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Waiting in the Emergency Department: Dynamics of Patients' Vital Signs

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Waiting in the Emergency Department: Dynamics of Patients' Vital Signs

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Abstract

Most Emergency Departments (ED) use a sorting system to distinguish between patients who require immediate attention and those who are stable enough to wait. However, the order within a group is determined using the First Come-First Serve (FCFS) principle. This policy may lead to the incorrect assumption that a patient's severity is time dependent meaning that patients that have waited longer might have a higher severity. This work presents the results of an empirical study where patients' vital signs were monitored continuously while they were waiting in the ED. The patients' medical priority was reassessed according to the dynamics of their vital signs. Forty seven patients were assessed in a hospital. The results show that there were cases where a patient's condition improved during their waiting time. However, there were other cases where the patient degraded to the point where a physician had to intervene with the normal process and move the patient in front of the waiting list or request immediate attention for the patient.

Keywords
Vital signs, Triage, Healthcare, Emergency Department (ED)

1. Introduction

In order to recognize who is most in need of care, most Emergency Departments (ED) use a triage system to sort patients by severity of illness or injury [1, 2]. Triage is a term used to mean the sorting of patients for treatment priority in EDs [3]. This system is used to distinguish between patients who require immediate attention and those how are stable enough to wait. However, the order within a group is determined using the First Come-First Serve (FCFS) principle. This policy may lead to the incorrect assumption that the patient's severity is time dependent. In addition, the triage process may result in long waiting periods during which vital indicators of patients with apparently less urgent problems are not monitored. This may lead to inadvertence of patient deterioration.

While some medical research have made suggestions about bettering present triage system [4, 5], a major drawback continues to revolve around its dependency on the vital indicators originally measured by ED staff and not followed sequentially over the usually critical waiting period. This work presents an empirical study where patients' vital signs were continuously monitored while waiting in the ED.

Several vital signs such as temperature, respiratory and pulse rates were constantly measured by electronic devices and displayed in a computer screen. The data collected for most of the vital signs was examined every 3 to 5 minutes. Blood pressure was verified every 20-30 minutes. If critical changes occurred, patients' medical priority was immediately increased. The objective of the study was to periodically monitor the vital signs of waiting patients and increase their medical priority with the deterioration of vital indicators.

The rest of the paper is divided as follows. Section two contains a brief literature review on triage and waiting in the ED. Section three presents a brief description of the location of the study, the materials, subjects and procedure. Section four presents the results of the study while section five provides some conclusions and recommendations.

2. The Triage: Sorting and Waiting

Triage is a dynamic process in decision making where patients are prioritized according to their medical condition and chance of survival on arrival at the ED [1]. EDs in countries such as Australia and Canada have developed their own five-level acuity system. For example, Australia uses the Australasian (National) Triage Scale [6], Canada has the Canadian Triage and Acuity Scale (CTAS)[2], and the UK implements the Manchester Triage system[7]. Some EDs in the United States use a three-level system even though in the last few years five-level systems have gained acceptance as researchers have demonstrated the effectiveness and reliability of these when compared to the three-level system [8-10].

The triage system inevitably results in waiting periods, especially for those with less acute problems [11]. Patients who have been catalogued as non-urgent may encounter waiting times between 30 minutes and 2 hours [12]. This is true not only in the US but in other countries as well such as Canada, Australia, Great Britain, and Taiwan [13].

Vital signs such as heart rate, respiration rate, and body temperature are dynamically changing over time. For instance, one or more vital signs of a patient might improve or worsen during the time he/she waits in the ED after going through the triage. Because of the unpredictable conditions of the ED, it can be difficult to identify patients who are seriously ill or at risk of clinical deterioration [14]. The need for vigilance for unexpected clinical deterioration in the ED waiting area continues to increase [15].

