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ORIGINAL RESEARCH

Mushroom intoxications presented to emergency departments in South Korea: a 2011-2019 national registry study

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Abstract

This study aimed to investigate the association of characteristics and clinical outcomes of patients who presented with mushroom intoxication. We conducted a retrospective study of mushroom intoxication cases using national registry data (representative of the period 01 January 2011 to 31 December 2019). Specifically, we analyzed the demographics, vital signs, mental status, intoxication related factors, and clinical presentations of the patients. The outcomes were assessed based on general ward admission, intensive care unit (ICU) admission, length of hospitalization, and mortality. The *t*-test or chi-square test were used to compare the emergency department (ED) discharge group and admission group. Logistic regressions were used to predict patients that were high-risk with regards to being admitted. A total of 393 patients with mushroom intoxication were presented at the ED, and the highest number of visits occurred in the month of September. Overall, 277 (70.5%) patients were discharged from the ED and 116 (29.5%) patients were admitted. Of these, 25 (6.4%) patients were admitted to the ICU, and 3 (2.6%) patients died. Patients are more likely to be admitted to the general ward or ICU when symptoms presented after 6 h: 6 to 24 h (Odds ratio (OR) 2.158; 95% Confidence interval (CI), 1.218–3.816) or >24 h (OR: 3.382; 95% CI, 1.438–8.050). Additionally, when the patients presented with diarrhea, they were more likely to be discharged with favorable outcomes with a less likelihood for admission (OR: 0.237; 95% CI, 0.093–0.523). Most cases of mushroom intoxication presented with gastrointestinal symptoms and followed a benign course. The longer time to onset of symptoms increased the likelihood of hospitalization. Clinicians should evaluate more carefully, observe, or admit those with delayed symptom onset.

Keywords

Mushroom poisoning; Emergency department; South Korea; Podostroma; Registry

1. Introduction

Currently, over 2000 species of mushrooms have been reported; however, among these, only approximately 400 species are edible in South Korea [1]. Mushrooms are a popular food considered for the overall well-being and Koreans consume a significant amount of mushrooms. Recently, with the increasing interest in trekking or mountain climbing during the COVID-19 pandemic, intoxication due to wild mushrooms has been increasing [2]. It is difficult to distinguish edible mushrooms from poisonous mushrooms; therefore, the picking and consumption of wild mushrooms should be carefully done [3].

Mushroom intoxication accounts for a small percentage of all patients who are present to the ED. Patients may present with gastrointestinal symptoms, often severe, which in rare case progress from dehydration to multiorgan system failure and death [4–6]. From 2012 to 2017, seven South Koreans died due to mushroom intoxication [7]. In a previously published single-center research, 23 patients presented with acute liver injury due to mushroom intoxication during a 11-year period [8].

Some studies highlighted the importance of identifying non-toxic and toxic mushroom species [9]. However, at the ED, identification of mushrooms is not readily availed, if at all. Most patients do not bring the mushrooms and cooking of the mushrooms causes disfiguration which affects its identification. Analysis of the sample by the poison center is rarely performed [1]. Moreover, there are no poison centers, which can test for 'amatoxin' in South Korea, although amatoxin being the most common mushroom-related toxin in the country [10, 11].

Because the cases were rare and the incidence varied across the country, emergency physicians often lacked experience in screening for and treating severe mushroom intoxication [12]. There is limited data on the clinical presentation and outcomes of mushroom intoxication at the ED. As of now, there are only case reports or case series of adult cases in certain settings.

The aim of this multicenter observational study was to provide the clinician with epidemiological data and a description of the clinical features, predicting admission, and clinical outcomes of mushroom poisoning, which may serve as the early warning signs for addressing this disease and to optimize the available resources for its management.

2. Materials and methods

2.1 Study design

This retrospective observational study evaluated the characteristics and affecting factors of the clinical outcomes of mushroom intoxication patients presented to the emergency room. We studied nine years of the national registry.

