Modeling the risk: Innovative approaches to understand and quantify the risk of severe FB injury

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A R T I C L E   I N F O

A B S T R A C T

Objectives: The entry of a small item into the respiratory or digestive tract is still one of the leading causes of injuries in children up to 14 years old. The aim of the paper is to provide a quantitative risk assessment analysis for identifying consumer product features which contribute to increase the risk of sustaining a severe injury.
Methods: Data on foreign body injuries were collected in 28 European countries and one Pakistani hospital. A total of 7296 cases were classified according to ICD-9CM 931–935. Information about injuries included age and gender of the injured child, circumstances of the accident and foreign body features. A classification tree was set up in order to analyze the impact of the item features like volume shape and rigidity on the severity of the injury.
Results: Males are involved in severe injuries more often than females. Most severe injuries when the foreign body is localized in the ears were due to objects with volume lesser than 49 mm^3. Volume cut-off is slightly higher for foreign bodies that have been found in the nose (55 mm^3). Objects with conforming rigidity pose children to higher risk of severe injury.
Conclusions: The presence and supervision of an adult is crucial in reducing the risk for severe injuries both in pharynx and laryhnx and in mouth.

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1. Introduction

The entry of a small item into the mouth or into the nose and from there into the respiratory or digestive tract is one of the leading causes of injuries in children up to 14 years old and still represent a significant challenge for the health care system in terms of life threatening and resources utilization. Children commonly place objects in the mouth. This often results in accidental swallowing of foreign bodies. Children usually place things in their ear canal because they are bored, curious, or copying other children. Sometimes one child may put an object in another child's ear during play. Injuries due to foreign body aspirations and ingestions are quite common in childhood because of their link with some important developmental factors, such as the exploration of the environment using the sense of taste ('mouthing') and the diversification of infant's diet with solid food [1].

Whereas some authors (Milkovich 2003) are distinguishing the concept of insertion (in the nose or ears) from that of ingestion, of

aspiration and of choking, some other authors recognize that all such aspects are closely inter-related, and propose to keep as unique category ingestion, aspiration, choking (Rider e Wilson 1995). As recalled by [2] strategies for successful interventions from public and private health care providers are based upon principles of avoidance, caretaker vigilance and pre-emptive design strategies. Safety of a product depends on appropriate use of materials, quality of manufacturing and on design safety. A "safe" design is determined by whether a product provides anyone who might come into contact with it a satisfactory level of safety. This issue should extend to include foreseeable misuse, for instance children who may play with an object in a way not intended by the producer. The interaction between a product and its user and even misusers is affected by the features of the product like volume and shape, the characteristics of the user such as age and gender and environmental factors such as social conditions [3]. It follows the need for severity injuries prediction and risk assessment. Many studies were carried out to characterize types, shapes, and sizes of objects causing injuries.

The seriousness of an accident is often disputed. For example, a child may be taken to hospital and admitted for observation (an apparent serious accident) but in the event, the small object swallowed is passed naturally with no adverse effects. In [4] an

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injury which lead to a medical intervention is categorized as 'severe', while physical findings including abnormality of breathing functions define a 'moderate' injury. In [5] non-fatal accident was classified into: trivial, if the 'patient did not wait' or he was 'Examined but no treatment given'; Minor if the patient was 'Treated; no more treatment required' or he was 'Admitted to hospital for less than 1 day'; Serious if the injured child was 'Admitted for one, two or three days'; Very Serious if he was 'Admitted for more than three days' or 'Transferred to a specialist hospital'. On this basis we considered an injury as 'severe' if the child involved was hospitalized for at least one day.

In order to describe the role of the FB characteristics and the impact of the circumstances which leaded to an injury, we set up a tree based model. The aim of this paper is to provide a quantitative risk assessment analysis for the identification of product features which much more contribute to an increased risk of sustaining a severe injury. Following a short presentation of the methodology, the classification tree model will be described and its performance and results will be discussed.

