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Experiences of Using a Mobile RFID-Based Triage System

Jokela Jorma[1]*, Laapotti Heli[2], Engblom Janne[3] and Harkke Ville[3]

[1]Laurea Simulated Hospital, Laurea University of Applied Sciences, Hyvinkää, Finland
[2]Päijät-Häme Social and Health Care Group, Centre for Prehospital Care and Emergency Medicine Lahti, Finland
[3]Turku School of Economics, University of Turku, Finland

Abstract

A number of triage support systems which use Radio Frequency Identification (RFID) have been introduced in recent years. This paper will focus on one mobile triage system; known as "mTriage" The purpose of this paper was to determine the applicability of Radio Frequency communication (RFID) technology and a "mobile triage" system in a simulated multicasualty situation by examining the system's performance during a military winter exercise in Finland year 2009. This paper focuses on the medical personnel's opinion on this matter, answering the question: Are the medical personnel who use the system in the field satisfied with its performance.

Several field medics were asked to complete a questionnaire. The results of the evaluation were mainly positive. Conclusion was that mobile triage has potential to contribute to the management of mass casualty situations.

Keywords: Triage; Radio frequency identification; Mobile technology and simulation

Introduction

Triage is used daily by the emergency and health care workers around the world. It is a very important tool when processing and categorising casualties. In mass casualty events, those with severe, life-threatening injuries may receive a lower priority than those with more survivable injuries. [1]. According to Szul [2] triage is an attempt to make order during chaos and to make an overwhelming situation manageable. There is no standardised system of triage and several are in use throughout the world. The most common classification uses the four-colour code system: red signals high priority, yellow for medium priority, green is used for ambulatory patients and black for deceased [1].

This paper sets out to examine the applicability of a digital triage marking system for mass casualty situations. We present the findings of a field test conducted during a military field exercise. This paper is organized as follows: First we introduce the existing methods for triage tagging, including the mTriage system that is under study here. Then we define the test setting and methodology and present the results of the tests. In the final chapter we discuss the implications of the findings for managing mass casualty situations and needs for further research.

All prehospital triage systems have different documentation methods. Primitive types are based on paper tags, and others on triage tags with Radio Frequency Identification (RFID) or other wireless "intelligent" tags. Most of the current mass casualty triage systems still rely on a paper triage tags on which rescue and medical workers write the casualties' triage status and limited medical information [3,4].There are different methods for marking the paper tags, either by writing on them or by making tears on designated spots. Regardless of the type the paper tags have serious limitations. The space for recording medical information is very limited. The "tear-off" triage tags allow only unidirectional changes in casualty's condition. Paper triage tags are not weather proof and are easily destroyed [5]. According to Gao et al. [6] paper triage tags are difficult for responders to update the triage color at the designation easily, tags have little room for manually write the vital signs and complaints and reading tags can be difficult because casualty information recorded is poorly written. Baker [7] wrote how important is to retriage casualties at every medical facility in their travel and how triage priority may also be altered by new findings.

Castren et al. [8] states that triage tags should show who gave treatment to casualties, who made decisions about what kind of treatment of care to give, which unit transported the casualties and what treatment facility were used. This is something that paper tags cannot always do; because there is not enough room to write to the required information.

Mobile systems of triage have recently been introduced. Newer methods are using triage tags with Radio Frequency Identification (RFID) or other wireless "intelligent" tags for casualty triage and tracking. These systems promise to produce accurate and on time information on victims status and triage class in the field [3]. Medical command must coordinate the number of casualties and their needs with the known availability of resources, such as on-scene medical personnel, ambulance locations, and medical capacities. Real-time information is also critical to determining the appropriate patient destination, the type of injuries and the capabilities of the receiving facilities [5, 9].

According to the researchers working on the Finnish project, getting relevant information about casualty location, numbers and categorizations to the command center has taken up to 24 hours in previous exercises.

Triage tags with Radio Frequency Identification (RFID) or other wireless "intelligent" tags might be the future of systems for both identification and tracking the casualties [7]. Real-time information is critical to overall management of field medical care [3].

Chan et al. [4] write that information technology used in

***Corresponding author:** Jokela Jorma, Laurea Simulated Hospital, Laurea University of Applied Sciences, Hyvinkää, Finland, E-mail: Jorma.Jokela@laurea.fi

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emergency health care should be easy to use. Effective training should also be provided. Lack of adequate training has prevented deployment of many systems [10]. Patient tracking devices would need to be small, durable and rugged enough to withstand environmental and manmade elements.

