

# Building a System for the Hospital's Emergency Departments Based on the Queuing Theory

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**Abstract** - Reducing the waiting time in the emergency departments is one of the most important factors that saving lives depends on, which means every minute we have is saving someone else life. In a traditional system, doctors and the other health care staffs waste about 15 to 25 min's on average to check the patient information which is considered too much time in such cases. The proposed system handle this problem by designing a queuing model, that takes the patient's initial information within no more than five minutes, and then classifies his health situation, using the Canadian's system which is determined health case using one of the different five colors (grey: Non-Urgency, green: Less Urgency, yellow: Urgency, red: Emergency, blue: Resuscitation case); Thus, the medical staff can deal with the cases in the proper order. Also, the proposed system records the patient's arrival time (AT), so that the ordering in the queue done correctly in case of more than one patient is classified in the same medical case. Eventually, the researchers implemented the system as a desktop application using Python programming language to design the main interfaces, and SQL to design the databases.

**Keywords:** Queuing theory; Queuing model; Queuing systems; Emergency room; Emergency department; Medical systems; Hospital management; waiting time.

## I. INTRODUCTION

Patient expect a good and fast treatment, even when he has a simple or case. What are medical staffs should do at emergency department? What are their missions? And their role in providing service and how are patients treated? What are the cases that need fast treatment? And how are these cases get sorted?

Hospitals face the issue of cases queuing for their patients in the emergency department, which lead them to lose the efficiency of their service.

In this model the researcher classified cases into categories depending on patient health situation. And, when there are many patients in the same level, deal with them according to their arriving time. Considering that the waiting time is one of the most important factors determining the quality of health services provided.

Often, the emergency department is so crowded in any hospital, which needs to rearrange all time. So, this designed system aimed to provide an electronic, auto updated case panel showing patients information in different colors. The emergency department needs to manage the information which is going to be displayed on the screen to help to improve services.

The system will have a significant impact, as it is compatible with the Canadian system [1] which is used by the ministry of health in the Saudi Arabia kingdom hospitals. On the other side, other hospitals outside can customize it according to their needs.

The system will arrange all patient details, and makes it reachable to the staff, so doctors can treat more patients and there will be no long queue, which is good for both.

The system will show patient information on a large screen, so the medical staff working at the emergency department can see it, (what is patient initially diagnose, And who will see a doctor next).

## II. RELATED WORK

As in [2], system designed for emergency centers in New Zealand, and it depends on direct video communication between the patients and emergency department staff, before

they directed to the hospital, and before they reach the staff will classify the case. This application reduces waiting time for patients by sorting cases and directing them remotely before reaching the emergency center; eliminating number of patients who do not need an emergency service, make the staff can focus on emergency cases. On the other hand, the application is designed to work in New Zealand hospitals, it is a custom application, and therefore needs to redesigned in case of deploy it outside New Zealand, while the proposed system depends on the Canadian which can be applied everywhere. Furthermore [2] classified patients into only two categories emergency and non-emergency, while the proposed system classified patients into 5 categories based on the Canadian system.

In [3] the main function of the system is locating medical centers near the patient geographically through GPS, calculating the arrival time. Also, it Links the NHS medical site to record information (expected waiting time or destiny and the quality of the injury and the degree of classification), which reduces the time allocated for treatment as well as reduced the arrival time, waiting time, sorting time and classification. Finally it records the symptoms and complaint of the patient before arrival.

But it is limited to the emergency facilities that developed for, while the proposed model is based on a general system that can be applied in any emergency department, effectively organizes queues based on the classification accuracy and the actual arrival time, thus reducing the expected waiting time for other cases.

In [4], the system uses a colorful screen (5 colors) numbered from 1 to 5 by Canadian classification of priority cases where the number 1 of the red bar means (Very Dangerous), 2 Orange (Unstable Critical), 3 Yellow (Stable Sickness), 4 Green (Very Stable), 5 Blue (Non-Emergency), Number of Waiters (patients in queue) and Waiting time for all Registered Cases.

