HOSPITAL EMERGENCY DEPARTMENT COSTS: A FINANCIAL MANAGEMENT PERSPECTIVE

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Abstract
A significant share of public healthcare expenditure is devoted to the treatment of severe trauma cases in Emergency Departments (EDs), many of which involve orthopedic injuries. Although existing trauma scoring systems support clinical assessment, they rarely incorporate logistical and economic factors that influence efficient resource allocation. This study proposes the development of a software application that records patients' clinical status alongside procedure-related costs to support decision-making in orthopedic emergencies. By integrating medical and economic data, the system facilitates the selection of appropriate diagnostic methods while improving cost estimation in the Emergency Departments. The proposed tool aims to enhance resource management and reduce unnecessary diagnostic examinations.

JEL Classification*: I11, I18, D24, H51*

Keywords: *hospital financial management, cost assessment, emergency departments, health economics, hospital efficiency*

1. Introduction

Health systems worldwide increasingly face the challenge of rising demand for healthcare services. One important factor influencing healthcare utilization is **induced demand**, defined as situations in which healthcare services are provided beyond what is medically necessary, often driven by factors unrelated to patients' actual health needs (Roemer, 1961; Fuchs, 1978).

Several determinants contribute to the demand for healthcare services. First, **supply-side factors** play a significant role, as a high availability of medical resources may lead to the provision of services beyond clinical necessity (Delamater et al., 2013). Second, **information asymmetry** between healthcare providers and patients may influence patients' decisions regarding diagnostic and therapeutic procedures. Because healthcare professionals possess substantially greater medical knowledge, they may inadvertently or intentionally shape patients' choices, potentially leading to the overutilization of healthcare services (McGuire, 2000). Third, **financial incentives** embedded in reimbursement mechanisms can affect provider behavior. In systems where providers are compensated according to the volume of services delivered, there may be incentives to recommend unnecessary diagnostic tests or treatments (Labelle et al., 1994).

Induced demand may result in increased healthcare expenditures, inefficient allocation of resources, and potential reductions in the overall quality of care (Bickerdyke et al., 2002). Consequently, various policy instruments and management tools have been proposed to mitigate this phenomenon.

One such approach involves **cost-sharing mechanisms**, such as co-payments or co-insurance, which aim to increase patients' awareness of the costs associated with healthcare consumption (Zweifel & Manning, 2000). Additionally, **performance-based payment systems** that reward healthcare providers based on quality outcomes rather than service volume may reduce incentives for unnecessary procedures (Rosenthal et al., 2004). Another important policy tool is **Health Technology Assessment (HTA)**, which systematically evaluates the clinical effectiveness and cost-effectiveness of medical technologies and treatments before their widespread adoption (Drummond et al., 2008).

Improved **transparency and patient education** can also contribute to more efficient healthcare utilization. Providing patients with clear information regarding treatment options, costs, and quality indicators enables more informed decision-making (Stacey et al., 2017). Furthermore, **digital health technologies** have the potential to reduce induced demand by supporting standardized clinical decision-making. The implementation of clinical guidelines and monitoring systems may limit unnecessary diagnostic and therapeutic interventions (Woolf et al., 1999).

In this context, **clinical decision-support systems (CDSS)** play an increasingly important role. These systems analyze clinical data and support evidence-based decision-making processes that are less susceptible to provider-induced demand (Bashshur et al., 2016). Decision-support systems designed for emergency care often integrate advanced technologies, including artificial intelligence and data analytics, enabling faster information processing and improved clinical outcomes (Yang et al., 2013).

In orthopedic trauma care, the classification of **open fractures** is based on several clinical parameters used to assess injury severity. These parameters typically include skin damage, muscle injury, arterial injury, infection risk, and bone loss (Orthopaedic Trauma Association, 2010). Such classification systems enable clinicians to group injuries with similar characteristics, facilitating standardized communication and more effective clinical decision-making.