Background

A number of types of triage have been introduced in recent years. Technology has been combined with triage through the use of barcodes, tag readers, passive RFID tags, hand-held computers, and geolocation to collect data about the mass casualty events [11]. Rapid triage with flexible data management is vital in response to emergency care. RFID technology is making its way into emergency health care to enhance emergency data management. This article will focus on a RFID triage system, mTriage.

mTriage

The mTriage system is based on RFID technology, Nokia Field Force Management Solution using Near Field Communication (NFC) and WM-data (is part of CGI) mTriage software. The medical personnel on the field used the triage system via a Nokia 5140i phone and RFID mTriage tags. The system is specifically designed to triage and track casualties in the battlefield [12].

Medical personnel have their own RFID tags-(B) and casualties their own personal tags-(A); one per person. Instead of writing- and hand-collecting, the triage information is transmitted to the system via nokia 5140i phones, used by medical personnel. When casualties transported forward to medical facilities, the RFID tags carry the triage information [12].

Casualties are classified to four triage categories; immediate, delayed, minor and dead. Triage category at the tag is possible to change if needed by the medic or the medical personnel at the medical facilities [12].

Methods

The purpose of this paper is to determine the applicability of Radio Frequency Identification (RFID) technology and commercial cellular networks to provide an online triage system for handling mass casualty situation. The system was tested during a military exercise in actual field conditions. The users are field medics who received the standard Finnish military medical training.

The usability of the new triage system is evaluated with a standard post-test questionnaire, with 19 questions regarding the field medics' subjective confidence in the personal use, general use and applicability of the system. Free comments are allowed to be made at the end of the questionnaire [12,13].

The questionnaire is divided into five groups, each one dealing with a different aspect of the user experience: overall reactions to 1) reading the tag, 2) technology, 3) time consumption, 4) triage and 5) training.

Field medics in the exercise are given a personal RFID tag and a Nokia 5140i phone with integrated RFID reader/writer and mTriage software from a division of Logica.

Several medical facilities and 5 evacuation vehicles are equipped with the RFID tags and readers as well [12].

The mock casualties include 130 randomly selected conscripts, each tagged with an injury card (including triage Tag) of their injury [12]. During the study in the field, medics treat casualties with paper triage tags or RFID-tags.

Results

The test took place during the Finnish military's Pyry 2006 exercise. Sub-arctic weather conditions gave the Finnish Defence Forces good testing fields to test medical technology [12].

All 10 field medics complete the entire questionnaire [12]. The field medics had various professional backgrounds. One is a physician, two have hospital background, four have finished high school, and two have graduated from a vocational school and one with unknown background. Since we were especially interested in the reactions of the users who are not familiar with the RFID technology, none of these field medics had RFID-triage experience before. Before the study started users were briefly taught the basic concepts needed to operate the system. They had 10 minutes of training how to operate the equipment. Medics also had change to ask questions if they had any difficulties while using the equipment on the scene. The staff from the Finnish National Center for Military Medicine were on the scene to provide support if there were any difficulties [12].

After users complete their task, the questionnaire collects their subjective opinion concerning the usability of the system. As earlier mentioned the questionnaire is divided into five groups, each one dealing with a different aspect of the user experience. Here we take a closer look at these groups.

Reading the tag: While using the equipment in the field medics felt that that RFID-tag reading was not difficult and was mostly successful. Most of the users strongly disagreed and disagreed that reading the RFID-tag would be difficult and only one had neutral. When asked if the RFID-tag reading was slow; nine of the field medics disagreed only one agreed to that opinion. All medics agreed that RFID- tag reading was mostly successful.

Technology: Reader operation was mostly problem free and the reader operation was not difficult. All users agreed the reader operation was mostly problem free. While using the RFID-reader all field medics disagreed or strongly disagreed that reader operation was difficult.

Questionnaire responses show also that field medics found the application easy to use and stable. All field medics found the application easy to use. They also found application stable.

Time: Five of the users felt that RFID-patients required more time than normal patients, one had neutral opinion and four disagreed that RFID-patients required more time. Normal patient is here referred as a patient with paper triage tag.