2. Materials and methods

2.1. Data source

According to the International Classification Disease ICD-9CM 931–935, at the end of 2009 a total of 7296 injuries in paediatric patients were gathered by the Susy Safe EU funded Web-registry using hospital discharge records in one Pakistani and 28 European hospitals. Data encompassed four main aspects of the FB injuries: (i) the characteristics (age and gender) of the injured children; (ii) the characteristics of the objects (foreign body type, shape, consistency, dimensions and whether it was associated to another object); (iii) circumstances of injury (presence of caregivers during

the accident, the activity the child was engaged in at the time the accident occurred); (iv) hospitalization's details (removal technique used to extract the FB, whether a hospitalization was experienced, whether complications occurred). Objects were characterised by size, shape and consistency following the basic definitions in [6]. With regard to the shape, FBs were assigned to one of the following categories: spherical (ball, pebble, etc.); Three-dimensional (3D) (FBs with irregular shape); Two-dimensional (2D) (paper sheet, cellophane); Cylinder (coin, button, cylinder batteries); 2D-circle (2D circle objects other than batteries, coins and buttons); Needle-shape (e.g. pin and needle). In addition three categories of consistency were considered: conforming (e.g. balloon, elastic); semi-rigid (e.g. eraser) and rigid (e.g. coin). Whit regard to the size, when the dimensions (expressed in millimetres) of the object were reported, the volume was calculated by approximation to the nearest simple geometric shape, e.g. for three-dimensional objects the volume of an ellipsis was calculated using the length of the axis. Such volume measures represent how much space the smallest geometrical figure containing the irregular-shaped FB takes up. Finally, we considered five different FB categories: (i) non-industrial component; (ii) piece of an object: the FB was a broken part of the product (e.g. a broken part of a pen, the wheel of a toy car, etc.); (iii) whole objects; (iv) co-presence with another object: when the objects were sold together like the cap with the pen, the marble with a board game, etc., (v) package or part of a package of a product (e.g. the tinfoil containing chocolate, a polystyrene ball, a piece of cardboard, etc.

2.2. Statistical methods

With the aim to analyze the impact of the FB characteristics and the circumstances of the injury on the severity, a classification tree was constructed. The indicator of the event the injured child
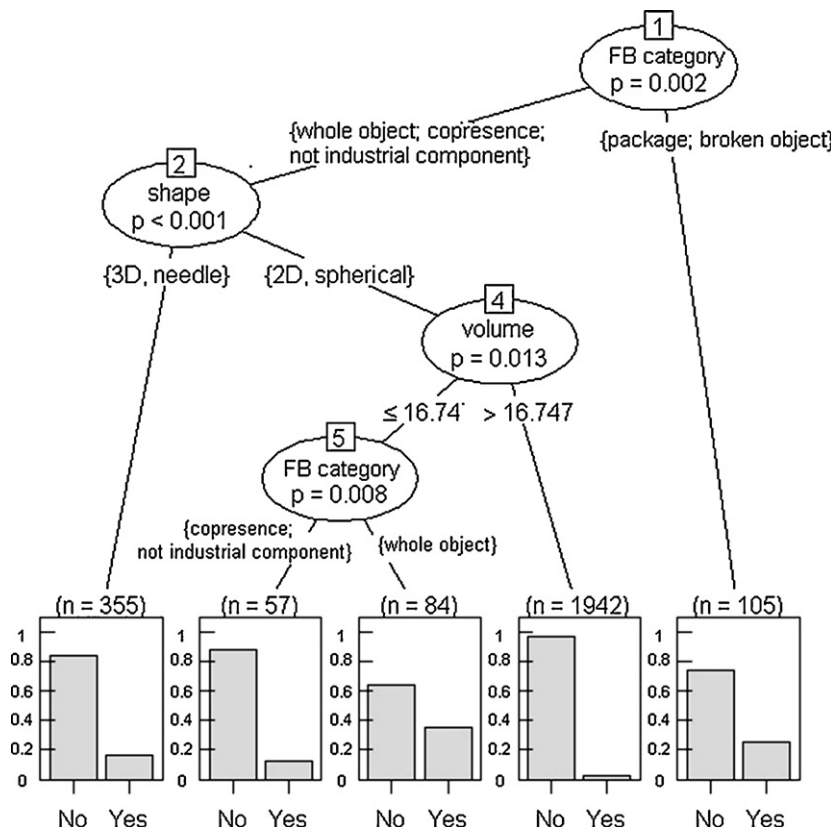

Fig. 1. Classification tree for FBs located in the ears and in the nose (ICD931–932).