2.2 National registry

The data were collected retrospectively from the Emergency Department-Based Injury In-Depth Surveillance (EDIIS) in South Korea. The EDIIS is a high-quality national injury registry which was initiated from 2006 that includes all injured patients admitted to the 25 EDs across South Korea. EDIIS had been developed and operated by Korea Centers for Disease Control and Prevention (KCDC). KCDC selected EDs based on the location of hospital (rural or urban), level of hospital, trauma centers, hospitals with toxicology centers, and so on. On an average, 200,000 patients with all kinds of injury visit ED and are enrolled in the registry annually. This registry includes basic demographics, prehospital data, clinical findings, diagnosis based on the International Classification of Disease 10th Revision (ICD-10), ED disposition, and patient outcomes after admission. The site coordinators collected data from the electronic medical records. Each ED has coordinators for collecting standard data, and the KCDC monitors the quality of the data on a monthly basis. The coordinators participating in the survey were expected to follow-up the outcome once more within 2 weeks of the entire missing or invalid survey target patients, and the date of diagnosis, detailed diagnosis according to ICD-10 code, surgery date, and types were listed [13, 14].

2.3 Participants

We included the records of patients who presented with mushroom poisoning from 01 January 2011 to 31 December 2019. Fig. 1 describes the patients' selection. We selected patients who presented with intoxication. Subsequently, we extracted the cases in which the poisonous material was mushroom and excluded cases in which explicit documentation regarding edible mushroom cases was present.

2.4 Measure

We investigated the patient demographics, initial vital signs, mental status, intoxication-related factors, date, and time-related information. The demographics included age and sex. Furthermore, 65 years of age was set as the cutoff point, as this age has been linked with high mortality with respect to acute poisoning [15, 16]. The vital signs included systolic and diastolic blood pressures, pulse rate, respiratory rate, and body temperature. The mental status data were described as "awake, verbal, pain, and unresponsive" on an AVPU scale. The intoxication related factors included alcohol-related factors, identity of the intoxicating mushroom, type of toxin, and symptoms. The time related factors included season, symptom onset time since ingestion, visit or discharge date, length of hospitalization. An investigation of the ICU admission cases was performed.

2.5 Outcomes

The intoxication outcomes were assessed based on the patient disposition at the ED, length of hospitalization, general ward admission, ICU admission, and mortality. Moreover, we investigated clinical outcomes based on time to symptom onset as a secondary outcome. We divided the interval from mushroom ingestion to the onset of the first symptoms of poisoning based on previous studies [9]. Thereafter, we investigated the clinical outcomes in terms of time to symptom onset as $<$6 h, 6 to 24 h, and over 24 h. Mortality is calculated by combining ED deaths and death after admission.

2.6 Statistical analysis

All continuous variables were described as the mean (standard deviation) and categorical variables as n (%). To test for normality, we performed the Shapiro-Wilk test. For continuous variables, we used the t-test or Wilcoxon rank sum test; for categorical values, we used the chi-square test or Fisher's exact test, as appropriate. We used a proportion test, or Kruskal-Wallis test and a post-hoc analysis to compare clinical outcomes between three groups from the time of symptom onset. We conducted a univariable and multivariable logistic analysis to identify factors associated with admission. We included age, sex, and several types of clinical presentations to construct a logistic regression model. We selected variables for multivariable logistic regression using the forward stepwise selection method. Finally, we selected clinically-relevant variables such as age, sex, time until symptom onset, and variables that exhibited a p-value $>$ 0.1 in univariable analysis. This was performed to apply the multivariable logistic regression model. The results were presented with an odds ratio (OR) and a 95% confidence interval (CI). For all statistical analyses, a p-value $<$ 0.05 was considered as statistically significant. Statistical analyses were performed using R Software (version 4.1.2, the R Foundation for Statistical Computing, Vienna, Austria, https://www.R-project.org).