Six of the field medics disagree that RFID-triage took longer because of technology. Four agreed that RFID technology influenced they triage timxe, and RFID-patient triage took longer because of the technology. Field medics found RFID-patient triage to be quick and reliable, all of the users agreed to that opinion (Figure 1).

Triage: Seven of the user disagree that they viewed RFID-patients differently to normal patients, two were neutral and one agree. Field medics did not found RFID –patient triage labour intensive. Eight of them disagreed that RFID-patient triage was more labour intensive and two were neutral in their opinion. To question "normal patient triage was even more labour intensive" four of the users had neutral opinion, four disagreed and two agreed.

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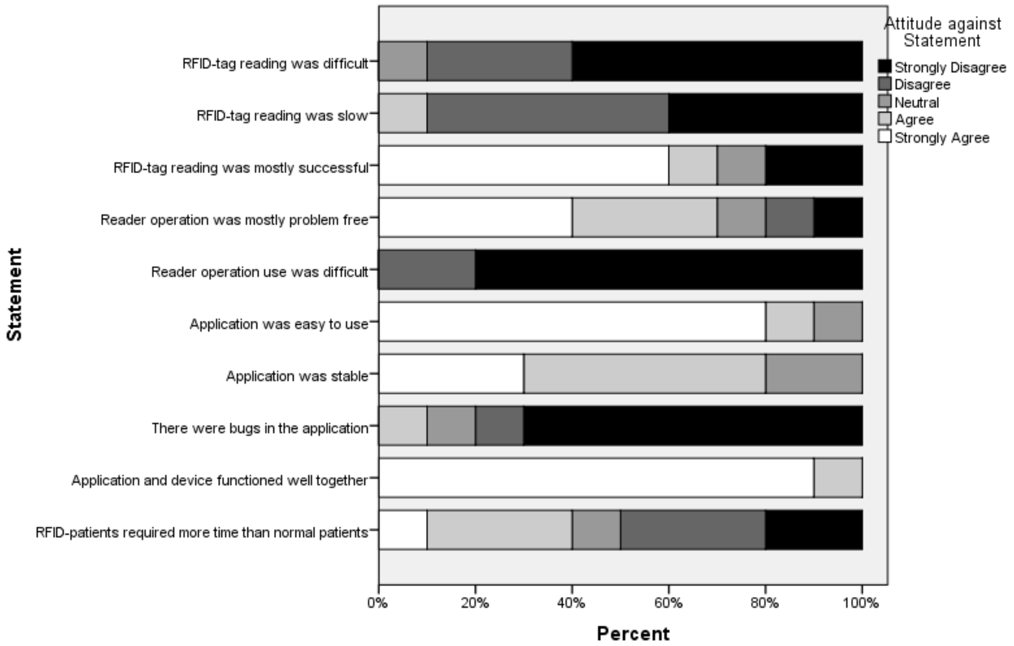

Figure 1: The attitudes towards statements about tag reading, technology operation and time.