There have been reports of cases where patients have died while waiting in the ED after being seen at the triage [16, 17]. It is possible that these deaths could have been prevented by either better assessment during triage or by better patient monitoring. Some experts argue that a patient waiting to see a physician in the ED should be reassessed periodically. However, this may not be possible in an understaffed ED or an overcrowded one[18]. In fact, many hospitals have no written policy on patient triage reassessment and those that have a verbal policy do not act on it because nurses are busy receiving new patients. Accordingly, the healthcare industry must look for ways of using new technology to improve their processes.

This research focuses on the behavior of the vital signs of non-critical patients seeking treatment in an emergency department (ED). If critical changes occurred, patients' medical priorities were immediately increased. To the best of our knowledge, there is no medical literature investigating critical vital signs variations for patients waiting in the ED after being seen at the triage.

3. Methods

3.1 Location

The study was carried on in the ED of a University Hospital in Puerto Rico. The ED has a waiting area for patients that can sit 45 people. A three-level triage system is used where nurses assign colors to patients according to their criticality. Emergent patients are catalogued as red, while urgent patients are catalogued as yellow and semi-urgent patients are catalogued as green. Typically, yellow and green patients are sent back to the ED waiting area where they need to wait to be called. Even though patients that are sent to the waiting area are sorted by yellow and green, they are all called by the order of arrival. The hospital has no written policy for reassessing patients when they wait for long periods of time at the ED. Some nurses stated that there is a general non-written rule for reassessing patients every 30 minutes or every hour but this is not done because nurses are too busy either receiving new arrivals or dealing with patients that are already in the beds.

3.2 Subjects

A total of forty seven subjects participated in the study. They all participated voluntarily and they did not exhibit any major life-threatening issues during the study. The average age of the patients was 44.8 years and 59.56% of them were female. The sample age can be broken as: 59% ages 21-40, 30% ages 41-64, 11% 65 and more. A total of 62% of the patients suffered from some type of chronic disease. There was a light predominance of 18-to-40-year-old patients with chronic diseases since 41-year-old patients or older, particularly those with chronic illnesses, were more prone to arrive by ambulance or with severely decompensated medical problems, thus, requiring no ED waiting period. Figure 1 shows the distribution of the affected anatomical areas related to subjects' chief medical complaint. From the figure it can be seen that patients' medical complaints related to abdomen and lower back prevailed.

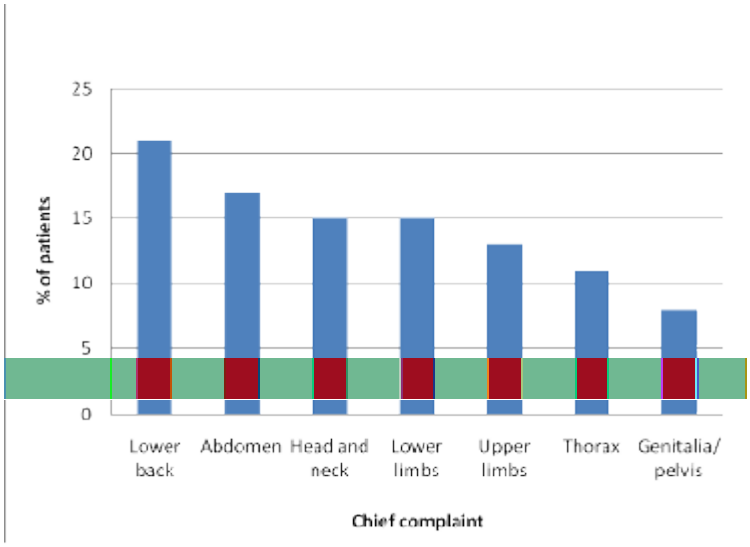
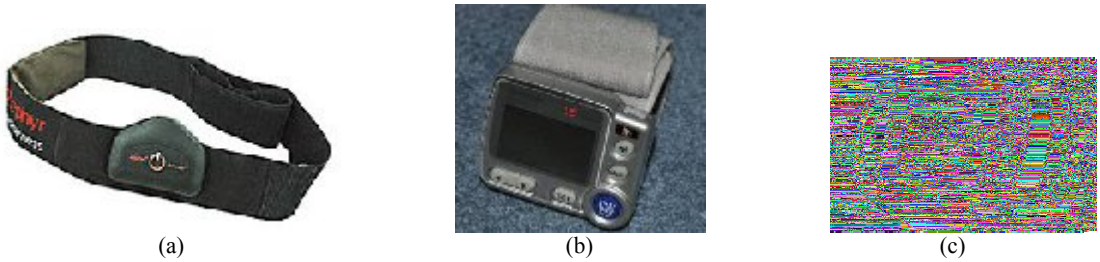