The project reduces the waiting time by distracting the medical staff of the highest priority cases with appropriate waiting times for other cases. System lacks the ability of calculating the expected waiting time for each patient, while the proposed system added feature of recording the arrival time, so that it calculates the expected waiting time depending on case classification and the arrival time, even when there are several cases with the same classification reach the department in times close to each other.

All the previous solutions focused on arranging patients according to their health situation or their arrival time. In the proposed model, each case will be sorted according to both the arrival time and the medical situation of each.

### III. BACKGROUND

Before we move on to building the model we must define some important terms, which include:

“A **queuing theory** is the mathematical study of the congestion and delays of waiting in line. Queuing theory examines every component of waiting in line to be served, including the arrival process, service process, number of servers, number of system places, and the number of customers—which might be people, data packets, cars, etc.”[5]

**The emergency department**, or accident and emergency department (ER), is a medical treatment department in hospitals for urgent cases that cannot wait for any role, where the emergency doctor is called and in turn he performs the necessary first aid such as stopping the bleeding if the patient is bleeding, then determines the specialist doctor who is called To remedy the situation. Most of the cases that come to the emergency department are from traffic accidents or ambulance cases.

**The Canadian system** is determined each case with a specific color:

- Non-Urgency: classified by grey and it's the case which we can let the patient wait for less than 120 mins, the color will turn to Purple if he will wait.
- Less Urgency: classified by green, he will wait less than 60 mins.
- Urgency: classified by yellow, he will wait less than 30 mins.
- Emergency: classified by red, he will wait less than 15 mins.
- Resuscitation: classified by blue, which means see patient immediately.

The Arrival time means the time the patient arrives at the hospital's emergency department, abbreviated by AT in this work.

### IV. METHOD

#### a) Proposed Process

Firstly, the data entry “better to be a nurse” should enter the patient information and determine the level of the medical situation after the initial examination “the database allows only authorized users”. Secondly, the database accepts a number of requests include adding patient data, delete or modify it. The system display the patient's arrival time and other data that follows him, as well as his health situation represented in a specific color “according to the Canadian system”.

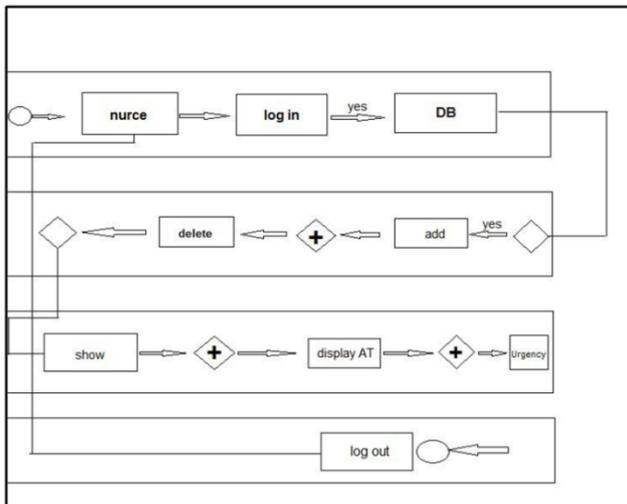


Figure 1: Proposed Business Process

**b) Proposed system functional requirements**

The proposed system includes the following requirements:

1. With regard to the emergency department, the main requirements to be store in the database is the basic information, such as Dept. no, Dept. name, capacity, number of medical staff... etc; allow update of these information and search permissions with different criteria.
2. With regard to the Patient, the requirements are the ability to store patient’s information including ID, name, gender, medical status and the arrival time.
3. With regard to the data entry user “probably nurse”, the requirements should include login with valid user name and password, entering patient’s information and update it.

