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Original Contribution

webPOISONCONTROL: can poison control be automated?☆,☆☆,★

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ABSTRACT

Background: A free webPOISONCONTROL app allows the public to determine the appropriate triage of poison ingestions without calling poison control. If accepted and safe, this alternative expands access to reliable poison control services to those who prefer the Internet over the telephone. This study assesses feasibility, safety, and user-acceptance of automated online triage of asymptomatic, nonsuicidal poison ingestion cases.
Methods: The user provides substance name, amount, age, and weight in an automated online tool or downloadable app, and is given a specific triage recommendation to stay home, go to the emergency department, or call poison control for further guidance. Safety was determined by assessing outcomes of consecutive home-triaged cases with follow-up and by confirming the correct application of algorithms. Case completion times and user perceptions of speed and ease of use were measures of user-acceptance.
Results: Of 9256 cases, 73.3% were triaged to home, 2.1% to an emergency department, and 24.5% directed to call poison control. Children younger than 6 years were involved in 75.2% of cases. Automated follow-up was done in 31.2% of home-triaged cases; 82.3% of these had no effect. No major or fatal outcomes were reported. More than 91% of survey respondents found the tool quick and easy to use. Median case completion time was 4.1 minutes.
Conclusion: webPOISONCONTROL augments traditional poison control services by providing automated, accurate online access to case-specific triage and first aid guidance for poison ingestions. It is safe, quick, and easy to use.

1. Introduction

With an estimated 4 million US poison exposures annually [1], poison control telephone guidance prevents unnecessary emergency department visits and reduces health care expenses [2–9]. To maximize service benefits, the public must know to call and be willing to in an emergency. However, public access to health information is changing. In 2013, 83.8% of US households owned computers and 72% of Internet users looked for health information online [10,11]. Furthermore, 64% of Americans own smartphones and 62% of owners use their phone to obtain health information [12]. The shift toward online services is a worrisome trend because of inaccurate, even unsafe, poison exposure guidance on the Internet.

This analysis assesses the feasibility, safety, and public acceptance of a new Web-based poison control application—webPOISONCONTROL.* If successful, the application has the potential to improve public access to accurate poisoning information, reduce poison center operating expenses by diverting cases to an automated app, increase poison center efficiency by minimizing the time required to reach a triage decision, and harmonize triage practices across the United States.

2. Methods

webPOISONCONTROL is both an online application available at www.webpoisoncontrol.org (click the orange "HELP ME with a possible poisoning" button) and a downloadable mobile app (Fig. 1) available on the App Store and Google play. The app guides the user through questions to provide a triage recommendation for a poison ingestion. The user confirms that the exposed individual is 6 months to 79 years of

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* webPOISONCONTROL® is a registered trademark of the National Capital Poison Center.