Figure 1- Distribution according to affected anatomical areas related to subjects' chief medical complaint

3.3 Materials

As part of the research it was necessary to measure the vital signs of the patients that were waiting in the ED. It was decided to use the BioHarness, manufactured by Zephyr Technology [19]. The BioHarness is a chest strap that is placed in direct contact with the skin underneath the patient's breast. It has the capability of measuring heart rate, temperature, and respiration rate wirelessly. However, for this study there were two other vital signs that needed to be measured. The BioHarness was combined with a wireless oxygen meter, model CMS-50E, which measured oxygen level (saturation) in the blood. In addition, the blood pressure was taken manually every 20-30 minutes to all the patients that were participating in the study. The Omron Wrist Blood Pressure Monitor, model HEM-670IT, was used for this purpose. All of the devices were validated against the devices used by the nurses at the triage. Figure 2 present pictures of the different devices used whereas table 1 presents a summary of the vital signs that were measured in the study.



(a) (b) (c)

Figure 2- Devices used for the study: (a) BioHarness manufactured by Zephyr Technology [19];
(b) Omron Wrist Blood Pressure Monitor model HEM-670IT; (c) Wireless Oxygen meter- model CMS-50E

Table 1- Vital signs measured in the study

Vital Sign	**Unit of measurement**	**Measured with**
Heart rate	beats per minute (bpm)	BioHarness (validated with other two devices)
Respiration rate	respirations (or breaths) per minute (rpm)	BioHarness
Temperature	Celsius (^{o}C)	BioHarness
Oxygen Saturation	% oxygen in the blood (%)	Wireless Oxygen Meter
Systolic blood pressure	mmHg	Omron Wrist Blood Pressure Monitor
Diastolic blood pressure	mmHg	Omron Wrist Blood Pressure Monitor

3.4 Procedure

Patients were approached to obtain informed consent as soon as they were called to the triage. The purpose of the study was explained to them and they were asked to accept or decline the participation at that moment. Patients needed to be alert, awake, and able to speak; cognizant; and competent enough to read an informed consent form and make an informed decision to enroll in the research. Individuals with skin or muscle conditions that might impede them from wearing the equipment such as cuts, bleeding, fractured bones of muscles, or conditions that might be transmitted through indirect contact with the skin, such as Conjunctivitis or Respiratory Syncytial Virus (RSV), were excluded to eliminate any possible harm to the patient due to the equipment or infecting other patients through the equipment. This included persons involved in a motor vehicle collision. In addition, persons with pacemakers and pregnant women were not included in the study. Participants were asked to wear the equipment while they were in the ED waiting area. Once they were called to see a physician, the equipment was removed and their participation was concluded.

During their stay in the ED waiting room, a physician was monitoring the changes in the vital signs. When important changes in vital signs occurred, the patient's medical priority was immediately increased by placing his/her medical record first to be taken by the emergency physician (EP). The following criteria would lead to placement of the patient's record next in line to be seen by the EP:

a) Blood pressure higher than 170/95 mmHg or lower than 90/60 mmHg;
b) Increase or decrease in diastolic or systolic blood pressure of more than 15 mmHg when compared to the initial basal level if measurement fell in the abnormal range (higher than 130/85 mmHg or lower than 90/60 mmHg);
c) Heart rate faster than 120 beats per minute (bpm) or slower than 45 bpm;
d) Increase or decrease in heart rate of more than 20 bpm when compared to the initial basal level if measurement fell in the abnormal range (equal or faster than 100 bpm or equal or slower than 60 bpm);
e) Respiratory rate faster than 25 respirations per minute (rpm) or equal or slower than 10 rpm;
f) Increase or decrease in respiratory rate of more than 10 rpm when compared to the initial basal level;
g) Body temperature higher than 39.0ºC or lower than 35.0ºC;
h) Increase or decrease in body temperature of more than 2.0ºC when compared to the initial basal level if measurement fell in the abnormal range (higher than 37.5ºC or lower than 36.0ºC);
i) Oxygen saturation lower than 90%; and
j) Decrease in oxygen saturation of more than 5% when compared to the initial basal level