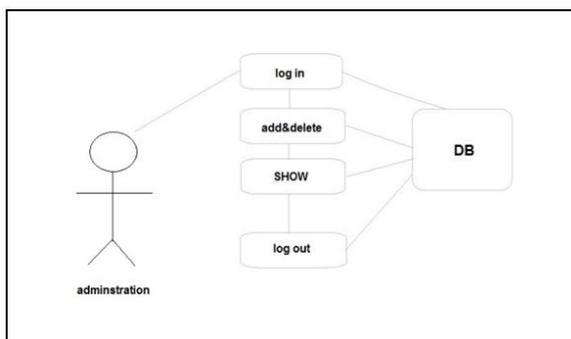


Figure 2: Use case for Functional Requirements

**c) System Modelling**

System modelling is the process of developing abstract models of a system, with each model presenting a different view or perspective of that system. It’s about representing a system using some kind of graphical notation, which is now based on notations in the Unified Modeling Language UML [6].

**1. Activity diagrams**

The following activity diagram is drawn with all activities of the proposed system.

The Figure 3 shows the process of using the system, Starting with making a choice, whether the user has an account to log in or make a new one ( which can get the accessibility to login from the system administrator); so, the system have four choices:

1. **Patient**, which use to enter a new patient’s information.
2. **Show**, which display the other patient’s information with the colors.
3. **Manage**, which give a choice to delete any patient information from the system by entering his ID. no.
4. **Logout**, which allow user to sign out.

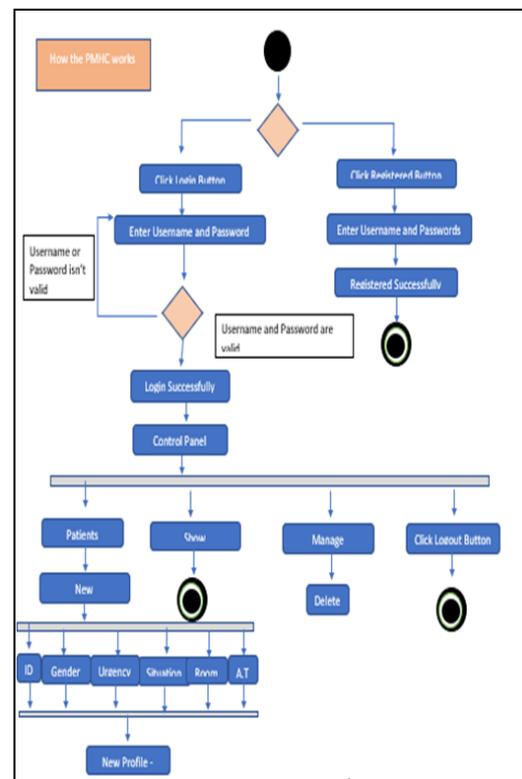


Figure 3: Activity Diagram

**2. Class Diagram**

The class diagram shows the objects, their properties, the operations of each object and the relations between these objects. The system consists of the following classes as shown in figure (4).

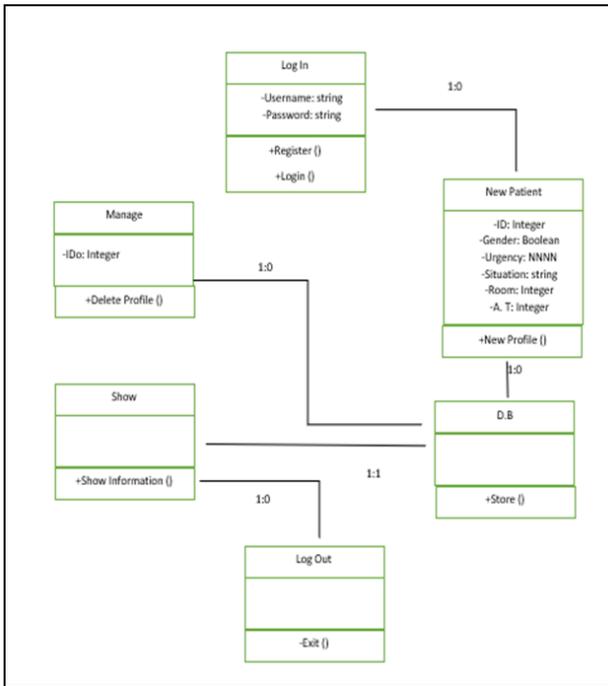


Figure 4: Class Diagram

### 3. Sequence Diagrams

The sequence diagram shows the order in which activities are carried out in chronological order.

