. As an efficient and valuable data management information system [21], a registry is a crucial tool for case management to identify critical patients at risk [22].

The clinical registry is an organized system to collect uniform data (clinical & other). This system helps to evaluate the identified outcomes in a population defined by a specific disease, condition, or exposure that serves the predetermined scientific, clinical, or political goals [23].

Most registries' mission is to promote patients' health by improving the quality of patient care; accordingly, the purpose of surveillance and evaluation of patient care is performed in the registries [24]. Some essential features are included for the successful implementation of registries as having an easy and comprehensive method. Such an approach helps to identify patients and gathering data elements electronically, real-time data accessibility, the ability to search, providing feedback to decision providers and supporters, developing strategies to increase information completion, and agreement on minimum data sets [25, 26].

Registries also have processes, including case finding, data collection, coding and abstracting, quality control, reporting, and patient follow-up. Case identifying indicates identifying new cases, i.e., screened in a certain period. Moreover, its goal is to identify potentially reportable cases. Data collection consists of completely and accurately collecting and maintaining patients' information. Abstracting and coding aim to provide a useful summary of patients' information. Quality control is an ongoing process by officials in the registry over time; it is aimed to improve data and care quality and treatment. Reporting in the registry is any report published by the registry. Patient follow-up is conducted to control their health status after discharge [27, 28].

Poison information systems and registries play an essential role in the prevention, treatment, and patient follow-up in developed countries. Thus, it is an emerging tool in healthcare data management and support in developing countries [29].

The WHO established International Program on Chemical Safety (IPCS INTOX) in 1988 to prevent, monitor, manage, and follow poisoned patients in collaboration with experts from >75 countries. The program monitors activities to promote the establishment and strengthening of poison centers, provides information on chemicals, provides data management tools, and develops the international guidelines for the prevention and clinical management of poisoning. Finally, it maintains a network to share poisoning information through international cooperation and joint efforts. One of the INTOX data management system features is using multilingual

data collection tools applying defined terminologies and classifications [13].

The National Poison Information System (NPDS) is applied in the United States, i.e., launched in 2006 [30]. It includes 444000 inputs from viral and bacterial agents to chemicals, commercial, and pharmaceutical products [31]. This registry has specific and defined features and processes; they can provide the basis for the development and design of poisoning registers.

The Toxicology Investigators Consortium (ToxIC) was established by the American College of Medical Toxicology (ACMT) in 2010. A significant part of this database's information is unavailable in other sources, which includes medical information and demographics, e.g. race, ethnicity, and Human Immunodeficiency Virus (HIV) status [32].

Considering the design and development of poisoning registries require much attention to the main registry features and processes. Furthermore, exploring the experiences of leading countries in this field can help design and develop it for other countries. Documentation on the development and using the registries to manage the data of poisoned patients is scarce. Thus, the present study aimed to review and compare poison registry features and processes in the selected countries. Such a study helps to identify the experiences, main features, and processes of the poison registry to provide appropriate solutions for the design and development of these systems.

2. Materials and Methods

The present study adopted Arksey and O'Malley's framework to perform a scoping review, which comprises 5 main stages and one selective stage as follows:

1. Identifying the research question
2. Identifying relevant studies
3. Selecting the studies
4. Charting the data
5. Collating, summarizing, and reporting the results
6. Consultation exercise (the sixth stage was not included in this review.) [33]

The questions examined in this review study were as follows:

What are the goals of poisoning registries? What are the features of poisoning registries? What are the main processes in poisoning registries? What are the minimum data sets in poisoning registries?

Information sources and search strategy

All related published articles were extracted from PubMed, Scopus, Web of Science, and Embase databases. The search was performed using a combination of keywords (MeSH terms). Table 1 presents the keywords used in the search to retrieve related articles.

Eligibility criteria

Inclusion criteria

Articles published until January 27, 2020, were reviewed for inclusion without language restrictions. All original research articles in which the registry's features and main processes (case finding, data gathering, abstracting & coding, quality control, reporting, & patient follow-up) were identified and explained were included in the current study.