4. Results

Figure 3 presents a summary of the distribution of the patients according to the behavior of the vital signs over time. Patients were classified in one of three groups: (1) patients that showed deterioration in one or more vital signs for which their priority had to be increased, (2) patients whose vital signs remained relatively stable, or (3) patients whose vital signs improved while waiting.

From the figure it can be seen that a total of 17 patients (36%) had their priority increased due to critical changes in at least one of the vital signs. Similarly, 22 (46.81%) of the patients had stable signs while 8 (17.02%) improved their condition while waiting. Out of the 17 patients with increased priority, 12 were female, which accounts for 25.53% of all the patients and 70.59% of the patients with increased priority. This also represents 42.85% of the female sample population.

From the figure it can also be seen that the vital signs remained relatively stable for 22 patients (46.81%) where the majority was composed of males (13 out of 22). Finally, there were a total of 8 patients that had significant improvement in their vitals during their waiting period. This group was dominated by females (7 out of 8).

A correlation analysis was performed to investigate if there was any relationship between the behavior of the vital signs and age. The results show that, for this sample, there was no correlation between the age and the behavior of the vital signs ($\rho = -0.04925$).

One interesting finding was the fact that no patient fluctuated between the groups. This is partially due to the fact that patients that fell in the increased priority group were immediately seen by the physician and thus their participation was concluded at that time. However, patients whose vitals improved never showed signs of going back to their initial basal level or worsening of the vitals.

Another interesting finding was the fact that among all the vital signs measured, blood pressure resulted in the most useful and consistent indicator of a need for a priority change while body temperature was the least important. Thirteen out of the 17 increased-priority group (76.5%) had critical changes in blood pressure and only 1 (6.0%) needed his priority increased due to important changes in temperature. Three other patients had changes in heart rate with two of them being related to an increase in beats per minute (bpm) while the other one had a decrease bellow the lower limit.

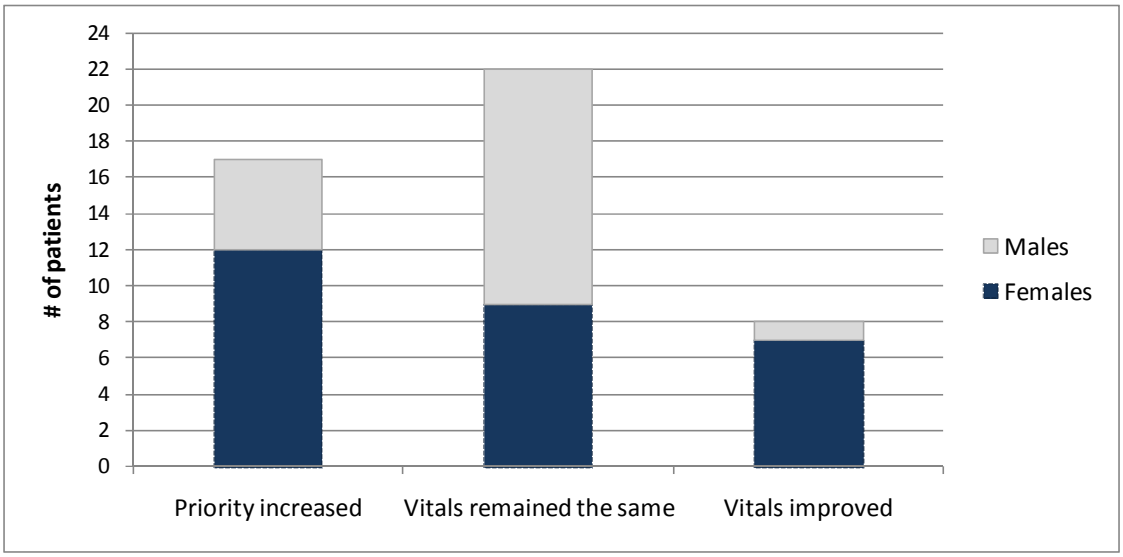


Figure 3- Distribution according to behavior of the vital signs

Table 2- Top five most outstanding cases according to the researchers (in no particular order)