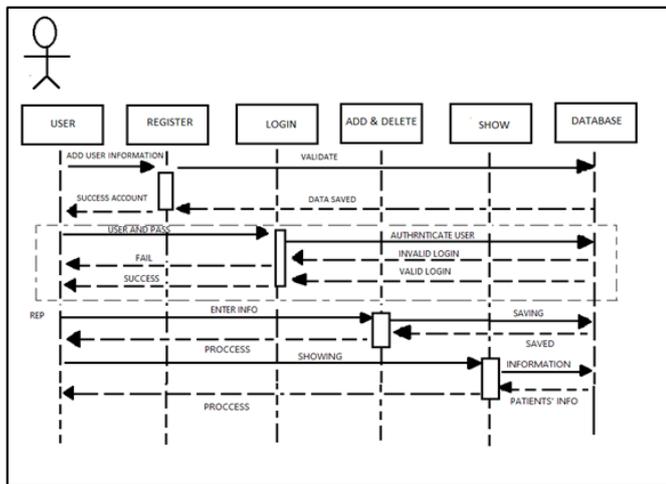


Figure 5: Sequence Diagram

As shown in figure 5 the sequence diagram shows the system functionalities, which are:

1. **Log in**, allow user to access system.
2. **Add & Delete**, allow the user adding a new patient or to deleting is record by entering the ID. no.
3. **D.B**, where the data will be stored. Then can be able to manage the data by rolling back to the last step.
4. **Show**, display the patient's information with colors.
5. **Logout**, allow the user sign out of the system.

### d) Data Modelling

#### 1. Entity Relationship diagram

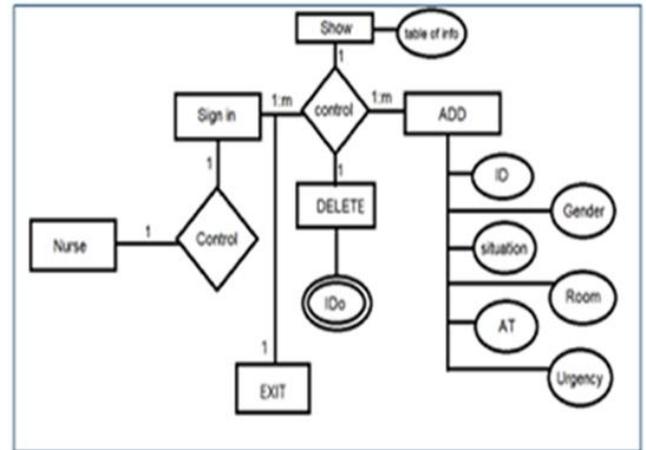


Figure 6: Entity Relationship Diagram

This figure shows the relationship between system entities.

#### 2. Data Dictionary

As shown in table1, the researcher designed the data dictionary to build the system database.

#### 3. Component Diagram

Figure 7 shows the component diagram which designed to help model implementation details and double-check that every aspect of the system's required functions is covered by planned development.

Table 1: Data Dictionary

Data	Type	Description
Username	String	The system user valid user name
Password	String	The system user valid password
ID	Integer	The identification numbers.
Gender	String	Whether a Female or Male.
Situation	String	The healthcare situation "diagnoses"
Urgency	String	The Urgency color (high-low).
Room	Integer	The room numbers.
A. T	Integer	The Arrival Time.
Add	String	Add a new patient's profile.
Delete	Integer	Delete a patient's profile.
Show	String	Show patient's information.
New Profile	String	Make a new profile for a patient.
DB	String	Store the data inside it.
IDo	Integer	Identification number for the database.