Exclusion criteria

The articles in which the registry processes and features were not explicitly presented or incompletely referred to registry processes or registry features were excluded. Sub-registries resulting from a registry were excluded due to duplicate items. The reports of a specific poisoning registry during different years were excluded; the complete report on registry features and processes was included. Non-authentic articles (e.g. review articles, editorials, & protocols) were excluded. Furthermore, articles without full -texts (for any reason) were also excluded from this research.

Study selection and data extraction

After retrieving the relevant articles, each article was independently reviewed by two authors (AS, FA). Subsequently, both authors provided the reason for the rejection of each article. In case of disagreement, other authors reviewed the article (SH SH, RR, AH). The reference lists of the included articles were reviewed for identifying other articles that met the inclusion criteria.

After selecting the registers with inclusion criteria, the required data were collected using a data extraction form per the objectives of the study. The data extraction form consisted of 3 main parts, as follows: General information about the registries (the name of a registry, the time

Table 1. Search strategy for scientific databases

Criteria	Variables	Specifications
Criteria	Time	The search was conducted up to January 27, 2020
	Language	No limitation
	Databases	PubMed: Title/Abstract
		Scopus: TITLE-ABS-KEY
		Embase: Title/Abstract
		Web of Science: Topic
#1	"Register" OR "data management" OR "information management" OR "surveillance system" OR "information system" OR "data system"	
#2	"Poison" OR "toxic substances" OR "medical toxicology" OR "Poisons" OR "intoxic"	
Search	#1 AND #2	

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of activity commencement, the country of creation, the scale of implementation, & the objectives of the registry); Registry features in the form of strengths and limitations; and registry processes.

3. Results

A summary of the study characteristics

In the preliminary examination of the 4 databases, 9455 articles were retrieved and imported to the EndNote reference management software. Then, the duplicates and irrelevant cases were removed based on the evaluation of titles, abstracts, and full-texts. Finally, 4 poisoning registries were selected for review. Figure 1 shows the research selection process.

Table 2 presents the included registries' general information based on the Preferred Reporting Items for Systematic Review and Meta-Analyses for Scoping Reviews (PRISMA-ScR) checklist [34].

Among the 4 included registries, 3 registries belonged to the United States and Israel. The oldest registry dates back to 1964. All registries were nationally implemented. Moreover, their primary purpose was to manage poison exposure cases.

Data elements in the selected registries were classified into 12 main categories, with the TOXIC registry providing the most frequent data elements (Table 3).

A summary of the main features of registries

Table 4 reflects the main features of registries as the strengths and limitations. Some common strengths in registries were as follows: The registries in question were considered valuable tools to facilitate the diagnosis and management of poisoned patients. Besides, all registries were equipped with various tools and technologies, including warning systems, Geographical Information System (GIS), text search and retrieval tools, and internet search engines to improve their capabilities and better manage the exposures. Some of the main detected features were having identical datasets and standard definitions, having a strong coding system and terminology, sharing data with other registries, and paying attention to the confidentiality of patients' information [30, 32, 35, 36].

Among the studied registers, the TOXIC registry is the only prospective registry and database in which the cases are evaluated by medical toxicologists and enter into the registry. Additionally, this registry has several sub-registries to collect further detailed information for specific areas. Some of these sub-registries include the following: Sub-registries on the plant, mushroom, and herbal toxicity, pediatric opioid exposures, pediatric marijuana exposures, North American snake bites, extracorporeal substance removal, caustic ingestions, and prescription opioid abuse.

In this registry, measures were taken to protect patients' confidentiality and privacy. For instance, it was per the Health Insurance Portability and Accountability Act (HIPAA) [32].