Age	Gender	Chief Complaint	Critical Vital Sign(s)	Initial Reading	Final Reading (before intervention)	Time Between Initial and Final Reading
47	F	Shoulder pain after a fall	Blood Pressure and Heart Rate	BP: 121/78 mmHg; HR: 101 bpm	BP: 176/94 mmHg; HR: 118 bpm	60 min.
49	F	Knee pain	Blood Pressure	BP: 167/97 mmHg	BP: 208/110 mmHg	25 min.
80	F	Pain in right inner tight	Blood Pressure	BP: 170/83 mmHg	BP: 215/95 mmHg	65 min.
62	F	Headache, left arm pain	Heart Rate	HR: 62 bpm	HR: 40 bpm	32 min.
27	M	Back and neck pain	Blood Pressure	BP: 172/93 mmHg	BP: 198/110	25 min.

Table 2 summarizes the top five most outstanding cases according to the researchers. The two criteria for ranking the cases were: (1) the criticality of the change in one or more vital signs; (2) the time interval for the changes. For example, the second patient had an increase of 32 mmHg for the systolic blood pressure in just 25 minutes. Similarly, the fourth patient in the table had a decrease of her heart rate down to 40 bpm just 32 minutes after being seen at the triage. She was complaining of a headache and pain in the left arm. Knowing this type of information can help nurses and doctors to contemplate the situation and take preventive action before any alarming situation come to pass.

Some of the cases demonstrate the severity of the change in the vitals while others demonstrate how fast the vitals can change. The results provide evidence of the effectiveness and necessity of continuously measuring the patients' vital signs after triage or perhaps even before triage. It shows that technology can be used to detect those patients that are deteriorating and take action before any major complication emerges. Integration of wireless sensing technology during ED waiting period provides an opportunity for prompt detection of critical changes in vital signs [20-22], thus, aiding in adequate ED patient prioritization and rapid medical care delivery. In fact, Claudio et al. [22] proved that patients and nurses have a positive reaction to the technology and the concept of continuous monitoring, which should be encouraging for the implementation of the technology in the ED.

The results suggest that the vital signs should be treated as dynamic variables and that the technology and the concept of continuous monitoring are needed. Periodical vital signs monitoring in patients who wait in the ED may detect critical changes that should prompt urgent medical management to avoid further decompensation, thus, leading to a better clinical outcome.

Since blood pressure monitoring was the leading indicator that led to the promptly detection of patients' increasing medical need during ED waiting period, periodic measurement of this vital sign alone might be a reasonable alternative to the constant full vital signs monitoring.

5. Conclusions

This paper presents an empirical study where patients' vital signs were monitored continuously while waiting in the ED. The patients' acuity was reassessed according to the dynamics of their vital signs. The results showed that there were cases where the patient's condition improved during their waiting time. However, there were other cases where the patient degraded to the point where a physician had to intervene with the normal process and move the patient in front of the waiting list or request immediate attention for the patient.

The research evidenced the effectiveness and necessity of continuously measuring the patients' vital signs after triage or perhaps even before triage. It showed that the technology can be used to detect those patients that are deteriorating and take action before any major complication emerges. Future research should focus on investigating the changes of the vitals with more patients.

Perhaps, with a larger number of subjects, the analysis could be clustered by condition or chief complaint. Another point that should be investigated is on any possible correlation of the deterioration of one or more of the vital signs with any pre-existing condition. Finally, there are some opportunities to investigate how the classical quality control tools can be applied to the monitoring of the vital signs.

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