Among the available classification methods, the **Gustilo–Anderson classification system** remains one of the most widely used and reliable tools for evaluating open fractures. Initially introduced in 1976 by Gustilo and Anderson and later revised in 1984, this system categorizes open fractures into three primary types according to the severity of the injury, the extent of soft tissue damage, the mechanism of injury, and the risk of infection (Gustilo et al., 1976; Gustilo et al., 1984, URL1).

2. Paper Body

2.1 Material and Methods

Front-end design refers to the part of a web application that is visible and interacted with by the user. The technologies used include programming languages such as HTML, CSS, JavaScript, as well as technologies such as Ajax and Bootstrap.

Bootstrap is a powerful and innovative front-end framework developed by Twitter designers over the past decade and is one of the most popular projects on GitHub. It is a collection of open-source tools (free software) that facilitates the creation of websites and web applications. It includes HTML and CSS for configuring typography, navigation buttons and other interface elements, as well as optional JavaScript extensions. The advantages of Bootstrap are numerous, which makes it very popular for developing web applications. It is free, supports all browsers, is easy to install and use, compatible with mobile devices and offers responsiveness.

It usually involves 3 main elements: the server, the application and the database. When a user visits a website and interacts with the front-end, his/her actions are limited to this layer.

However, when the user logs in and enters data, the application is responsible for storing it in the database configured by the server.

The **collaboration of the technologies** involved in the application is crucial, as each contributes uniquely to the overall outcome. HTML tags were used to configure the main pages, establishing the layout and presentation of the content. CSS defined stylistic elements such as colors, fonts, and layouts, resulting in an attractive and cohesive appearance for the application. In this context, Bootstrap facilitated the rapid and straightforward development of the web application, enabling the creation of a visually impressive interface.

On the other hand, AJAX (Asynchronous JavaScript and XML) allows for asynchronous data communication between the browser and server without requiring a page refresh. This functionality enables the application to update its content dynamically, providing a seamless browsing experience for users. JSON is utilized for efficient asynchronous data transfer. PHP is employed to manage data, interact with the database, and perform the necessary application functions. Finally, MySQL supports information management and data exchange (Nixon, R., 2014).

Overall, the integration of these technologies enables the development of a fully functional and dynamic application that enhances the information system. HTML and CSS create the structure and aesthetics, while AJAX, along with JSON, facilitates asynchronous data exchange with the server. PHP provides essential data management capabilities (Welling, L., & Thomson, L., 2003).

2.2 Development model

The Waterfall model is a linear approach to software development that consists of a sequence of well-defined phases executed in a strict order. Each phase must be completed before the next one begins, with minimal interaction between stages. Within this model, system requirements are specified at the initial stage of the project, and the development process proceeds sequentially. Consequently, returning to earlier phases to incorporate modifications can be difficult once the process has advanced to later stages.

One of the primary reasons for selecting the Waterfall methodology is the **clarity and stability of project requirements**. This approach enables comprehensive analysis and careful planning of system specifications prior to the implementation phase. As a result, it provides a clearer understanding of the system to be developed and reduces the likelihood of inconsistencies or significant changes in requirements during the development process (Veskoukis, 2015).

Despite its advantages, the Waterfall model also presents certain limitations. It lacks flexibility in adapting to evolving requirements and offers limited opportunities for meaningful user feedback before the completion of the project (Dimoulas, 2021).

2.3 Application Usage Scenario

The System Administrator can create, delete and edit users in the application. The approved user uses the username and password provided by the administrator and logs into the application. The application can be found at: http://orthologika.digithea.uop.gr/

Figure 1. *ORTHOLogika home page - User login*

The first form of the application has the option to select a Health Region and as the selection is made in the second drop down list only the nursing structures of the selected Health Region appear, to facilitate the user to select the hospital that will register the case.