Table 2. General specification of the included registries

ID	Registry Name	Starting Year	Country	Registry Implementation Scale	Purpose(s)
1	TESS (Toxic Exposure Surveillance System) [36]	1983	USA	National	Timely collection of information on exposure to potentially toxic chemicals or other poisonings for early detection of outbreaks.
2	NPDS (National Poison Data System) [30]	2006	USA	National	Managing poison exposure cases, collecting and coding data correctly, and responding to the ongoing need for general and professional training related to poisons. Its ongoing mission is to provide a global infrastructure to monitor public health for all exposure types to enable data sharing.
3	TOXIC (Toxicology Investigators Consortium) [32]	2010	USA	National	Providing timely surveillance for toxic exposure cases for several activities, including new and emerging drug reactions, syndrome surveillance for new diseases or chemical terrorism, or new drugs, or abuses. Creating the infrastructure for a multi-center research network.
4	IPIC (Israel National Poison Information Center) System [35]	1964	Israel	National	Providing first aid and triage counseling to health care providers and the community in cases of poisoning. Preventing unnecessary visits to medical centers and hospitals. Collecting epidemiological data on the incidence, severity, and course of poisoning and providing information on how to prevent poisoning.

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The main limitations of the examined registries were failure to represent the entire population of poisoned patients or all exposure cases. One of the most critical limitations in the Toxic Exposure Surveillance System (TESS), NPDS, and Israel National Poison Information Center (IPIC) registers was the non-confirmation of each report's complete accuracy by the poison control centers; it was due to the collection of information on phone calls and the lack of evaluation of bedside patients by toxicologists [30, 35, 36].

A summary of the main processes of registries

Table 5 illustrates the main processes of the selected registries. In-person patient evaluations perform the TOXIC registry case-finding process by medical toxicologists at the bedside or clinic; therefore, cases advised over the phone are not recorded in the registry [32]. In other registries, case finding is conducted through patients' self-reported calls, their families, and healthcare professionals [30, 35, 36].

The main data collection tool in the registers is electronic data collection forms [30, 32, 35, 36]. However, paper forms are also used in the TESS registry [36]. Those in charge of data collection in all registries are healthcare professionals at poison centers, including physicians, pharmacists, toxicologists, nurses, and trained secretaries. They gathered information from various sources,

including patients, emergency department information systems, laboratory information systems, toxicological, medical records, and other sources.

Forms are designed to summarize the registers' information based on the main goals and elements, facilitating data summarization. In all registries, data quality control measures are taken by checking for missing, duplicate, invalid, and audited medical records data to ensure accuracy, completeness, consistency, and data integrity.

Other results indicated that the most important organizations and individuals using various poisonous patient registry reports are poison control centers, the pharmaceutical industry, legislative agencies, interns and researchers, lawyers, the media, healthcare professionals, public health agencies, pharmaceutical, and consumer goods companies. Reports are extracted in the form of annual reports, articles, and summaries of information. The main indicators reported in the registers are poisoning indicators, treatment methods, medical implications, clinical effects, death causes, and rates.

Follow-ups in the registry are usually performed by telephone to determine medical implications, monitor case progress, make recommendations, and gather information [30, 32, 35, 36].

Table 3. The main data elements of selected registries

Data Elements		Registries			
		TESS	NPDS	TOXIC	IPIC
1	Demographic and general information	✓	✓	✓	✓
2	Reason of encounter	✓	✓	✓	✓
3	The duration of exposure	✓	✓	✓	-
4	Exposure route	✓	✓	✓	✓
5	Exposure agent	✓	✓	✓	✓
6	Clinical signs and symptoms	✓	✓	✓	-
7	The abnormalities of major vital sign	-	-	✓	-
8	The clinical severity of exposure	-	-	-	✓
9	Physical examination findings	✓	✓	✓	-
10	The results of laboratory tests	✓	✓	✓	✓
11	Treatment plan	✓	✓	✓	✓
12	Medical outcome	✓	✓	✓	✓

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TESS: Toxic Exposure Surveillance System; NPDS: National Poison Information System; TOXIC: Toxicology Investigators Consortium; IPIC: Israel National Poison Information Center.