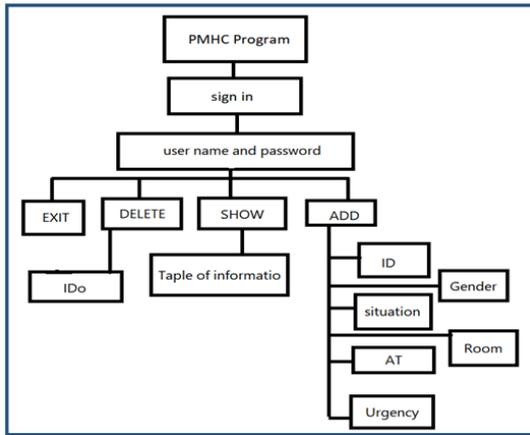


Figure 7: Component Diagram

e) Programming Language

Python is a dynamic, high level, free open source and interpreted programming language. It supports object-oriented programming as well as procedural oriented programming. It has many features made the researchers choose it to implement the system. One of them is that it is free and open source, and also, it is portable language, which helps users to run programs designed on any platform. The researchers took advantage of these features in implementing the system. [7]

f) System Requirements

The system requires a computer with RAM 256 MB, 1 GHz processor, 40 GB hard disk as minimum. And windows or Mac operating system to work efficiently.

V. SYSTEM TESTING

a) Features to be tested

1. Log in: which allow user accessing the system
2. Register: Adding a new user
3. Add: Adding a new patient profile
4. Show: show patient information
5. Delete: delete patient record
6. Logout: log out of the system

b) Test Cases

Table 2: Valid log in test case

Test Case #1	
Test Case	Valid log in
Test Priority (Low/Medium/High)	High
Test Title	Verify login process
Description	Test user log in with a valid username and password.

Pre-conditions: User has a valid username and password					
Dependencies:					
Steps	Test Steps	Test Data	Expected Result	Actual Result	Status (Pass/Fail)
1	Provide valid username	Asaiyl	The user is authorized to login		
2	Provide valid password	1234	login	The user is navigated to profile in program	Pass
Result: The username and password have been validated, and the account is logged in					

Table 3: Invalid login test case

Test Case #2					
Test Case			Invalid Log in		
Test Priority (Low/Medium/High):			High		
Test Title			Verify invalid login process		
Description			User try to log in with invalid username or password.		
Pre-conditions: User has invalid or wrong username and password					
Dependencies:					
Steps	Test Steps	Test Data	Expected Result	Actual Result	Status (Pass/Fail)
1	Provide username	Name= asaiyl123	Reject login	the message will be appeared (The username or password is Wrong)	Fail
2	Provide invalid password	Password= 5781			
Result: The user fails to log into the database, and then the login is denied					

Table 4: Register test case

Test Case #3					
Test case			Register		
Test Priority (Low/Medium/High):			High		
Test Title			New user system registration		
Description			Test the ability to add a new user.		
Pre-conditions: Provide a valid username, password and new user information.					
Dependencies:					
Steps	Test Steps	Test Data	Expected Result	Actual Result	Status (Pass/Fail)
1	Provide valid username	Mohammed	The user should be able to register	The user is navigated to register	Pass
2	Provide valid password	1234			
3	Click on the button register				
Result: The user is registered and validated in the database.					

Table 5: Add test case

Test Case #4					
Test Case			Add		
Test Priority (Low/Medium/High)			High		
Test Title			Adding patient profile		
Description			The ability to add patient information in the system		
Pre-conditions: Availability of patient information and health status					
Dependencies:					
Steps	Test Steps	Test Data	Expected Result	Actual Result	Status (Pass/Fail)
1	Log into system	Mohammed 1234	Accept log in information	Successful login	Pass
2	Click on the button add	Id, gender, room number	Add	The user can add data	Pass
Result: The user succeeds in adding new patient record to the database.					