3. Results

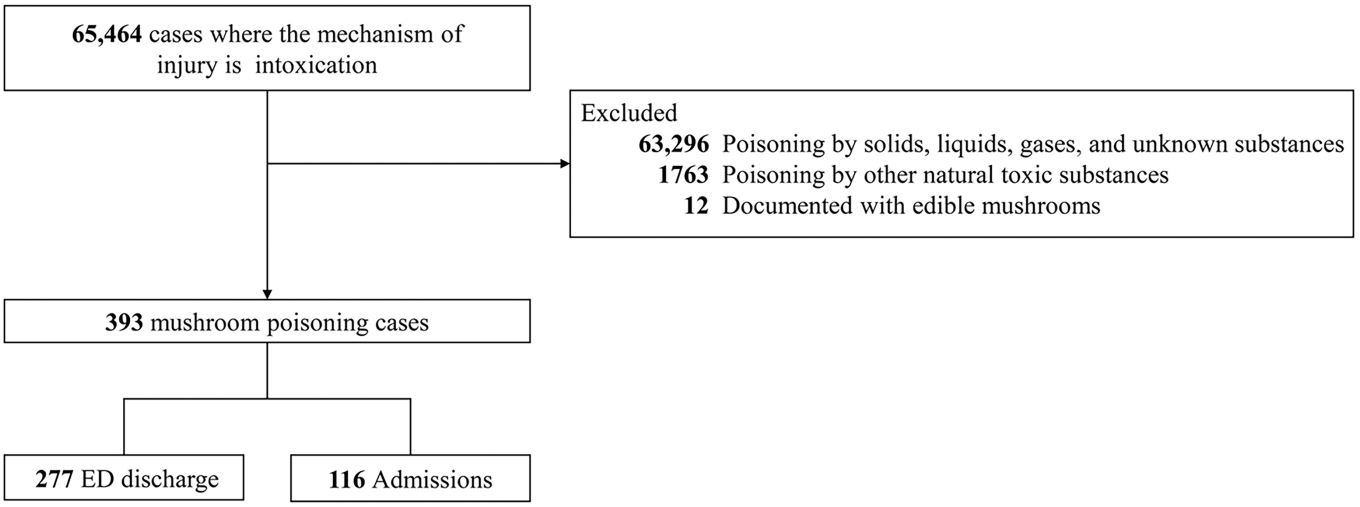

FIGURE 1. Patient selection diagram. ED, emergency department.