4. Discussion

Poison registries play a crucial role in preventing and managing the poisoning; reducing healthcare costs; providing first aid and triage counseling to providers; increasing the quality of clinical services; identifying risk factors in the management of poisoned patients; identifying vulnerable areas, and communities prone to poisoning. Given the importance of poisoning registries, paying attention to their features and processes is a fundamental step in achieving the registry's goals, design, and development of these systems.

Registries objectives

The present study results suggested that the main objective of poisoning registers is the timely information collection for early diagnosis and better management of the disease; timely surveillance of exposure cases; the surveillance of patients' health status and implications, and the management of costs and healthcare resources. The mission of some of them is to provide infrastructure for sharing data with other sources and creating a research network.

Numerous health systems' and registries' mission is to establish a national information network and integrate it with various other data sources. The registry should be a part of an electronic network that presents real-time data to all primary and secondary providers. In such a network, "span the continuum of care" includes the patient's home, laboratory, pharmacy, clinical visits, and other care centers [25]. It is also recommended to pay attention to the integration and interaction of registries with other data sources, including electronic health records. Such measures help to reduce providers' workload and improve data access [37, 38].

Registries features (strengths)

The current research results revealed some of the main strengths of the studied registers, as follows: having uniform data set and standard definitions, having a strong coding system and terminology, ability to share data with other registers, attention to the confidentiality of patient information, and being equipped with various tools and technologies such as GIS, warning systems, search, text retrieval tools, and so on.

Table 4. The most important features of the included registries

Registries	Strengths	Limitations
TESS	<p>Both inpatient and outpatient poisoning and fatal and non-fatal toxic exposure.</p> <p>Having a uniform data set and standard definitions.</p> <p>A useful tool for early diagnosis of the disease.</p> <p>An alert system to identify severe hazards and identify problems with newly approved or newly marketed products.</p> <p>A valuable resource for evaluating product safety.</p>	<p>Limitation on reporting and collecting telephone information (including non-confirmation of patient bedside information by toxicologists).</p> <p>It is a passive reporting system.</p> <p>Lack of laboratory confirmation for many exposure cases.</p> <p>Poison center data do not represent the entire population of poisoned patients or items such as pre-hospital cardiac or respiratory arrest, home mortality, suspected poisoning deaths until autopsy.</p>
NPDS	<p>One of the few real-time surveillance systems.</p> <p>Having a strong coding system and terminology.</p> <p>Facilitating the detection, analysis, and reporting of surveillance anomalies</p> <p>Ability to share data with other surveillance systems.</p> <p>Ability to generate the system alerts on adverse drug events and other drug or commercial products of public health interest such as contaminated food or product recalls.</p> <p>Providing useful data and a model for public health surveillance.</p> <p>Being equipped with GIS for data analysis and display.</p> <p>Increasing the use of text instead of voice communication.</p> <p>Being equipped with Internet search engines and web resources.</p> <p>Being equipped with a generic code system that allows reports or more details.</p>	<p>Indirect data collection, non-evaluation of bedside patients by toxicologists.</p> <p>The items recorded in this database are self-reported exposures, so only information is reflected that people or health care professionals report a real or potential exposure.</p> <p>Exposure does not necessarily indicate poisoning or overdose.</p> <p>Additional exposures may not be reported to poison centers.</p> <p>It is not possible to fully verify the accuracy of each report.</p> <p>Toxic center data do not represent the entire population of poisoned patients or all cases of exposure to chemicals and toxins.</p>
TOXIC	<p>It is a prospective case registry.</p> <p>Registry cases are unique because medical toxicologists evaluate cases in both inpatient and outpatient settings.</p> <p>Cases that were consulted over the phone will not be listed in the database.</p> <p>Most of the information in this database is not available in other sources.</p> <p>Providing a more accurate picture of the poisoning process and public health implications.</p> <p>A useful tool for trainees and researchers in the field of toxicology.</p> <p>Providing a free text entry field in the data collection form for more details or additional information.</p> <p>Ability to share data with other registries.</p> <p>To maintain patient information confidentiality, the registry is designed according to the HIPAA (Health Insurance Portability and Accountability Act). Having multiple sub-registries to collect more detailed information for specific areas.</p>	<p>It does not represent the entire population of poisoned patients (it is not population-based technically).</p> <p>Possible biases are reported in more severe and complex cases.</p> <p>Information about some exposure cases is highly dependent on the patient's report, and the patient may not be aware of or willing to disclose.</p> <p>Failure to record all factors and interventions involved in mortality.</p>
IPIC	<p>A valuable national resource for the collection and surveillance of poisoning cases.</p> <p>The only national poisoning registration system in Israel.</p> <p>A real-time surveillance system to assist public health.</p> <p>A useful tool to conduct clinical research, training guidance, and identifying chemical/bioterrorism incidents.</p> <p>Support regulatory actions (e.g. prompt product reformulations, repackaging, recalls, and bans).</p> <p>Contribute to post-marketing surveillance, and monitor the implications of marketing of over-the-counter (OTC) medications.</p> <p>Equipped with text-based search and retrieval tools (e.g. Toxnet).</p>	<p>It is a passive reporting system.</p> <p>It only reflects the information provided by the caller.</p> <p>Some cases of exposure may not be reported.</p> <p>The severity of the patient's condition is assessed at the time of consultation, not at the peak effect, so it is possible to show the severity less than the actual level.</p>