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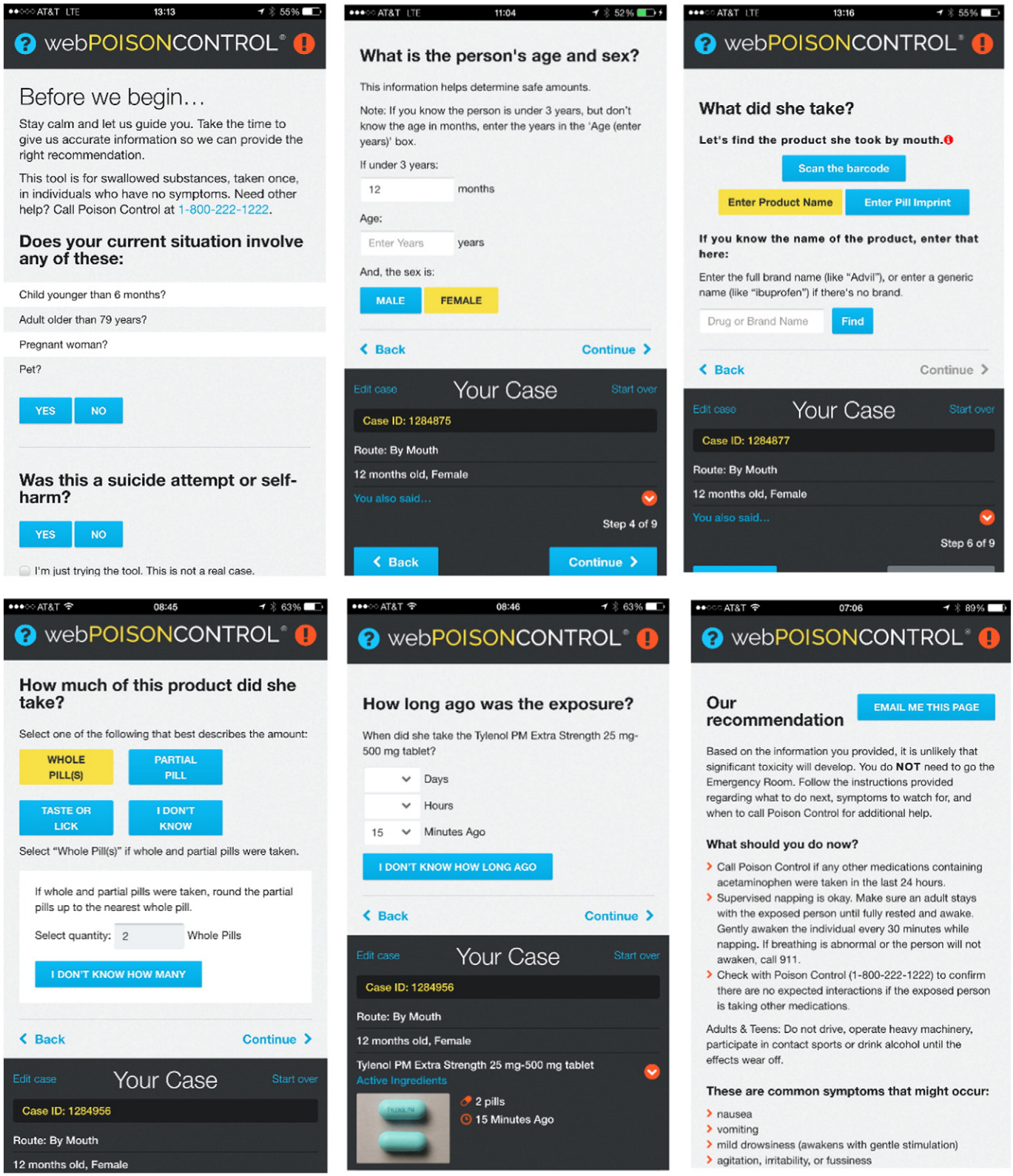

Fig. 1. The webPOISONCONTROL app.

age, not pregnant, not a pet, not suicidal, asymptomatic; swallowed only one substance; and has no underlying serious illnesses. Next the user enters age, sex, product or substance name, amount swallowed, weight (if needed), and time since ingestion. Geolocation is determined to make the case available to the appropriate poison center should further guidance be required. Users may opt to provide an e-mail address to participate in automated follow-up and receive a copy of the recommendations.

webPOISONCONTROL is powered by more than 1200 ingredient-specific algorithms developed by toxicologists and used by 8 participating poison centers. Participating centers also assist in algorithm development and play a critical role in their continued refinement. Each

algorithm delineates age- or weight-based triage thresholds, threshold justifications, likely minor symptoms, symptoms that require further medical evaluation, home treatment, symptom onset and duration, automated follow-up times, and a risk window. Both public user and poison center triage thresholds are specified, the latter often higher than user thresholds. Algorithms are matched to substance ingredients in a growing database currently containing 41 000 products and 179 000 barcodes (mobile app users can scan the product container). A follow-up module captures subsequent actions and symptoms for cases triaged to stay home and provides additional triage recommendations if applicable. Participating poison centers have Web access to view algorithms and local cases and can use "Calculate It for Me" to determine the appropriate triage for cases reported by phone.

webPOISONCONTROL was launched on December 30, 2014, as a pilot project. This analysis includes consecutive nonduplicated public cases (no demo cases) reported from February 11, 2015 (when the option to mark demo cases was implemented), through February 25, 2016. Excluded duplicate cases met these criteria: (1) age match, (2) temporal proximity (<24 hours), (3) similar substance, and (4) identical reporting IP or e-mail address.