**Table 6: Show test case**

Test Case #5					
Test Case			Show		
Test Priority (Low/Medium/High)			High		
Test Title			Show patients information on monitor.		
Description			Test the ability to display patient's information on monitor.		
Pre-conditions: Authorized user, and information to be display.					
Dependencies:					
Steps	Test Steps	Test Data	Expected Result	Actual Result	Status (Pass/Fail)
1	Click on the button show	Id, gender, healthy case classification, room...etc.	show	Display information	Pass
Result: The information is displayed on the monitor with different colors.					

**Table 7: Delete test case**

Test Case #6					
Test case			Delete		
Test Priority (Low/Medium/High)			Med		
Test Title			Delete patient's profile		
Description			Test the effectiveness of deleting one or more patients' record.		
Pre-conditions: Authorized user, and stored patient record.					
Dependencies:					
Steps	Test Steps	Test Data	Expected Result	Actual Result	Status (Pass/Fail)
1	Click on the display button				
2	Click on the Delete button	Id1 delete	Delete	Delete id1	pass
Result: User successfully delete one or more records.					

**Table 8: Log out test case**

Test Case #7					
Test Case			Log out		
Test Priority (Low/Medium/High)			High		
Test Title			Verify log out of the system		
Description			Test the validity of log out bottom		
Pre-conditions: A logged in user					
Dependencies:					
Steps	Test Steps	Test Data	Expected Result	Actual Result	Status (Pass/Fail)
1	Navigate to log out button				
4	Click on the Log out button	Log out	Log out from system	Log out from system	Pass
Result: The user logged out successfully.					

## VI. RESULT AND DISCUSSION

As a result, a system for the emergency department has been built depending on the Canadian system, which achieves its functionalities as mentioned below.

When the system starts, a welcome interface appears as in figure (8), which includes registration and login buttons to allow user login or register a new account.



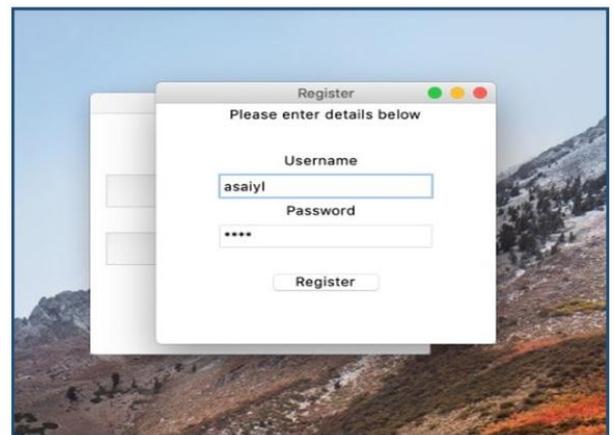
**Figure 8: Welcome Interface**

When a user click on log in bottom, a log in window appears, only authorized can login.

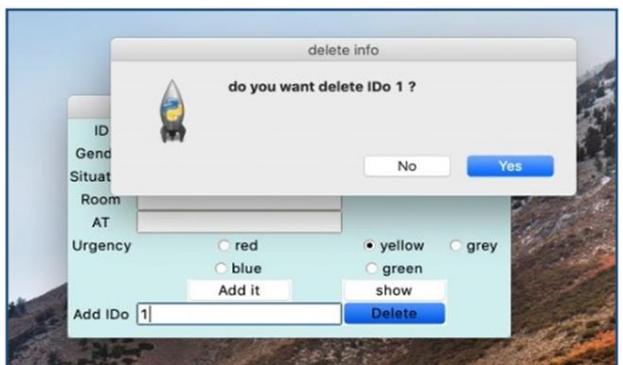


**Figure 9: Login process**

Figures (10) and (11) show the registration for a new system user.



**Figure 10: Registration**



**Figure 11: Registration success**

Figure (12) shows home page, where authorized user can add a new patient profile, show information, or delete a stored record.