Table 5. The main processes of included registries

Registries	Registries Process							
	Case Finding	Data Gathering		Data Quality Control Procedures		Reporting		Follow-up
		Data Gathering Tools	Responsible	Quality Control Procedure	Data Quality Criteria	Reporting Method	Report Users	Main Reported Indicators
TESS	The cases are reported to poison control centers by parents or patients and health professionals	A standardized report form, Computerized data collection programs	Toxic information specialists (nurses, pharmacists) collect data on the phone	Checking for invalid, missing data, or having excessive use of 'unknown' coding options	Consistency, Completeness, Accuracy	Annual reports, papers	The pharmaceutical industry, regulatory agencies, researchers, lawyers, media, poison control centers	Prevalence and incidence of the disease, indicators of poisoning (the type of exposure, cause of exposure, route of exposure, the reason for exposure, duration of exposure, number of substances involved in the exposure, adverse drug reactions (ADRs), and most common drugs associated with ADRs), medical outcomes, treatment procedures, indicators related to clinical effects (signs, symptoms, or laboratory abnormalities), mortality causes and rate.
NPDS	Through self-reported contacts and reports submitted indirectly to poison control centers (by the coroner, medical examiner, or other)	Electronic medical record systems	Healthcare professionals (medical and clinical toxicologists, registering nurses, pharmacists, physicians, and assistant physicians collect data over the telephone.	Checking for duplicate, mandatory data fields, anomaly detection	Integrity, Consistency, Completeness, Accuracy	Annual reports, papers, Update briefs	Health care professionals, researchers, public health agencies, regulatory agencies, pharmaceutical, and consumer goods companies, poison control centers	Prevalence and incidence of the disease, indicators of poisoning (the type of exposure, cause of exposure, route of exposure, the reason for exposure, duration of exposure, number of substances involved in the exposure, adverse drug reactions, and most common drugs associated with ADRs), medical outcomes, treatment procedures, indicators related to clinical effects (signs, symptoms, or laboratory abnormalities), mortality causes and rate.
TOXIC	Evaluating the patients by medical toxicologists in bedside or clinic	Online data collection form (a Case Report Form (CRF))	Medical toxicologists assess patients in person and collect data	Checking for missing, irrelevant, incorrect data	Accuracy, Completeness, consistency	Reports, papers, Published abstracts	Health care professionals, health agencies, trainees, and researchers in the field of toxicology, poison control centers	Prevalence and incidence of the disease, indicators of poisoning (the type of exposure, cause of exposure, route of exposure, the reason for exposure, duration of exposure, number of substances involved in the exposure, adverse drug reactions, and most common drugs associated with ADRs), medical outcomes, treatment procedures, indicators related to clinical effects (signs, symptoms, or laboratory abnormalities), mortality causes and rate.