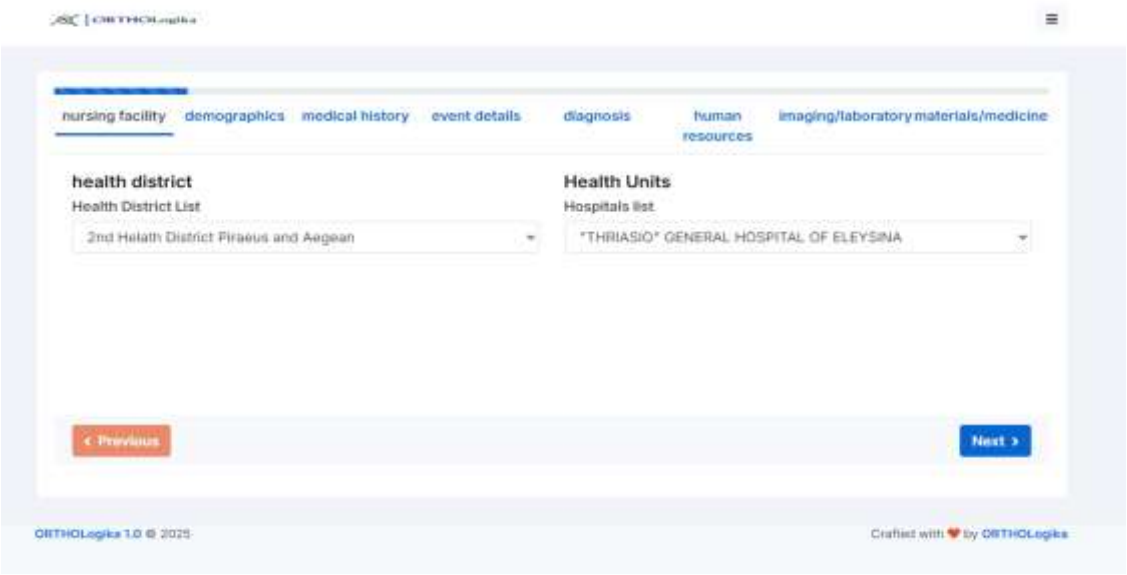

Figure 2. *Selection of Health Region and Nursing Facility*

The next form negotiates the entry of the basic demographic data shown in the image below.

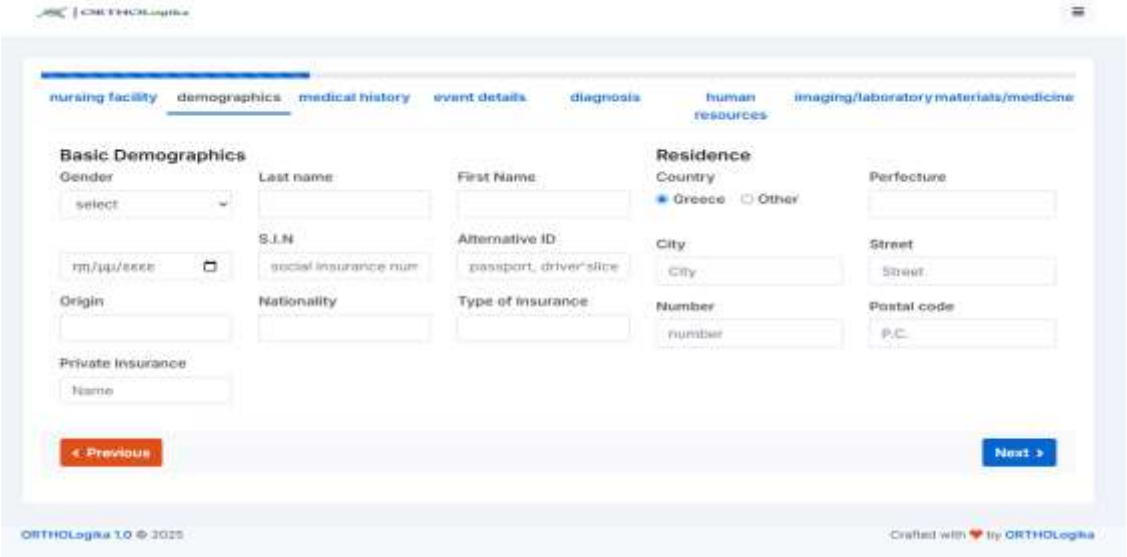

Figure 3. *Recording Basic Demographic Data*

Navigation between the forms is done through the Previous-Next buttons. In this form a complete and detailed record of the patient's Medical History is made.

