IJM - Italian Journal of Mycology
ISSN 2531-7342 - Vol. 54 (2025): 235 - 243
Journal homepage: https://italianmycology.unibo.it/

Short note

Epidemiology and clinical aspects of edible mushroom-related paediatric poisonings in Italy: 10-year retrospective study

Francesca Assisi[1], Sara Cordoni[2], Martina Ghezzi[3], Ilaria Rebutti[1], Andrea Stella[1], Alfredo Vizzini[4]

[1]Poison Control Centre in Milan, Niguarda Cà Granda Hospital, Italy
[2]Queen Elizabeth University Hospital, 1345 Govan Rd, Glasgow, G51 4TF, United Kingdom
[3]Polytechnic University of Milan
[4]Department of Life Sciences and Systems Biology, University of Turin, Viale P.A. Mattioli, 10125 Turin, Italy

Corresponding author e-mail: fassisi@tiscali.it

ARTICLE INFO
Received 10/04/2025; accepted 30/11/2025
https://doi.org/10.6092/issn.2531-7342/21730

Abstract
Intoxications caused by mushrooms (mycetisms) account for only 2% of the total toxicological consultations that the Milan Poison Control Centre receives and manages every year, but they are certainly the most challenging, both because they are potentially very dangerous and for the simultaneous involvement of multiple subjects, especially when patients are of paediatric age. The present retrospective study aims to analyse epidemiological data and the clinical course of edible mushroom poisonings in Italy. Only intoxications caused by edible mushrooms in paediatric patients were selected. Age information was missing for patients involved in collective exposures, so it is noticeable that the collected data are only a minority of real cases. The average number of vitamins, proteins and mineral salts in mushrooms is negligible, from a nutritional point of view; therefore, the results of our study show that it is preferable to avoid their consumption in children. In order to have more accurate data on the extent of mushroom-related problems in children, a nationwide homogeneous statistical survey is needed.

Keywords
poisonous edible mushrooms, treatment, outcome, Milan Poison Control Centre, Children

Introduction

Mushrooms are considered a delicious food worldwide. However, many species are highly poisonous, and even some edible ones can cause gastrointestinal symptoms (Holsen et al., 1997). Some edible species may cause toxicity due to their by-product substances, including ptomaines such as cadaverine and putrescine. These substances are the result of transportation in plastic bags and poor food preservation. In addition, saprophytic contamination can be known to cause food intolerances (Radlović et al., 2010; Ruiz-Capillas and Herrero, 2019).

The chemical composition of many mushrooms is well known, and species differ significantly from one another also in terms of edibility for humans (Kalač, 2013; Dimopoulo et al., 2022). What is well known, however, is that mushrooms are composed of about 90% water, while compounds such as vitamins, minerals, proteins, and antioxidants are present only in small amounts in fresh mushrooms; in contrast, dried mushrooms contain more concentrated compounds (Vetter, 2003; Leonardi et al., 2005; Borghi et al., 2019; Mleczek et al., 2021). Nutrition experts often strongly promote the nutritional content of mushroom species in the media (Reis et al., 2012; Senila et al., 2024), without considering that the concentrations of nutrients, vitamins and other chemical compounds are minimal compared to the physiological needs of the human body, particularly in children and adolescents (see Table 4 in Koletzko, 2008).

It is easy to understand that, in order to obtain a useful amount of nutrients, one would need to consume large quantities of mushrooms, with the risk of intoxication. Based on this consideration, it is prudent to avoid giving mushrooms, even those certified as edible, to children under the age of 12. In children, the digestion of certain compounds found in mushrooms, such as chitin, as well as sugars like mannitol and trehalose, is more complex (Gawlikowski et al., 2014; Heinzelmann et al., 2019). It is also well known that vomiting and diarrhoea can be problematic, as they can easily lead to dehydration. The ingestion of edible mushrooms, such as *Armillaria mellea* (Vahl) P. Kumm. complex or *Boletus edulis* Bull. complex, can also cause gastroenteritis, which may require medical intervention, especially in paediatric populations (Sesana et al., 2015). Intoxication can be caused by either the presence of chitin, which is usually poorly digested, or trehalose and mannitol which can lead to diarrhoea (Arola et al, 1999; Paoletti et al., 2007; Solomon et al., 2007; Montalto et al., 2013; Fiori et al., 2022). To investigate the problem of toxicity of edible mushrooms in children, a literature search found no previous studies describing any specific results.