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IPIC	Through self-reported calls by people and health care professionals to poison control centers	An electronic comprehensive structured form ("Medical toxicological record")	Healthcare professionals (most of whom are internal medicine, pediatricians, and clinical pharmacologists receiving additional training in clinical toxicology), trained nurses, and secretaries collecting data on the telephone.	Auditing the toxicological medical records	Comprehensive, Accuracy	Annual reports, papers	Health care professionals, public health agencies, regulatory agencies, pharmaceutical and consumer good companies, researchers, poison control centers	Prevalence of the disease, indicators related to poisoning (the type of exposure, exposure causes, route of exposure, the reason for exposure, duration of exposure, number of substances involved in the exposure, clinical severity of exposure), medical outcomes, treatment procedures, indicators related to clinical effects (signs, symptoms, or laboratory abnormalities), mortality causes and rate.

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The minimum data set is among the main requirements for successful registry programs [39]. Minimum data set development is the starting point to overcome the data variations among poison control centers. It leads to standardization and effective data management by providing uniform data elements, resulting in improved quality of care and cost control. Therefore, a logical, scalable, and flexible structure of data elements is a necessity to improve information quality [40]. The requirements for developing a successful national registry respecting auditory implants included the agreement on the registry data set. It is a significant challenge; the consensus on a registry data set is a fundamental challenge. Thus, we should involve the views of relevant stakeholders and patients and consider their needs to address this challenge [41].

Other features of poison registers have a strong coding and terminology system and sharing data with other registries. Cummins et al. [42] aimed to design a structural process for the cooperation and exchange of health information between emergency departments and poison control centers. The relevant data indicated that among coding systems and clinical terminology, Logical Observation Identifiers Names and Codes (LOINC), Systematized Nomenclature of Medicine-Clinical Terms (SNOMED-CT), and Data Elements for Emergency Department Systems (DESS) had higher coverage (50%-60%) for information exchange. This study recommended exchanging health information between the

emergency department and poison control centers using encoded data based on standard clinical terminology systems; it is necessary to define terms, information models, and value sets.

Del Fiore et al. identified a set of data standards to establish a health information exchange process between the emergency department and poison control centers in the USA. Their results suggested that information sharing between the emergency department and poison control centers can be standardized using the Health Level Seven Clinical Document Architecture (HL7 C-CDA), with important and positive implications for public health. Data exchange standards, like HL7, are a solid foundation for the integration and interoperability of information systems [43].

Another feature of studied registers was its attention to patient information confidentiality. The TOXIC registry follows Health Insurance Portability and Accountability (HIPAA). It aims to maintain patients' confidentiality and privacy; it is impossible to identify them through information, such as name, date of birth, medical record number, and the type of service received. Additionally, the patient has a TOXIC code identified by the medical toxicologist who uploaded the case to the registry [44]. Although easy access to the registry is essential, data privacy should be maintained, and data should be securely stored and not shared without proper permission. Data

dissemination should also be based on a shared agreement, specifying the safety and using the data [26]. A study suggested that the knowledge of local, national, and international regulations in the registry design would maintain and guarantee patient privacy [24].

Other features of current registries were their equipment with various tools and technologies, such as GIS, warning systems, search and text retrieval tools, and so on. Poison registry equipment with a GIS will help identify the high-risk region, better plan in the healthcare arena, such as locating facilities and service centers [45]. With geographical analysis capabilities, Drug Overdose Fatality Surveillance (DOFSS) data in Kentucky can be specifically tailored to individual communities' needs [10].

Using the warning systems in poison registries can be a starting point for public health interventions. Some of their applications include drug abuse warnings, drug interactions, drugs' adverse effects, and contaminated food or product recalls [30, 46].