Case data, collected in SQL, were analyzed with webPOISONCONTROL reports and dashboard. Case data are captured using applicable National Poison Data System (NPDS) fields and definitions, including NPDS outcomes (defined elsewhere) [13]. Cases triaged to home were assigned an outcome of "unknown, minimally toxic" until follow-up was provided, although some would have been coded as "unknown, nontoxic" in NPDS. If follow-up occurred, the outcome was automatically changed to a definitive outcome (no effect, minor, moderate, major, or death) based on symptoms and severity.

Feasibility and user acceptance were assessed through methods already implemented to guide software enhancements, including links to a voluntary survey. Case completion time was determined from app opening to recommendation determination, excluding cases with a pause greater than 10 minutes.

Changes to the user experience, substances implicated, and triage recommendations during the pilot period may have been affected by continued development of the app. The critical and ongoing changes included (1) addition of products, especially household products; (2) addition of algorithms; and (3) raising of triage thresholds in response to expert feedback that the thresholds were too low.

Safety was assessed through daily toxicologist quality assurance review of each case. The toxicologist manually confirmed each ingredient calculation and recommendation. User-provided follow-up information was also reviewed.

National Poison Data System data were obtained to compare follow-up rates. Nonsuicidal, non–food poisoning, ingestion cases managed onsite were used from NPDS to provide a comparable data set. US census data (July 1, 2015 estimates) and linear regression were used to compare app utilization by state.

This study was approved by the institutional review board after expedited review.

3. Results

Of 10 165 consecutive, public webPOISONCONTROL cases, 9256 were included (Fig. 2). US users comprised 86.3% of cases (7986), including cases from all states and the District of Columbia. The number of cases per state was proportional to population (linear regression, $R^2 = 0.90$). The 1270 international cases (13.7% of all cases) were from 86 countries, including overseas US military. Canada (450), the United Kingdom (363), and Australia (96) were the most frequent. Where time of ingestion was known (90.0%; 8330 cases), 67.7% (5638) reported in less than 30 minutes, 80.4% (6700) in less than 60 minutes, 82.0% (6827) in less than 2 hours, and 86.8% (7233) in less than 3 hours.

Children younger than 6 years were involved in 75.2% of cases (Table 1); 32.5% of all cases were 1 year of age and 50.7% were either

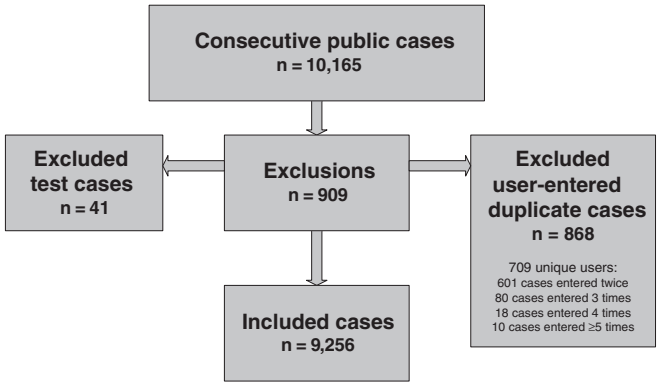

Fig. 2. Case flow diagram.

1 or 2 years of age. Only 1.3% of cases involved individuals 60 years or older. Males comprised 50.4% of cases.

Pharmaceuticals were implicated in 40.5% of cases; 59.5% involved household products or plants. Only 31.4% of cases involved pharmaceuticals in children younger than 3 years, compared with 51.1% in individuals older than 12 years. Cigarettes were the leading substance in children younger than 3 years (24.7%), followed by cleaners (14.7%) and cosmetics and personal care products (12.6%). Cosmetics and personal care products were the leading substances in individuals over 12 years (14.8%, with peroxide implicated in more than half of these cases [7.9%]), followed by analgesics (12.7%), cleaners (12.2%), and essential oils (7.6%).