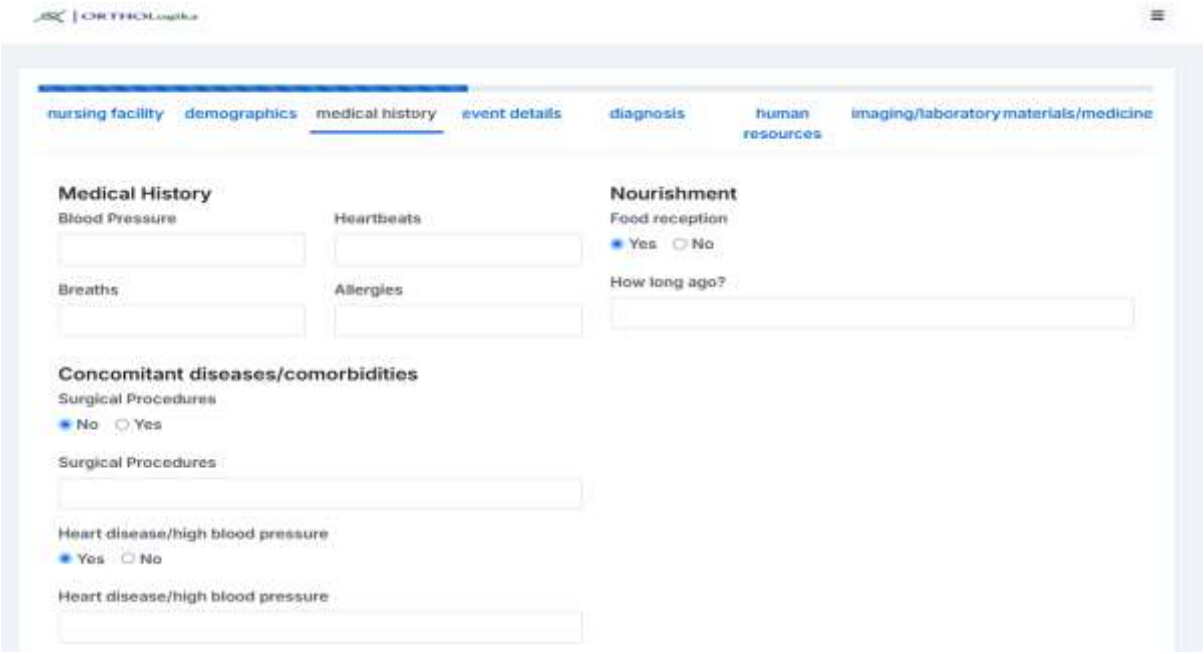

Figure 4. *Complete Medical Record*

The recording of the incident details continues with a separate section including *important times* such as time of arrival, notification, response etc., so that there is a clear picture of each incident individually and for the most effective drawing of conclusions and reports.