Registries equipment with search and text retrieval tools will also help in cases, like open-source fields, used in some registries, including TOXIC (to provide more details or additional information) and may not be easily searchable [47].

Registry features (limitations)

One of the common limitations in studying registries was the registry data to not represent the entire population of poisoned patients or all exposure cases. The registries in question were a database for poison control centers; thus, these centers played an essential role in case management. Besides, poisoning cases were reported to these centers. Some studies have stated that the reason for these limitations was the unawareness of subjects about the services, capabilities, and capacities of poison control centers. In general, the region's population, distance to poison centers, fluency in English, and race can be critical reasons for these limitations. It is recommended to increase public knowledge about poison centers and their role in society and strengthening outreach activities to remove the language and culture barriers [48]. Some other limitations refer to the processes performed in the poison registries that we have addressed them.

Registry processes

Case finding: The ToxIC registry cases were identified through patient evaluation by medical toxicologists at the bedside or clinic. In other registries, cases were iden-

tified through self-reported contacts by patients, their families, and healthcare professionals. This case finding method led to limitations, including the non-verification of each poison control center's report. Some differences between ToxIC and NPDS registries were due to the identification and reporting of exposure cases, directly affecting data quality. However, the ToxIC registry is much smaller than the NPDS; its data quality is very high. This is because the cases are identified and entered into the database through medical toxicologists [49]. Magalhaes et al. [50] documented no reports of exposure and incomplete data in the National Toxicological Information System (SINITOX). This was due to a lack of specialist awareness and inadequate understanding of the importance of reporting poisoning cases.

Some registries used incentive mechanisms to identify and report all exposure cases. In the DEET registry (DEET is the major component of most topically applied insect repellents used in the US), in addition to informing and reporting cases by poison control centers, registry information is inserted in professional journals and newsletters to encourage physicians to report possible events [51]. Therefore, it is recommended to identify cases by assessing toxicologists at the bedside or clinic in the first place. There should be information and incentive mechanisms for individuals and healthcare professionals to report exposure cases in the second place.

Data gathering and abstracting: All surveyed registries used electronic forms to collect the necessary data. The TOXIC registry was used an electronic case report form to record information. Although paper or electronic Case Report Forms (CRFs) can be used, electronic CRFs offer the advantages of automatic validation checks. They do not require the transfer of data from paper to electronic databases [52]. TESS and NPDS registries used the same data collection forms, and IPIC used complete structured forms. In addition to assisting to produce more valid data for better analysis of poisoning cases, using standard forms provides a uniform understanding among healthcare professionals [53]. The WHO IPCS INTOX also has a standard poisoning report form that can be applied by poison control centers [2]. In general, using standard data gathering and abstracting forms increases data quality, especially the completeness and accuracy of data [54].

The examined registries' results indicated that data gathering is usually conducted via phone and by the specialists of poison control centers, including specialists in toxicology, pharmacists, physicians, assistant physicians, nurses, and trained secretaries. Different individu-

als work in these centers; therefore, it is essential to pay attention to appropriate team knowledge and training [53], financial incentives, and mandatory fields to maximize data completion [26, 41]. Data collection in poison control centers is performed via phone. Moreover, the experiences of other countries in using web-based systems, such as TOXBASE in the UK [55] and DATATOX in Brazil [56] revealed that Web-based systems are beneficial in managing the calls of poison control centers. However, they cannot completely replace phone information; they are complementary to phone systems. Thus, due to the high volume of phone calls in poison control centers, using phone methods are helpful along with web-based data entry.

Quality control: In all reviewed registries, continuous quality control processes are performed to ensure accuracy, completeness, consistency, and integrity. In NPDS, automatic data edition checks are performed when loading and closing cases to ensure that mandatory data fields are collected and the data is consistent. Additionally, each regional poison control center provides an independent quality control program to ensure the accuracy of medical records [57]. Given the importance of quality information in decision-making and better performance of quality assurance activities, there must be consistency among databases concerning identical data collection methods, data definition, as well as data sharing, and reporting. Moreover, quality assurance activities require training, support, and budget allocation [58, 59]. Besides, applying competitive mechanisms among poison control centers, like having a minimal quality factor level required for poison center certification, can also improve the quality activities of poisoning programs [36].