Most of the time, it is thought that edible mushrooms cause problems if they are poorly cooked, improperly stored, or due to intolerance. However, this is not always the case. In this regard, a detailed study on the data of several mycological inspectorates confirmed that even edible mushrooms can cause serious clinical problems (Sitta et al., 2020). In particular, the study was conducted in 12 geographical areas in Italy, based on the official mycological reports issued by the Mycological Centres within Italian Health Authorities, and by the Mycological Centre attached to the Regional Agency for Environmental Protection and Energy in Bologna. The poisoning data span medium to long timescales, in most cases over a ten-year period, and show major differences in mushroom species that are responsible for most poisoning cases in the different geographical areas. The research of Sitta and colleagues (2020) focuses on the poisonings caused by edible species, showing that any edible mushroom species is potentially capable of causing poisonings with gastrointestinal syndromes (Table 1).

The mushroom-related problem for children is of interest to both paediatricians and parents. An obstacle to making an informed decision is the lack of information available regarding the possible risks due to the ingestion of controlled edible mushrooms in children. It is necessary to increase knowledge about paediatric cases that experienced problems after ingesting controlled edible mushrooms. However, this is not easy, as Italian emergency departments and Poison Control Centres often do not specify paediatric intoxications in their documentation. As a result, these cases are then registered together with adult intoxications, without distinction.

Table 1 – Comestible mushroom poisonings in 12 geographical areas in Italy (modified by Sitta et al., 2020)

Province	***Armillaria* spp.**		***Boletus* spp.**	
	n.	**%**	**n.**	**%**
Turin-Asti	45	33	27	20
VCO	14	34	2	5
Brescia	82	45	32	18
Pordenone	44	38	12	10
Trento	13	7	9	5
Emilia	51	11	37	8
Romagna	9	10	6	7
Grosseto	7	32	16	7
Terni	51	5	6	6
Frosinone	15	13	13	12
Brindisi	0	0	3	2
Cagliari	2	4	2	4

Intoxications caused by mushrooms (mycetisms) account for only 2% of the total toxicological consultations that the Milan Poison Control Centre (MPCC) receives and manages every year (Fig. 1). However, mycetisms are certainly the most challenging especially when patients are of paediatric age, because they are potentially very dangerous, even potentially fatal (e.g., amatoxins), or severely disabling (e.g., orellanine), and due to the simultaneous involvement of multiple subjects. This retrospective study evaluated the available data from the MPCC, focusing on paediatric cases. In particular, this study analysed paediatric intoxications following the ingestion of edible mushrooms (Assisi et al., 2014, 2019). The term "intoxication" was used based on the severity of the symptoms presented, and the cases due to allergies or intolerances were excluded from the study.

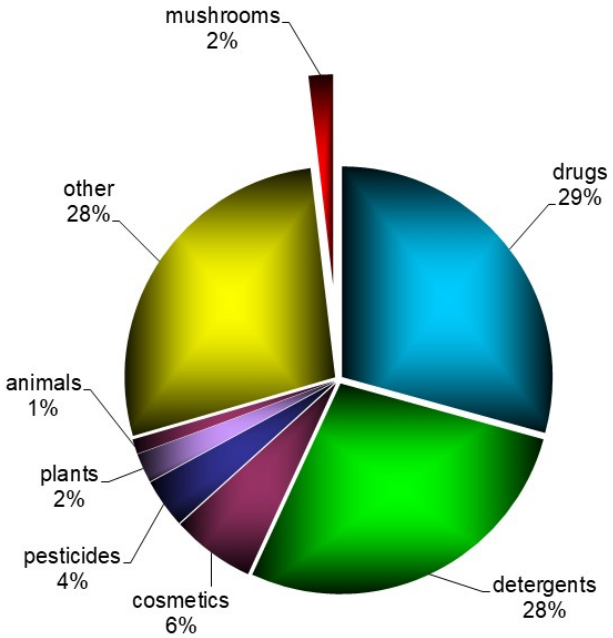

Fig. 1 – Statistics on the total intoxication cases, recorded by the Milan Poison Control Centre from 2009-2019.