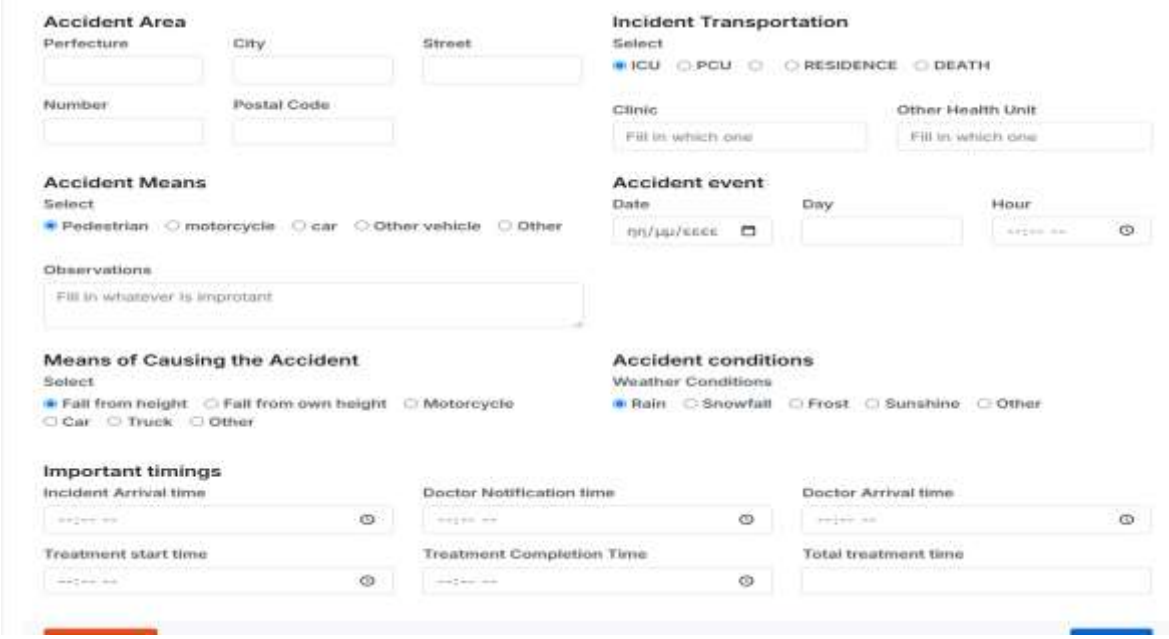

Figure 5. *Full Event Recording*

The diagnosis form is perhaps the most important form of the application because here the area of the injury and in particular the type of injury classified on the Gustillo scale is selected. As soon as the selection of the Fracture Type is made, the *recommendations (recommendations)* generated by the Application are displayed to enable the user to make the most appropriate choice in a) imaging services, b) laboratory tests, c) drugs and materials and d) human resources selection for the specific case (doctors and specialty - number of nurses and specialty).

The proposals of the application reduce financial costs and reduce significant time with unnecessary actions of incident response. The application's most accurate predictive methods are based primarily on the volume of cases registered. The more cases are registered in each fracture type on the Gustillo scale) the more accurate are the recommendations of the application showing the most used imaging procedures, laboratory tests, the most used choice of type and quantity of drugs and materials as well as the most indicative choice of the number and specialties of human resources to be involved in each case. Also, an indicative total cost of the actions is calculated to guide the user of the application to the most appropriate and correct choice for the treatment, making it a valuable tool in the management of orthopedic emergencies with a focus on the best possible treatment in relation to the resources to be used.