Reporting: The obtained results revealed that the reports in the registries are used for various purposes in the form of articles, summaries, and periodic reports for multiple individuals and organizations. Such settings include poison control centers, the pharmaceutical industry, legislative agencies, interns, researchers, lawyers, media, healthcare professionals, public health agencies, pharmaceutical, and consumer goods companies. Annual reports, at the national level, are often used in research on describing the poison exposure models. These reports also help private donors implement policies based on the safety of their products [60]. In general, reports should be based on organizations' goals, activities, and needs within the framework of collected data and processed indicators. To improve the processing power of registries, key indicators should be considered by identifying key stakeholders' data needs [61].

Follow-up: In the reviewed registries, follow-ups were usually conducted via telephone to determine medical outcomes, monitor cases' progress, provide recommendations, and collect information. In other poisoning information systems, such as DATATOX and DEET, where one-year follow-ups are conducted using phone interviews [51], follow-up aims to monitor and obtain further data on exposure cases. Gathering long-term follow-up data is often an important step in the registry goals; it is an essential component of the disease registry, usually for one year [62]. Therefore, due to the duration of the follow-up process and increasing patients' motivation to participate in registry programs, patient satisfaction and representatives of the patient group should participate in the registry from the very beginning [63]. Moreover, a systematic review on the characteristics of a successful registry revealed that patients who insert their data through the electronic patient portal could participate in the data collection and long-term follow-up process [26]. Therefore, it seems that, using self-management tools, like the electronic patient portal cause more patient participation in registry processes, like follow-up.

The present study was limited to articles related to the poisoning registry; therefore, the websites related to the poisoning registry in different countries were not examined. It is suggested to examine the poison registry websites in different countries in future work to provide more experiences related to the poison registry's features and processes, in addition to articles.

5. Conclusion

To design and develop poison registries, it is necessary to pay attention to the registry's main features and processes. Poison registries should have a minimum data set to effectively manage the data. It is necessary to pay attention to the relevant stakeholders' opinions and needs to achieve the minimum agreed data set. Integration and interoperability with other data sources were the objective and mission of poison registers. Using coding and terminology systems and data exchange standards are necessary for this purpose. Using mechanisms to keep patients' information confidential and their trust and participation should be considered in registry programs. Equipping the registry with various technologies, such as GIS and warning systems will help better manage poisoned patients. Poison registries should have an appropriate case-finding mechanism; the ability to collect and summarize the required data; periodic and continuous evaluations of data quality; comprehensive and appropriate reports to the target; competent individuals and organizations, and periodic follow-up of patients.

It is recommended to use educational, informational, incentive, competitive, participatory, and motivational mechanisms between all organizations and individuals involved in poisoning registry programs, including patients and healthcare professionals. The needs and views of registry stakeholders, support, and budget allocation for registry applications, using uniform and standard electronic forms, and web-based data collection methods should also be considered alongside telephone methods.

Ethical Considerations

Compliance with ethical guidelines

All ethical principles were considered in this article.

Funding

The paper was extracted from the PhD. Thesis or extracted from a research project of the first author, Department of Health Information Technology and Management Faculty of Allied Medical Sciences, Shahid Beheshti University of Medical Sciences.

Author's contributions

Conceptualization and Supervision: Azam Sabahi and Farkhondeh Asadi; Methodology: Azam Sabahi and Farkhondeh Asadi and Shahin Shadnia; Investigation, Writing – original draft, Writing – review & editing, Data collection, and Data analysis: All authors.

Conflict of interest

The authors declared no conflicts of interest

Acknowledgements

This study was a part of a Ph.D. project conducted at Shahid Beheshti University of Medical Sciences (Tehran, Iran).

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