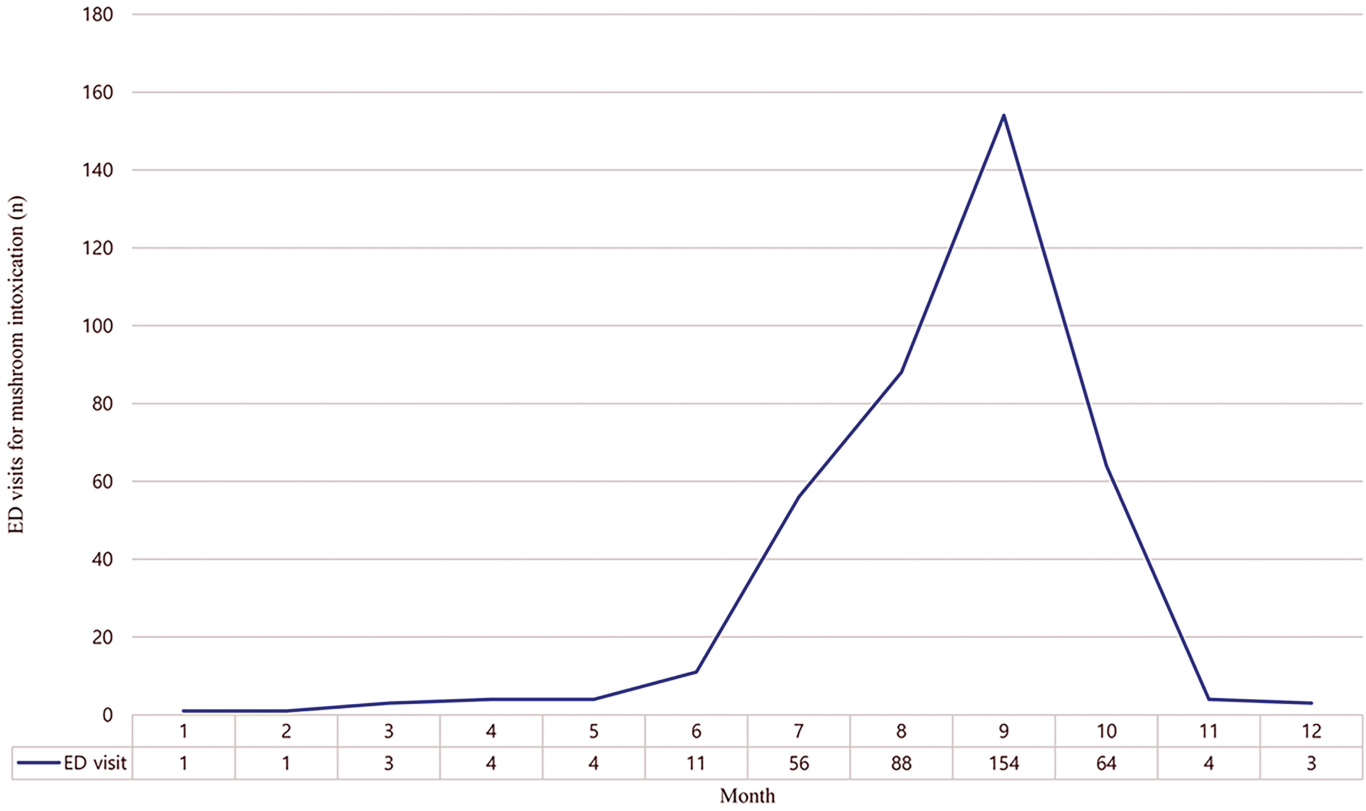

FIGURE 2. Emergency department visits for mushroom intoxication by month. ED: emergency department.

3.1 General characteristics

During the study period, 393 patients with mushroom intoxication visited the ED. Table 1 presents the general characteristics and clinical outcomes of the study population. The mean (SD) age was 56.7 (14.1) years and 51.4% were men. A majority of mushroom intoxication events occurred during the summer and autumn, comprising 95.9% of the total patients. Intoxications frequently occurred in September, that is, 154 (39.2%) cases (Fig. 2).

Most patients arrived to the ED in vehicles and only 11 (2.8%) patients arrived by walking. A total of 99 (25.2%) patients arrived through emergency medical services (EMS) and 43 patients (10.7%) used a private or hospital ambulance. Most patients presented with stable vital signs at the initial ED triage. The mean with SD of each vital sign was as follow: systolic blood pressure, 134.3 (26.2); diastolic blood pressure, 80.3 (15.6); pulse rate, 81.8 (13.8); respiratory rate, 18.9 (2.2); and body temperature, 36.5 (0.5). At ED triage, 326 (82.9 %) patients were alert (mental state), and no patients were unresponsive. Eleven (2.8%) patients presented psychiatric symptoms such as hallucination, aggressive behavior, and allergic symptoms such as skin rash (1.3%) and facial swelling (1.3%).

TABLE 1. General characteristics of the study population.

Characteristic	Overall (n = 393)	ED discharge (n = 277)	Admission (n = 116)	*p* value
Age, n (%)				
<65-year-old	288 (73.3)	215 (77.6)	73 (62.9)	0.004
≥65-year-old	105 (26.7)	62 (22.4)	43 (37.1)	
Sex, n (%)				
Male	202 (51.4)	136 (49.1)	66 (56.9)	0.099
Female	191 (48.6)	141 (50.9)	50 (43.1)	
Insurance, n (%)				
National health insurance	374 (95.2)	264 (95.3)	110 (94.8)	0.548
Medical care beneficiary	11 (2.8)	9 (3.3)	2 (1.7)	
Others[a]	8 (2.0)	4 (1.4)	4 (3.4)	
Season (months) of ED visit, n (%)				
Spring (3, 4, 5)	11 (2.8)	8 (2.9)	3 (2.5)	0.005
Summer (6, 7, 8)	155 (39.4)	94 (33.9)	61 (52.6)	
Autumn (9, 10, 11)	222 (56.5)	171 (61.7)	51 (44.0)	
Winter (12, 1, 2)	5 (1.3)	4 (1.4)	1 (0.9)	
Mode of arrival, n (%)				
EMS (119)	99 (25.2)	65 (23.5)	34 (29.3)	0.007
hospital ambulance	19 (4.8)	9 (3.2)	10 (8.6)	
Private ambulance	23 (5.9)	12 (4.3)	11 (9.5)	
Walk-in	11 (2.8)	10 (3.6)	1 (0.9)	
Others[b] and unknown	241 (61.3)	181 (65.3)	60 (51.7)	
Alcohol use, n (%)				
No evidence of alcohol use	367 (93.4)	259 (93.6)	108 (93.1)	0.809
No information available	5 (1.3)	4 (1.4)	1 (0.9)	
Alcohol use by the poisoned person	19 (4.8)	12 (4.3)	7 (6.0)	
Alcohol use by both poisoned person and other person(s) involved	2 (0.5)	2 (0.7)	0 (0.0)	
Initial vital sign, n (%)				
Systolic blood pressure <90 mmHg	7 (1.8)	1 (0.4)	6 (5.2)	0.004
Diastolic blood pressure <60 mmHg	18 (4.6)	6 (2.2)	12 (10.3)	0.001
Mean blood pressure <65 mmHg	9 (2.3)	1 (0.4)	8 (6.9)	<0.001
Pulse rate >120 beats/min	26 (6.6)	14 (5.1)	12 (10.3)	0.090
Respiratory rate >20 breaths/min	25 (6.4)	12 (4.3)	13 (11.2)	0.021
Body temperature ≥38.0 °C	2 (0.5)	0 (0.0)	2 (1/7)	0.087
Initial mental status, n (%)**				
Awake	326 (82.9)	235 (84.8)	91 (78.4)	0.002
Verbal	13 (3.3)	7 (2.5)	6 (5.2)	
Pain	7 (1.8)	1 (0.4)	6 (5.2)	
Unresponsive	0 (0.0)	0 (0.0)	0 (0.0)	
Unknown	47 (12.0)	34 (12.3)	13 (11.2)	