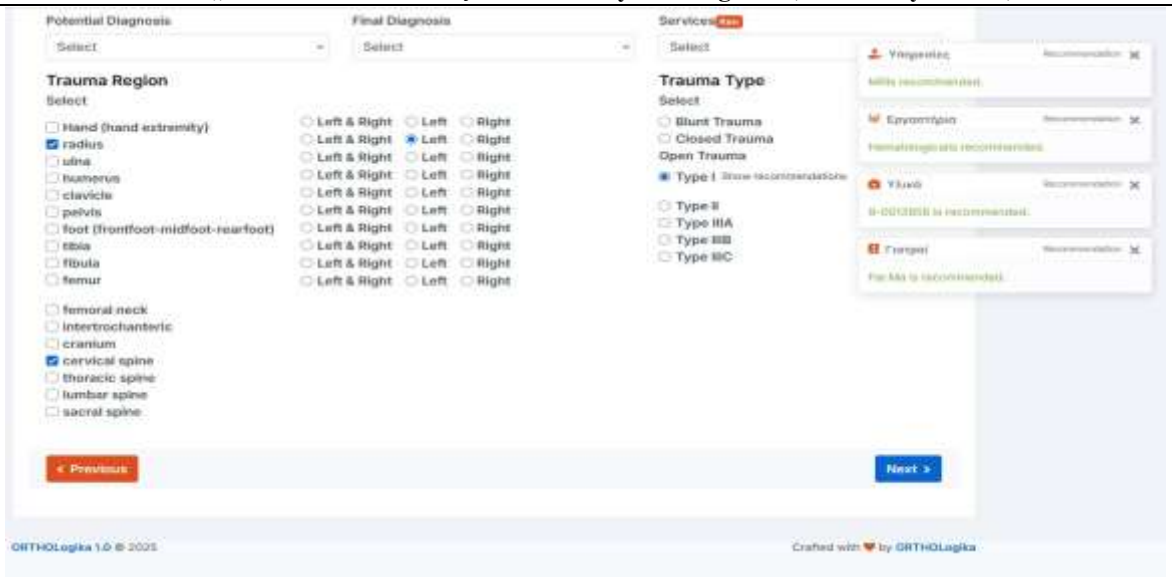

Figure 6. *Diagnosis and Resource Use Recommendations*

In this form, the number of doctors and their specialty as well as their grade and years of service are selected, which are directly linked to the database to calculate their salary and thus the cost. The same logic is followed for nursing staff and their specialties.

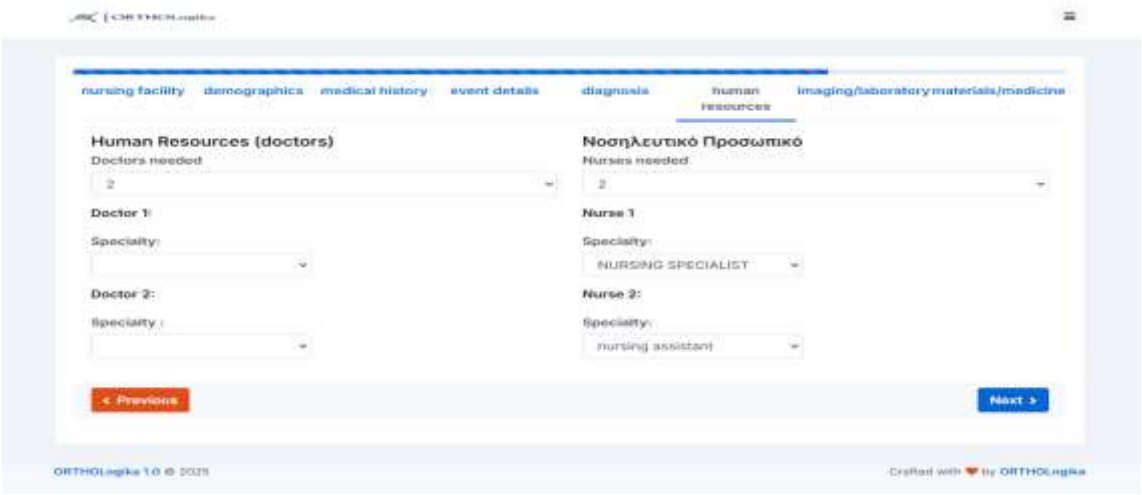

Figure 7. *Selection of Healthcare Staff*

In the form of services and examinations there is the possibility of several options in each category and each action is linked to the official cost list of these, parallel calculation of the cost of each action separately and of all of them.