Materials and Methods

All cases of mushroom exposure that occurred between 2009 and 2019 were identified from the MPCC database (Fig. 2, Supplementary Table S1). We considered a case as poisoning when the disorders caused by the ingestion of a meal containing mushrooms required access to medical services. Most poisonings were caused by the ingestion of mushrooms that had not been checked by a mycologist after being collected. This study only considered cases caused by edible mushrooms, excluding poisonings due to ingestion of uncontrolled mushrooms. Patients were divided into age groups, and for the most critical group (from 1 to 12 years old), a record was kept of the fungal species responsible, clinical signs, relative severity and therapeutic measures. Additionally, place of origin of the request for advice to the MPCC was sought. Most paediatric cases were individual patients, and only 9 cases also reported the presence of other symptomatic commensals (> 12 years). However, in the consultations where multiple cases were reported, the age of each patient was not specified, making it impossible to verify the presence of children. Therefore, it is intuitive that the data extrapolated represent only a small portion of the actual ones.

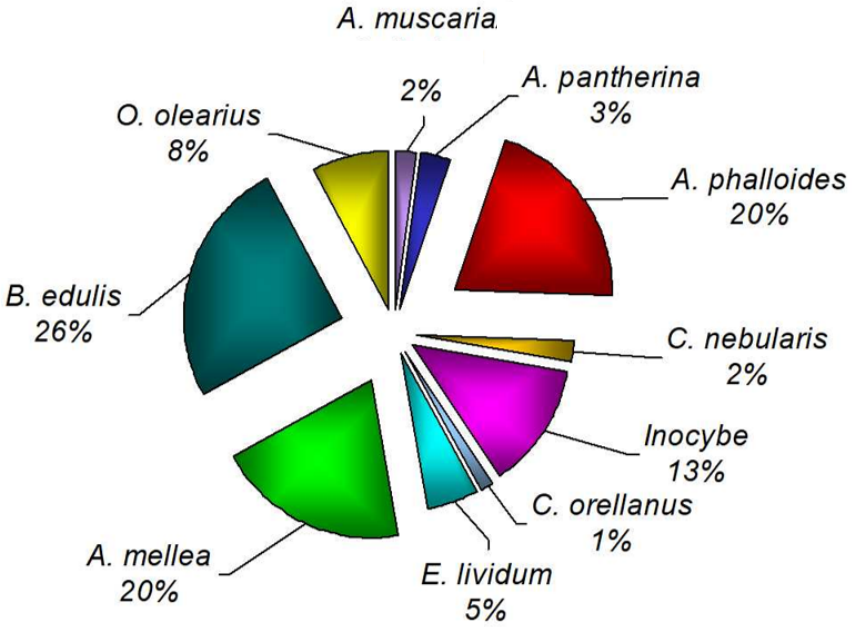

Fig. 2 – Total intoxications caused by mushroom ingestion, based on the species recorded by the Milan Poison Control Centre from 2009 to 2019.

Results and discussion

From January 2009 to December 2019, the MPCC received 1203 requests for medical advice for cases of suspected mushroom intoxication in patients aged between 1 and 89 years (Fig. 3), after consuming controlled mushrooms or verified as such after further mycological control. Of these, a total of 79 (6.6%) children showed clinical problems after ingesting mushrooms that were deemed edible. Forty (50.6%) of the consultancy requests came from a paediatric hospital, while the remaining 39 (49.4%) requests came from the community, carried out either by a general paediatrician or by a parent. This suggests that the patients presented alarming symptoms that caused

parents to seek emergency care. Symptoms occurred in 63 (79.7%) patients after the ingestion of controlled mushrooms whose species were not specified.