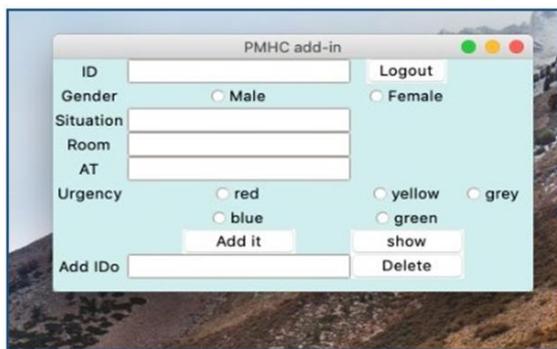


Figure 12: Home page

Figure (13) shows adding a new patient profile steps.

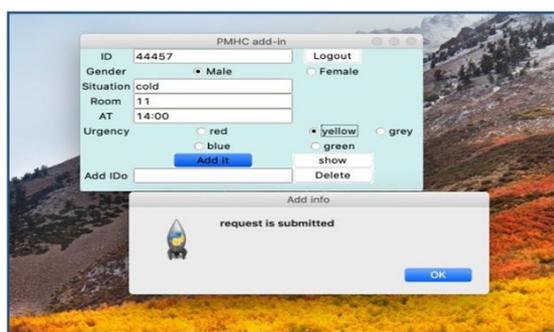
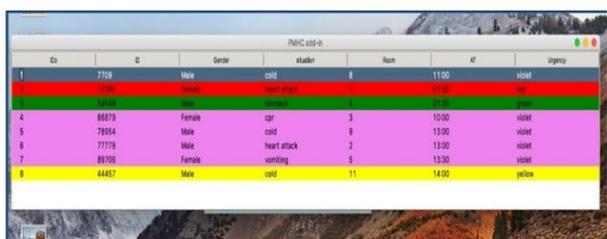


Figure 13: Adding a new patient profile

Figure (14) shows the sorted patients information with different colors, according to the Canadian system and patient arrival time.



ID	C	Gender	Status	Room	AT	Urgency
1	7759	Male	cold	8	11:00	violet
2	7759	Male	heart attack	8	11:00	red
3	7759	Male	heart attack	8	11:00	green
4	68873	Female	cpr	3	10:00	violet
5	78934	Male	cold	9	13:00	violet
6	77778	Male	heart attack	2	13:00	violet
7	80795	Female	swelling	5	13:30	violet
8	44457	Male	cold	11	14:30	yellow

Figure 14: Display monitor

Authorized user can delete a patient record, by his ID number, as shown in figure (15).



Figure 15: Delete a patient record

## VII. CONCLUSION

A queuing model system is built depending on the Canadian system, and implemented using python and SQL programming languages. The system performs number of tasks, include adding a new patient profile, deleting an existing one, and the most important task is showing sorted patients' information in different colors depending on their health situation and arrival time. Also, one of the main functionalities is to have an electronic control panel to observe patient's status from sign in till the leaving decision.

## REFERENCES

- [1] Gilboy, Nicki; Tanbue, Paula,; ESI - A Triage Tool for Emergency Department Care, Boston: Harverd Medical School, 2011.
- [2] "Emergency Q," [Online]. Available: <https://www.emergencyq.com/>. [Accessed 2020].
- [3] H. & C. I. Network, "NHSquicker," [Online]. Available: <https://nhsquicker.co.uk/>. [Accessed 22 May 2020].
- [4] K. A. U. HOSPITAL, "SHIFAA," King Abdulaziz University Hospital - Information Technology, 2017. [Online]. Available: <https://shifaa.kau.edu.sa/default-en.aspx>. [Accessed 22 May 2020].
- [5] W. KENTON, "Investopedia," Dotdash, 10 Jul 2019. [Online]. Available: <https://www.investopedia.com/terms/q/queuing-theory.asp>. [Accessed 23 May 2020].
- [6] Sommerville Ian, 2011. Software Engineering 9th Ed, Pearson Education Inc, USA.
- [7] MKS075, "GeeksforGeeks," [Online]. Available: <https://www.geeksforgeeks.org/python-features/>. [Accessed 11 June 2020].

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