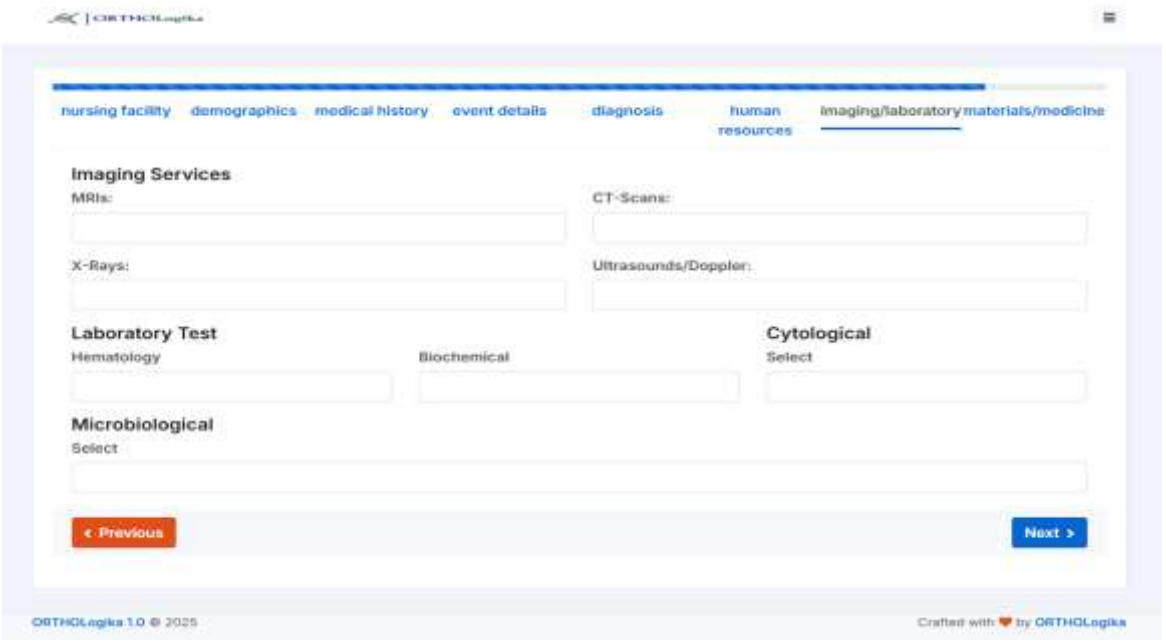

Figure 8. *Choice of Imaging Services and Laboratory Tests*

The same logic applies to the choice of medicines and materials. Here the user can add or remove materials/medicines and at the same time the cost calculation can be done in relation to the quantities of each material/medicine.

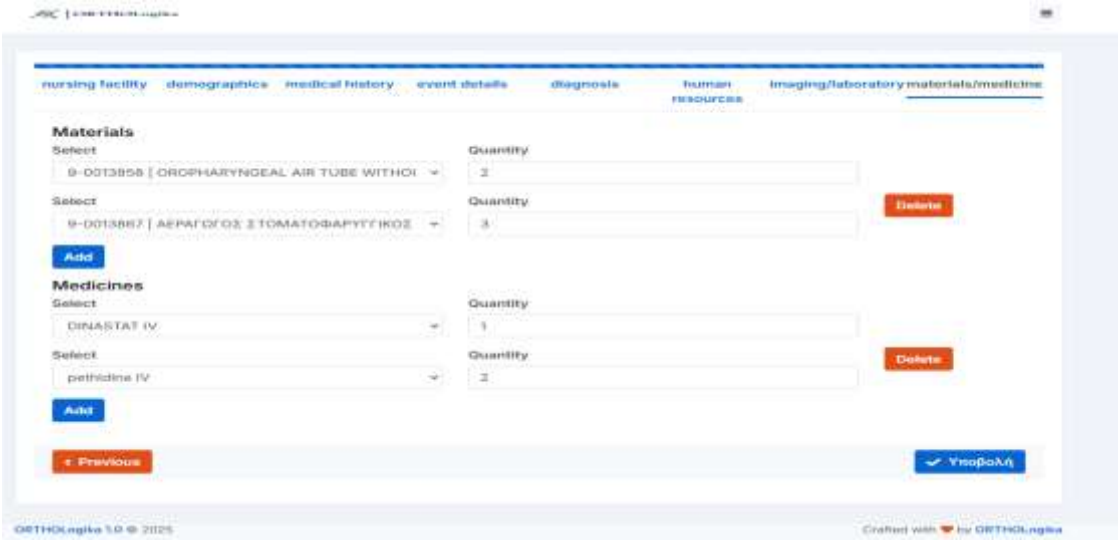

Figure 9. *Selection of Materials and Drugs and their Quantities*

Finally, having made all the entries by clicking *Submit,* we can see the total cost of all the actions that have been made. In the main menu of the application, we have the possibility to see the *reports of* the system with 6 filters as shown in the image below. (Y.I.E., hospital, diagnosis, area of injury, type of injury, doctors' specialty) but also classification of cases either by date or by cost.