Of the 9256 cases, 6787 (73.3%) were advised that it was safe to stay home and given treatment recommendations and a list of likely symptoms of little concern and more worrisome manifestations which would necessitate a call to poison control or an emergency department visit. Users were advised to call poison control immediately in 2272 cases (24.5%) and referred to an emergency department in 197 cases (2.1%). It is not known what percent of cases referred to poison control were eventually managed at home or in an emergency department.

Of the 6787 cases triaged to home, 2118 cases (31.2%) had follow-up information logged by the user. For these 2118 cases, there were 3561 follow-ups done; 51.9% provided 1 follow-up, 32.1% provided 2, 12.8% provided 3, and 3.2% provided 4 to 6 follow-ups.

Most cases (82.3%) triaged to home with follow-up had no effect (Table 2); minor effects were seen in 10.4% and moderate effects in 1.4%. No major effects or deaths were reported. The systematic toxicologist review of all 9256 cases demonstrated 100% algorithm adherence and uniformly correct calculations.

Table 1
Age distribution

	Count	%	Cum total	Cum %
6-11 mo	1080	11.7	1080	11.7
1 y	3004	32.5	4084	44.1
2 y	1693	18.3	5777	62.4
3 y	742	8.0	6519	70.4
4 y	296	3.2	6815	73.6
5 y	148	1.6	6963	75.2
6-12 y	372	4.0	7335	79.2
13-19 y	422	4.6	7757	83.8
20-29 y	587	6.3	8344	90.1
30-39 y	381	4.1	8725	94.3
40-49 y	219	2.4	8944	96.6
50-59 y	191	2.1	9135	98.7
60-69 y	98	1.1	9233	99.8
70-79 y	23	0.2	9256	100.0
Total	9256			

Table 2
Outcome for cases triaged to stay home

Outcome	Cases triaged to home with follow-up		All cases triaged to home	
	No.	%	No.	%
No effect	1744	82.3	1744	25.7
Minor	220	10.4	220	3.2
Moderate	29	1.4	29	0.4
Major effect	0	0.0	0	0.0
Death	0	0.0	0	0.0
Unknown, nontoxic or minimally toxic	25	1.2	4694	69.2
Confirmed nonexposure	100	4.7	100	1.5
Total	2118	100.0	6787	100.0

Symptoms were reported in 11.9% of 2118 cases triaged to home with follow-up. Vomiting (61 cases), diarrhea (44), drowsiness or lethargy (44), nausea (44), abdominal pain (32), mouth or throat irritation (19), headache (12), and dizziness (11) were the most common.

Twenty-six cases initially triaged to home (1.2% of 2118 home-triage cases with follow-up) had a changed triage recommendation on follow-up, with a subsequent deliberately cautious recommendation to call poison control (21 cases) or go to an emergency department (5 cases).

Of the 2118 home-triaged cases with follow-up, 2047 (96.6%) stayed home. Despite a recommendation that it was safe to stay home, 152 (7.2%) called poison control anyway. Of those with follow-up who used the app and also called, 90.1% stayed home; only 1 reported going to an emergency department. Twelve of all home-triaged cases with follow-up went to an emergency department and were treated and released and 2 were admitted to a hospital. The 2 admitted cases included the following:

- An 8-year-old ingested an attention-deficit hyperactivity disorder drug and was admitted for tachycardia (rate in the 130's, resolved within 32 hours).
- An adult ingested levothyroxine and developed hypertension.

The median time to complete the app was 4.1 minutes. A recommendation was received in less than 5 minutes in 66.9% of cases and less than 10 minutes in 96.1%.

During the pilot period, 1339 online feedback survey respondents had used webPOISONCONTROL for a poison emergency, and 97.3% of respondents found it easy or somewhat easy to use; 91.3% found the time to get a recommendation was quick or very quick; and 95.8% found it met or more than met their needs. Of survey respondents, 183 (13.7%) also called poison control, with 67 (37%) calling poison control first then using the app and 114 (62%) calling poison control after using the app. Of the 114 who called after using the app, 68% (77) were advised to call by the app; others still had questions or wanted to talk to a live expert.