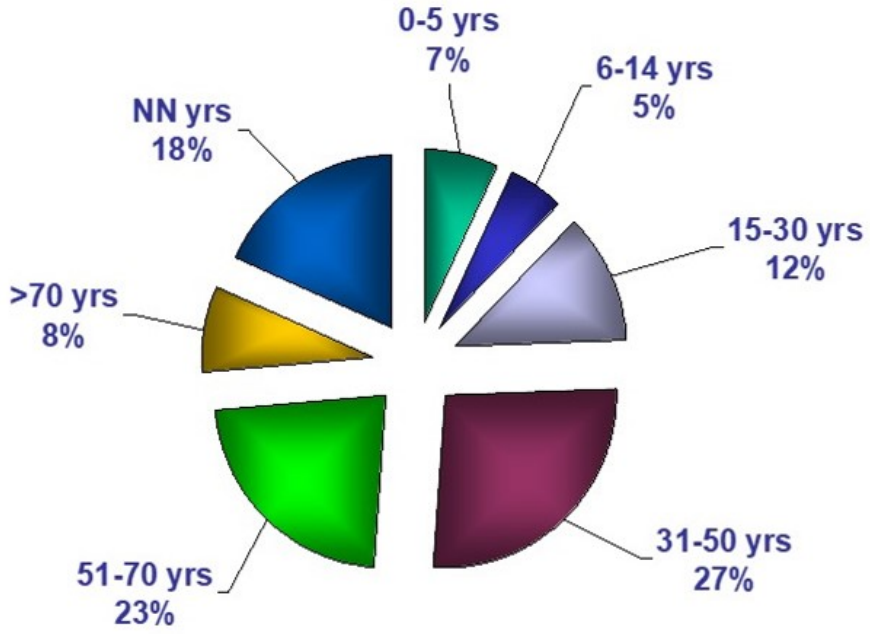

Fig. 3 – Intoxications caused by mushroom ingestion based on the age recorded by the Milan Poison Control Centre from 2009 to 2019. NN = age not detected due to involvement of multiple cases.

The other cases were due to species of the *Armillaria mellea* complex (6 cases, 7.6%), *Boletus edulis* complex (7 cases, 8.9%), or *Agaricus* spp. (3 cases, 3.8%). In 9 (11.4%) cases the mushrooms were consumed in a public place, whereas in 66 (83.5%) cases they were consumed at home. However, it has not been recorded in the database whether the consumption was of raw or cooked mushrooms, or prepared incorrectly for *Armillaria* mushrooms, trimmed and blanched. The precise amount ingested was not reported in the data collection; for a child, it can be assumed that only tastings were taken (about 30 g).

As expected, the clinical manifestations were primarily gastrointestinal. In most cases, patients experienced vomiting and diarrhoea (from 1-2 episodes to more than 6), while in 6 cases diarrhoea was associated with abdominal pain. In only 6 cases, patients were pyrexial, and other concomitant pathologies could not be excluded. Hospital admission was not recommended in 14 (18%) cases, entrusting the patients to the care of their community paediatrician. An observation period from 6 hours to 1 day at the hospital was necessary in 63 (80%) cases, in order to monitor the progression of fungal intoxication. Medical management was based on symptom severity. Paediatric patients who had shown mild symptoms after ingesting controlled mushrooms were only treated with the administration of oral activated charcoal and symptomatic drug therapy in order to avoid dehydration. In 10 of the most severe cases (8%), administration of charcoal was preceded by gastric lavage (Fig. 4) (Anonymous, 1997a,b).

Fig. 4 - Gastric lavage in poisoning: *Armillaria mellea* (Picture by M. Verzolla)

Vomiting and diarrhoea are defence mechanism to eliminate toxins from the body. Obviously, with gastric lavage, this process is accelerated, reducing the potential consequences of repeated vomiting. Activated charcoal in powder form binds to toxins, preventing their absorption and promoting their elimination through faeces (Zhong et al., 2021).

The number of paediatric cases that were extracted from the MPCC database was small compared to the size of the wider population. Despite this, the mere presence of these cases points out that edible mushrooms can cause intoxication, and it can be stated that mushrooms must be considered "high-risk food" and must only be consumed after certification of edibility and in moderation. Poison Control Centres are a relevant source of data for surveillance of mushroom-related poisonings; however, it is advisable to improve the current database in use by collecting more homogeneous and detailed data on intoxications, allergies and intolerances caused by mushrooms. It would be very important to specify, with great precision, the mushroom species involved, the maturation stage of the fruiting body, and the type of cooking method used. Additionally, recording clinical manifestations, age, weight, health status, and sex for each affected individual would make it easier to better understand the severity of all mushroom intoxications and make prevention strategies more effective. Furthermore, in order to establish a definitive evaluation pathway of mushroom-related poisonings, close attention must be paid to the most vulnerable groups, such as children and the elderly, their symptoms, responsible species and their medical management. Greater caution is needed when recommending the consumption of inspected mushrooms for children, especially if they have not been checked by a mycologist after harvesting. In general, we hope for responsible mushroom consumption by everyone, in order to prevent it from transforming from a delicacy for many into an insidious public health issue.

It is necessary for all Poison Control Centres to interact with each other for a more precise statistical evaluation and to coordinate preventative interventions with the aim of informing consumers about the risks associated with mushroom consumption, especially if they are not controlled (Gawlikowski et al., 2014). A national research project (national registry), with univocal data collection procedures and subsequent data analysis would be necessary to obtain statistically significant results.

Acknowledgements

We thank the Milan Poison Control Centre for making their data available.

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