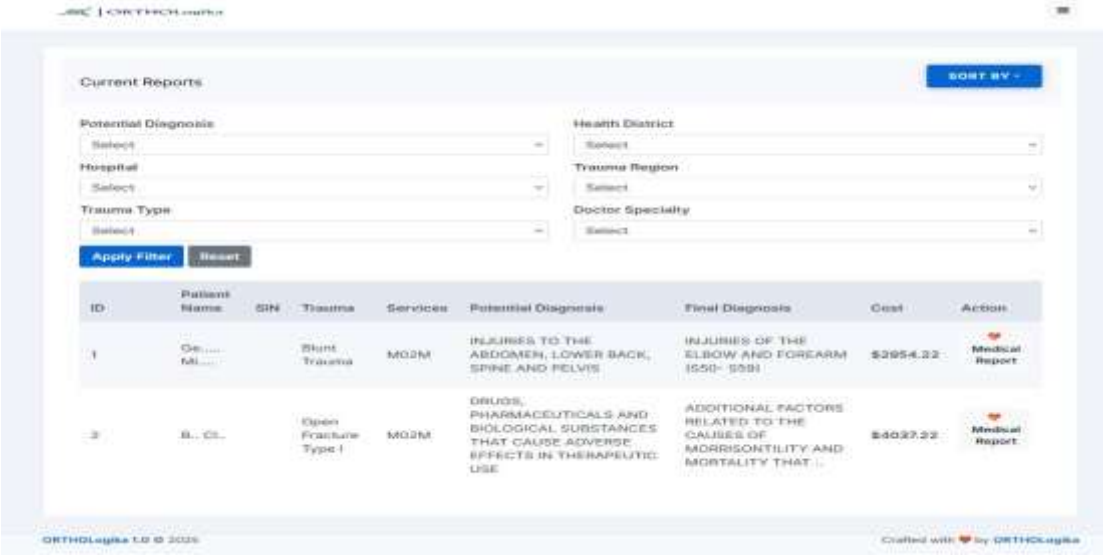

Figure 1 *Report Categories*

3. Discussion

Orthopedic trauma care in the Emergency Department (ED) represents a substantial expense, accounting for approximately 25% of all ED cases and a similar proportion of the ED budget (Bauer et al., 2016). High costs pose sustainability challenges, particularly when treatment involves emergency management by general or surgical specialists prior to transfer to organized orthopedic centers, which does not reduce overall expenses. Research indicates that care at dedicated orthopedic trauma centers significantly lowers costs, whereas delays and severity of injury increase expenditures (Pean et al., 2022; Baitzer et al., 2023). Contributing factors include advanced imaging, intravenous medications, and specialized personnel requirements (Bauer et al., 2016). The ORTHOLogika software addresses these challenges by providing case-specific recommendations, enabling timely, informed decision-making based on synthesized clinical and operational data (Comfort et al., 2013). By optimizing the allocation of human and material resources, minimizing overuse, and expediting responses, the application reduces waste and enhances efficiency (Altay & Green, 2006; Chen et al., 2008). Overall, ORTHOLogika supports effective resource management in emergency orthopedic care, promoting cost containment while maintaining high-quality patient outcomes.

4. Conclusions

Both the literature and the architecture of the ORTHOLogika software highlight the critical role of emerging technologies in supporting healthcare professionals. Such tools enable faster, more accurate decision-making in emergency scenarios while optimizing resource use to achieve effective therapeutic outcomes with minimal waste. ORTHOLogika addresses gaps in procedure cost assessment and real-time resource tracking for orthopedic injuries in the Emergency Department. By integrating data on material costs and government reimbursements for medical personnel, the software empowers clinicians to select the most effective diagnostic and therapeutic strategies through its recommendation system, enhancing both clinical efficiency and cost-effectiveness.

5. Restrictions

The development of the ORTHOLogika information system is a research tool and there are restrictions on the collection of personal data of both patients and the human resources involved in the treatment of emergencies, as this defined by the European personal data regulations (EU Regulation 216/679 27^{h} April 2016 and incorporated into the national legal system (GDPR - General Data Protection Regulation) N 4624/2019 (Government Gazette A' 137/29-08-2019).

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