Of survey respondents using the app for a poison emergency, 85.8% were 20 to 49 years of age (30.7% in their 20s, 41.6% in their 30s, 13.5% in their 40s) and 85.1% were female. Nearly two-thirds (64.8%) of respondents used webPOISONCONTROL on a mobile device.

>Recurring survey comments revealed that users especially liked the ease of use, simplicity, speed, helpfulness, and convenience. Not having to call was repeatedly cited as an advantage. Other most liked features included the following: specific tips; personalized, step-by-step approach; privacy and anonymity; reassurance; trusted and accurate information source; written information to refer back to; international access when abroad; and follow-up e-mails. Least liked features included inability to find the exact product, guidance limited to ingestions and one-time exposures of a single product, no human interaction or opportunity to ask questions, page load delays, and concern that the user was unaware of the app or that it was hard to find.

4. Discussion

Our analysis demonstrates that poison help can be provided through an automated application. Most convincingly, the app was launched and used; 9256 users found the site, although there was little promotion, and completed the app to receive a recommendation. A third of users triaged to home provided follow-up data through the automated follow-up module, at intervals after the ingestion. The median time to get a recommendation was only 4.1 minutes, similar to the time required for a telephone call to a US poison center [14].

webPOISONCONTROL provides safe triage guidance in a poison emergency. Toxicologist case review showed uniformly correct dose calculations and appropriate triage recommendations. The app delivered consistent recommendations and uniform algorithm adherence—phenomena not observed in traditional poison centers because of variability between centers with differing guidelines, lack of guidelines, and individual deviation from established guidelines where they exist [15,16]. Safety was also demonstrated through automated follow-up, with 82.3% of followed, home-triaged cases having no effect. No major or fatal outcomes were reported through follow-up of this home-triaged group. Although webPOISONCONTROL follow-up was only completed in 31.2% of cases triaged to home, this rate is comparable to that observed in traditional poison centers where 30.0% of single-substance, nonsuicidal ingestions managed onsite without health care intervention were followed in the first 5 months of 2015.[†]

User acceptance was remarkably positive, with 91.3% of users seeking help in a poison emergency finding the app quick or very quick, and 97.3% finding it easy or somewhat easy to use.

Several interesting differences between online cases and traditional phone-based poison control cases emerged. Online cases were younger, with 75.2% of cases involving children younger than 6 years (62.4% <3 years), compared with 46.9% younger than 6 years (35.1% <3 years) for traditional poison control cases handled by telephone throughout the United States during the same period [17]. We suspect that this difference reflects the greater appeal of an online solution to the age demographic of the parents of these young children with a corresponding lesser usage by older adults. The distribution of substances also differed. For example, cigarette ingestions comprised 24.7% of online cases younger 3 years but were implicated in only 0.9% of traditional poison control cases in that age group during the same period [17]. This difference demonstrates the unpredictable impact of search engines on webPOISONCONTROL use, as a single online article proved to be the major referral source for cigarette cases.

Remarkable similarities were observed when online cases were compared with cases reported by telephone. Both achieved follow-up in a similar percentage of home-triaged cases, and both managed most cases at home, without health care facility referral. During the same period, traditional poison centers managed 67.2% of cases onsite [17]. At least 73.3% of online cases were managed onsite. Only 2.1%

[†] National Poison Data System (NPDS) data on follow-up rates were provided on 7–21-2015 by the American Association of Poison Control Centers. See the NPDS Disclosure Statement.

were known to have been referred to an emergency department, and of the 24.5% advised to call a traditional poison center, the percent eventually managed onsite is not known. As with traditional poison centers, webPOISONCONTROL referrals are dynamic and responsive to changes in the individual's condition. Of individuals initially triaged to home (with follow-up), 1.2% were later directed to call poison control or go to an emergency department.