Abbreviations: ED, emergency department; EMS, emergency medical service; LOS: length of stay.
Others[a]; self-pay, others, and unknown Others[b]; different types of transportation (electric wheelchair, motorized vehicle, bicycle).

3.2 Clinical presentation and outcomes

Table 2 shows the clinical presentation and outcomes of the study population. Overall, 277 (70.5%) patients were discharged from the ED and 116 (29.5%) patients were admitted. Of these, 25 (6.4%) patients were admitted to the intensive care unit (ICU), and 3 (2.6%) patients died. The mean ED length of stay (LOS) was 6.4 (5.3) h. In the admission group, the mean in-hospital LOS was 3.1 (7.4) days.

Half of the patients presented with gastrointestinal symptoms. Notably, 192 (48.9%) patients presented with vomiting, over 15% patients reported nausea, abdominal pain, and diarrhea. The other symptoms that were common were neurologic symptoms (most common was dizziness or lethargy, 39 (9.9%)) and cardiology symptoms (most common was palpitation, 26 (6.6%)). Additionally, psychiatric symptoms and allergy symptoms were observed to be less frequent (under 2% of patients) and the frequency was similar between the groups.

3.3 Predicting factors to admission

The patients were more likely to be admitted to the general ward or ICU when the symptoms presented after 6 h: 6 to 24 h (OR: 2.158; 95% CI, 1.218–3.816) or over 24 h (OR: 3.382; 95% CI, 1.438–8.050). Additionally, when patients presented with diarrhea, the patients were more likely to be discharged with favorable outcomes showing less likelihood to admission (OR: 0.237; 95% CI, 0.093–0.523) (Table 3).

3.4 Clinical outcomes based on time to symptom onset

Table 4 shows the clinical outcomes according to the time to symptom onset. Notably, $\geq$70% patients with mushroom poisoning experienced symptoms within 6 h of ingestion. Eighty one (20.6%) patients presented with symptoms 6 to 24 h after consumption, whereas 32 (8.2%) patients reported symptoms over 24 h after ingestion. The rate of ICU admission was significantly different depending on the onset of symptoms. Eight of 31 (25.8%) patients who reported symptoms after 24 h were admitted to the ICU, compared to only 14 of 274 (5.1%) patients who presented with symptoms within 6 h ($p <$ 0.001). Among hospitalized patients, the LOS was increased when the symptom onset was delayed. The mean (SD) LOS for patients who reported symptoms within 6 h was 1.4 (1.3) days. However, when symptoms appeared after 6 h, the hospital stays were longer, that is, 2.3 (4.0) days in the 6–24-h group and 9.7 (15.5) days in >24-h group. Two deaths occurred in the group whose symptoms appeared between 6 and 24 h, whereas one person died in the group whose symptoms appeared after 24 h.

3.5 ICU admission cases

We conducted an in-depth investigation of 25 cases who were admitted to the ICU. Notably, 19 of the 25 (76.0%) patients were men. Only 10 cases were documented as mushroom poisoning of the following species: *Podostroma cornu-damae* (3), *Amanita* species (3), *Macrolepiota neomastoidea* (3), *Ramaria* species (1), *Maegacollybia platyphylla* (1). The hospital deaths included two cases due to *Podostroma cornu-damae* intoxication and one case from Ramaria species. Over 50% of the patients presented with vomiting as the most common symptom, followed by an altered mental status. Additional detailed data have been presented in online **Supplementary material**.

4. Discussion

We conducted 9 years of surveillance of mushroom intoxication in South Korea. To the best of our knowledge, this is the first study to address cases of mushroom intoxication presented to the EDs in South Korea. We identified 393 cases and most cases occurred during summer and autumn. Almost all the cases showed a benign course, only 25 (6.3%) cases required ICU care and 3 patients died.

Two death cases were identified as being due to *Podostroma cornu-damae* poisoning and one case was suspected with *Ramaria* species. *Podostroma cornu-damae* grow around tree stumps in summer and autumn. These mushrooms contain a toxin called trichothecene. Acute poisoning caused by trichothecene varies from gastrointestinal symptoms to epidermal exfoliation of the skin or mucous membranes at the site where the toxin has touched the skin to multiorgan failure [17, 18]. *Podostroma cornu-damae* intoxication was rare and only several reports in the literature. According to previous reports, the symptom onset was various from within 6 hours after eating mushroom to over a day. Most patients presented severe pancytopenia and desquamation on skins, multi-organ failure, and sepsis due to prolonged neutropenia over times. Only one patient was discharged on hospital day (HD) 27, other patients died on HD 6 and HD 13 due to severe pancytopenia and retractable multiorgan failure, respectively [19, 20].

All three cases due to *Podostroma cornu-damae* intoxication in this study presented with hypotension at the initial ED triage. One of them presented with allergic symptoms, such as facial swelling, dyspnea, and itching, and was discharged 5.7 days after admission. Similarly, in 2013, a case had been reported in South Korea that was confused with hypersensitivity at the initial stage and was finally diagnosed with *Podostroma cornu-damae* intoxication [21]. We suggest that physicians have to pay more attention when patients who consumed mushrooms showed allergic symptoms combined with hypotension and *Podostroma cornu-damae* intoxication should be suspected [22].

The other case of death was suspected to be due to the *Ramaria* species. *Ramaria* species are well-known edible mushrooms; however, *R. formosa* intoxication reportedly induced lethal gastrointestinal symptoms, such as diarrhea, vomiting, and abdominal pain in an animal study [23]. As the morphology is similar to that of the edible *Ramaria* species, even an expert would face difficulty in distinguishing these two species [24].

We found that some characteristics were statistically different between the ED discharge and admission groups. For example, in the ED discharge group, the most common season for ER visits was autumn, whereas summer was the most common season for the admission group. Additionally, in the admission group, more patients arrived at the ED *via* the EMS system or other ambulances than in the discharge group.

TABLE 2. Clinical presentation and outcomes of the study population.

Characteristic	Overall (n = 393)	ED discharge (n = 277)	Admission (n = 116)	*p* value
Time to symptom onset, n (%)				
<6 h	278 (70.7)	212 (76.5)	60 (51.7)	<0.001
6 to 24 h	81 (20.6)	51 (18.4)	30 (25.9)	
>24 h	32 (8.2)	13 (4.7)	19 (16.5)	
Unknown	2 (0.5)	1 (0.4)	1 (0.9)	
GI symptoms, n (%)				
Vomiting	192 (48.9)	142 (51.3)	50 (43.1)	0.261
Nausea	74 (18.8)	55 (19.9)	19 (16.4)	0.484
Abdominal pain	60 (15.3)	41 (14.8)	19 (16.4)	0.689
Diarrhea	64 (16.3)	55 (19.9)	9 (7.8)	0.007
None of symptoms	158 (40.2)	107 (38.6)	51 (44.0)	0.384
Neurologic symptoms, n (%)				
Dizziness or lethargy	39 (9.9)	28 (10.1)	11 (9.5)	0.997
General weakness	11 (2.8)	7 (2.5)	4 (3.4)	0.519
Dysarthria	6 (1.5)	5 (1.8)	1 (0.9)	0.030
Headache	11 (2.8)	7 (2.5)	4 (3.4)	0.519
Confused mentality	11 (2.8)	2 (0.7)	9 (7.8)	<0.001
Others[a]	7 (1.8)	3 (1.1)	4 (3.4)	0.878
None of symptoms	325 (82.7)	240 (86.6)	85 (72.6)	0.002
Cardiologic symptoms, n (%)				
Palpitation	26 (6.6)	14 (5.1)	12 (10.3)	0.127
Hypotension	19 (4.8)	6 (2.1)	13 (11.2)	<0.001
Sweating	2 (0.5)	2 (0.7)	0 (0.0)	NA
Chest discomfort	7 (1.8)	6 (2.2)	1 (0.9)	0.678
Dyspnea	8 (2.0)	7 (2.5)	1 (0.9)	0.448
None of symptoms	335 (85.2)	246 (88.8)	89 (76.7)	0.003
Psychiatric symptoms, n (%)				
Hallucination	5 (1.3)	2 (0.7)	3 (2.6)	0.154
Others[b]	6 (1.5)	0 (0.0)	6 (5.2)	NA
None of symptoms	386 (98.2)	275 (99.3)	111 (95.7)	0.030
Allergic symptoms, n (%)				
Skin rash	5 (1.3)	4 (1.4)	1 (0.9)	1.000
Facial swelling	5 (1.3)	2 (0.7)	3 (2.6)	0.154
Flushing	1 (0.3)	1 (0.4)	0 (0.0)	NA
None of symptoms	9 (2.3)	271 (97.8)	113 (97.4)	0.730
ED LOS, hour, Median (IQR)	3.7 (4.9)	3.7 (2.6)	3.8 (5.9)	0.510