The cost-effectiveness of traditional poison centers has been established through at least a dozen investigations over several decades, with a 2012 report pegging the return on investment at $13.39 per dollar spent on poison control services [9]. That savings predominantly reflects decreased health care cost realized by avoiding unnecessary emergency department visits. The high rate of home management of poison exposures by webPOISONCONTROL and the low marginal cost suggest that if volume increases, the app has the potential to be even more cost-effective than traditional poison centers. Unlike a traditional poison center, the application's capacity is not dependent on hiring additional personnel.

webPOISONCONTROL is not a replacement for traditional poison control centers. Instead, it augments their services by providing another way to access expert guidance. A quarter (24.5%) of app users were directed to call poison control for further guidance and a definitive recommendation. webPOISONCONTROL cannot handle complex cases, symptomatic exposures, routes other than ingestion, chronic exposures, suicidal cases, cases involving multiple products, pregnant individuals, or cases that require referral to a health care facility. Although minor symptoms and other routes may be handled in future versions, even with enhancements, the app can only target clinical situations that are amenable to algorithms. Its use is also limited to a specific target audience—those who prefer to use an app rather than call, even in a stressful situation. Furthermore, in its present form with no chat capabilities, app users cannot ask more questions or explore the nuances of an exposure, such as “what if he swallowed twice as much?” Interestingly, 7.7% of online users worked around this limitation by reentering the case to explore a slightly different dose or other small case variation. It is remarkable that these users chose to reenter their case rather than call, although the poison control number was prominently displayed.

webPOISONCONTROL shows promise as a tool to enhance our current poison control system. With additional refinement and increased public awareness of the availability of a reliable online triage tool for poison exposures, webPOISONCONTROL may eventually offload a significant number of ingestions from traditional, personnel-intensive telephone-based poison centers, possibly minimizing the cost and resources required to provide a robust poison control system. The app offers features not currently provided by traditional poison control, such as comprehensive written recommendations on the user's screen and by e-mail. Traditional poison centers provide only verbal instructions to the public. webPOISONCONTROL also offers barcode product entry, making product identification easier and more accurate. Furthermore, the app brings poison control services to a segment of the population that may not find those services accessible when they are only provided by telephone. These individuals may prefer an online solution because of an ingrained habit of using electronic resources, lack of cell or phone service, perceived greater anonymity, impatience with telephone queues, and a fear of being “judged” or embarrassed.

webPOISONCONTROL also has the potential to harmonize poison exposure triage. To reduce the tremendous variability in triage practices [15], 17 US national triage guidelines were published from 2003 to 2008, but address only 107 ingredients [18–34]. Most substances are not covered by national guidelines, and most poison centers have only a limited set of additional site-specific guidelines; thus, there is a high degree of triage variability both between and within centers and considerable time spent reassessing toxicity each time an exposure occurs. webPOISONCONTROL operates on an ever-expanding set of triage algorithms—currently more than 1200. As more poison centers adopt these guidelines and as more users find the app, harmonization of triage guidelines has the potential to minimize conflicting recommendations and patient confusion, improve staff efficiency (eliminating duplicate efforts to develop guidelines and time spent reassessing toxicity when no guideline exists), and continue to reduce unnecessary emergency department visits. In addition, participating centers have noted more efficient training of new Specialists in Poison Information because of the large number of guidelines.

5. Study limitations

Whether handled by telephone by a traditional poison center or triaged online, outcome data are limited by incomplete follow-up. Just as with traditional poison centers, there could have been additional patients triaged to home who self-referred to the emergency department or were admitted to a hospital but did not use the follow-up module to document their subsequent clinical course. However, the follow-up rate for our home-triaged cases was similar to that of traditional poison centers. The distribution of substances implicated in the reported poison ingestions was distorted by several factors, including (1) the gradual rollout of nonpharmaceutical products and algorithms during the pilot period, and (2) the reliance on browser-based search engines to direct Internet traffic to the site. The survey response was low so it is possible that aggregate responses do not completely reflect the experiences of the user population.

6. Conclusion

It is possible to automate many traditional features of poison control. webPOISONCONTROL augments traditional poison control services by providing automated, online triage and first aid guidance in a poison ingestion emergency for those who prefer not to call. A review of each case recommendation, follow-up outcome, and symptoms shows the app is safe. More than 91% of users found the tool quick and easy. webPOISONCONTROL development is ongoing, focusing on additional enhancements and expanded scope. We urge health professionals and safety advocates to promote the webPOISONCONTROL site so those who prefer not to call will have access to accurate guidance for a poison ingestion.

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