Abbreviations: LOS, length of stay. ED, emergency department. GI, Gastrointestinal. IQR, Interquartile Range.
Others[a]; numbness, lateralizing sign, blurred vision, Others[b]; euphoria, agitation, aggressive behavior, abnormal behavior.

TABLE 3. Logistic regression analysis of factors predicting admission.

	Univariate			Multivariate		
	OR	95% CI	*p* value	OR	95% CI	*p* value
Age						
<65 y	(Reference)		0.524	(Reference)		0.102
≥65 y	1.188	0.624–2.220		0.984	0.966–1.003	
Sex						
Female	(Reference)		0.149	(Reference)		0.772
Male	0.651	0.371–1.130		0.722	0.416–1.242	
Time to symptom onset, n (%)						
<6 h	(Reference)			(Reference)		
6 to 24 h	2.089	1.055–4.125	0.023	2.158	1.218–3.816	0.010
>24 h	3.993	1.356–11.935	0.037	3.382	1.438–8.050	0.003
Unknown	1.954	0.070–54.202	0.824	2.622	0.103–67.014	0.799
Initial mental status, n (%)						
Awake	(Reference)					
Verbal	0.765	0.135–3.644	0.715			
Pain	7.398	0.858–170.035	0.115			
Unresponsive	0.104	0.002–1.188	0.148			
GI symptoms						
Vomiting						
No	(Reference)					
Yes	0.673	0.250–1.881	0.422			
Nausea						
No	(Reference)					
Yes	1.030	0.463–2.229	0.855			
Abdominal pain						
No	(Reference)					
Yes	1.181	0.472–2.858	0.688			
Diarrhea***						
No	(Reference)			(Reference)		
Yes	0.210	0.072–0.532	0.003	0.237	0.093–0.523	<0.001
Neurologic symptoms, n (%)						
No	(Reference)					
Yes	1.587	0.686–3.639	0.280			
Cardiologic symptoms, n (%)						
No	(Reference)					
Yes	1.477	0.500–4.348	0.480			
Psychiatric symptoms, n (%)						
No	(Reference)					
Yes	3.118	0.455–32.500	0.259			
Allergic symptoms, n (%)						
No	(Reference)					
Yes	0.187	0.004–2.939	0.312			

OR, odds ratio; CI, confidence interval; GI, Gastrointestinal.

TABLE 4. Clinical outcomes according to time to symptom onset after ingestion.

Clinical outcomes	Group I (n = 274)	Group II (n = 80)	Group III (n = 31)	*p* value	Post hoc analysis		
					I *vs.* II	I *vs.* III	II *vs.* III
General ward admission, n (%)	52 (19.0)	25 (31.3)	11 (35.5)	0.015	0.086	0.165	1.000
ICU admission, n (%)	14 (5.1)	6 (6.2)	8 (25.8)	<0.001	1.000	<0.001	0.070
Hospital Length of stay, day, median (IQR)	1.1 (1.1)	2.3 (1.2)	4.9 (7.1)	<0.001	0.030	<0.001	<0.001
Death	0 (0.0)	2 (2.5)	1 (3.2)	0.5637	-	-	-

IQR, Interquartile Range; ICU, Intensive Care Unit.
Group I; <6 h, Group II; 6 to 24 h, Group III; >24 h.

Patients in the admission group had a more severely impacted mental status, blood pressure, and respiratory rate when they arrived at the ED than patients in the ED discharge group. Other factors, such as sex, insurance, pulse rate, and body temperature were not different between the two groups at the initial stage.

We identified that the time from ingestion to symptom onset and diarrhea were the associated factors ED disposition. Most patients who presented with diarrhea were discharged from the ED. We deduced that patients with benign progression of mushroom intoxication were more likely to present GI symptoms; overall, this pattern manifested itself in patients with diarrhea having more ED discharges. Some patients with dysarthria or hallucinations were discharged from the ED. This observation was impacted by factors such as ED treatment, an observation unit before hospitalization, etc. However, we could not investigate further to evaluate the suitability of ED treatment and admission due to the anonymous nature of the registry we used.

As with previous studies, a delayed symptom onset (>6 h after ingestion) was associated with serious and potentially lethal toxicity [25–27]. This study showed the same findings supporting the results of previous studies. When symptom onset was delayed, the admission to ICU was observed, and the hospital LOS was prolonged.

The classification of poisonings according to their clinical manifestations has been found to assist in the diagnosis and treatment of poisoning [1, 26, 28]. In this study, however, more than half of the patients reported GI symptoms; additionally, non-specific symptoms, such as general weakness, were prevalent, causing difficulty in the identification of cases according to the clinical symptoms. In some previous studies, diarrhea was found to cause dehydration and severe renal failure [10, 29]. In this study, diarrhea was not related to admission.

A few cases of mushroom poisoning resulted in life-threatening conditions, although it is uncommon [30, 31]. Mushroom intoxication varied by region and climate; therefore, a nationwide surveillance of mushroom intoxication would be useful in determining its overall characteristics and the population with the largest need for special attention.

This study has some limitations. Information of poisonous toxic mushrooms were unavailable in most cases. Only 30 cases were documented with the types of intoxicating mushrooms. This reflected the difficulty in distinguishing the mushroom type in the ED environment. Therefore, when patients arrived at the ED, physicians should have been attentive to the history of ingestion and the timing associated with the onset of symptoms that may indicate consumption of a more lethal variety of mushroom toxins. In addition, educating the public to bring in ingested fungal remains would improve diagnostic outcomes (*i.e.*, in terms of increasing the frequency of accurate fungal identifications by emergency department referring mycologists).

Because of the observational nature of the study and the limitations of the registry, we did not have access to the lab findings or final diagnoses. Hence, we did not specify complications, such as acute kidney injury or acute liver failure. This limitation could bias the analysis of predictive factors linked to poor prognosis.

In this retrospective study, we did not include all the EDs of South Korea. Thus, it may not cover all instances of mushroom intoxication, as very mild or severe cases may not have visited the ED or have resulted in immediate death. In addition, mortality outside of the hospital could not be confirmed because the discharged patients were not followed up.

5. Conclusions

In the ED environment, the time from ingestion to symptom onset was a reliable predictor of admission, ICU admission, and prolonged hospitalization. Overall, clinicians should carefully evaluate, observe, or admit those with delayed symptom onset.

AVAILABILITY OF DATA AND MATERIALS

Due to Korea Centers for Disease Control and Prevention regulations, the raw data for deep learning are not publicly available. Upon reasonable request, the corresponding author can provide simulation examples and data that support the findings of this study.

AUTHOR CONTRIBUTIONS

TK—Conceptualization. SH, SYH and HY—Data curation. SH, GTL and JEP—Formal analysis. HS and TGS—Investigation. SUL and MSS—Methodology. IJJ—Visualization. SH—Writing-original draft. SH, TK and WCC—Writing-review & editing.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study was approved by the Institutional Review Board (IRB) of Samsung Medical Center, IRB No. 2022-05-152. Informed consent was waived by the IRB due to the retrospective design.

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CONFLICT OF INTEREST

The authors declare no conflict of interest. Won Chul Cha is serving as one of the Editorial Board members of this journal. We declare that Won Chul Cha had no involvement in the peer review of this article and has no access to information regarding its peer review. Full responsibility for the editorial process for this article was delegated to OK.

SUPPLEMENTARY MATERIAL

Supplementary material associated with this article can be found, in the online version, at https://oss.signavitae.com/mre-signavitae/article/1699971693498253312/attachment/Supplementary%20material.docx.

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