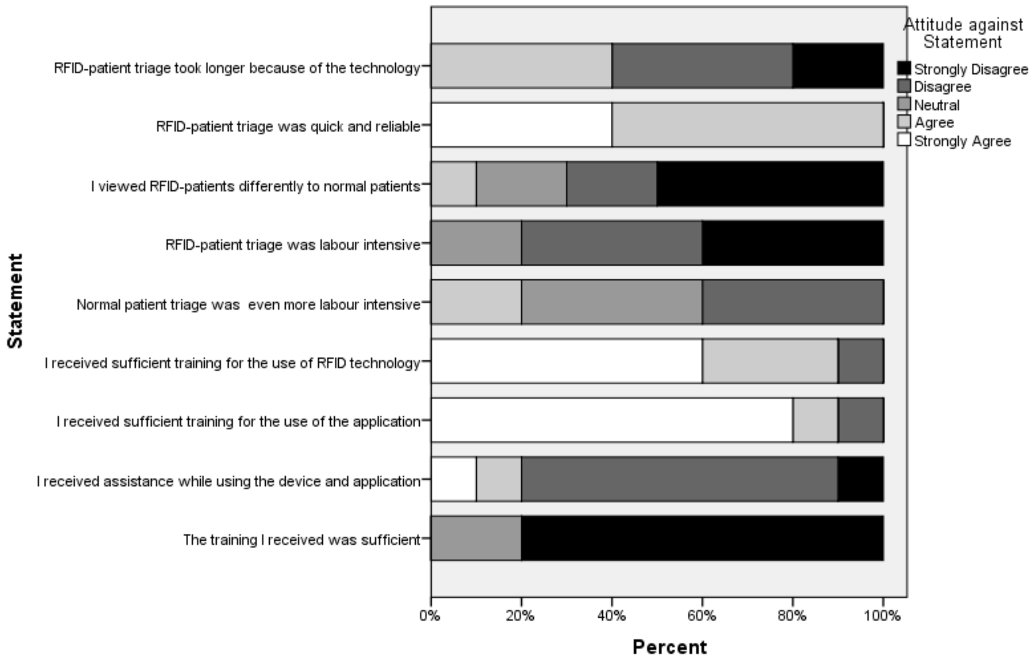

Figure 2: The attitudes towards statements on triage and received training.

Training: Most field medics agreed that they received sufficient training for the use of the RFID-technology and the use of the application. Almost every medics agreed that they received sufficient training for the use of the RFID-technology.

While using the application, nine medics strongly agreed that they received sufficient training and one disagreed. Eight of the users disagreed that they have received assistance while using the device and application and two agreed that they have received assistance while using the system (Figure 2).

Statistical Dependence Between Statement Questions

Statistical dependence i.e. correlations between statement questions were examined using explorative factor analysis. In (Table 1) varimax-rotated factor loadings (i.e. correlations between statements and factors;

	Factor					
	1	2	3	4	5	6
I received sufficient training for the use of the application	,940					
I received assistance while using the device and application	-,935					
I received sufficient training for the use of RFID technology	,932					
I viewed RFID-patients differently to normal patients	-,684					
Application was stable	,643					
RFID-tag reading was mostly successful		-,905				
Reader operation was mostly problem free		-,835				
RFID-patients required more time than normal patients		,815				
RFID-patient triage was quick and reliable		-,637				
RFID-tag reading was difficult			,919			
Application was easy to use			-,910			
The training I received was sufficient			,657			
Application and device functioned well together				-,938		
There were bugs in the application				,929		
Reader operation use was difficult				,851		
RFID-patient triage took longer because of the technology					,909	
Normal patient triage was even more labour intensive					-,752	
RFID-patient triage was labour intensive						,744
RFID-tag reading was slow						-,605

Mineigen criteria were used to define the number of factors (i.e. principal components) as 6. Factor loadings which were smaller than 0.5 or greater than -0.5 are not presented in the table

Negative factor loadings with the factor means positive correlations with each other

Table 1: Factor loading of descriptive factor analysis.

	Cluster	
	1	2
I received sufficient training for the use of the application	2	1
RFID-tag reading was mostly successful	1	4
RFID-tag reading was difficult	5	4
Application and device functioned well together	1	1
RFID-patient triage took longer because of the technology	4	3
RFID-patient triage was labour intensive	5	4

Table 2: Final cluster centers.

Factors can be interpret as groups of statement variables) are presented. Principal component method was used to obtain the estimates.

Statement question "I received sufficient training for the use of the application" had a very high factor loading with factor 1. It means it had a high correlation with other statements within this factor as well. In practice respondents with positive attitude against this statement usually also had positive attitude against "I received sufficient training for the use of RFID technology" and "Application was stable" as well. On the other hand respondents in these cases tended to have negative attitudes more often with "I received assistance while using the device and application" and "I viewed RFID-patients differently to normal patients". These first five statements didn't correlate highly with other statements in the questionnaire.

In the second factor "RFID-tag reading was mostly successful", "Reader operation was mostly problem free" and "RFID-patient triage was quick and reliable" had a high positive correlation with each other. They all correlated negatively with "RFID-patients required more time than normal patients".

The third factor consisted of three statements: "RFID-tag reading was difficult", "Application was easy to use" and "The training I received was sufficient" of which the second had a high negative correlation with other two.

The last three factors had three, two and two statements with high positive or negative correlations. This result indicates that instead of 19 statements only six could be used to measure opinions against these features experiences of Mobile RFID-Based Triage Systems. Although it is difficult to name the factors (groups of statements) they had some common features. For example some statements in the first factor had something to do with training. The second factor may be called "No problem" factor. The fourth factor with three statements may be called the "Flaws" factor. Six factors explained 91.4% of the total variance of the statement variables which justified the grouping the statements into six groups and also indicated high model fit with the data.

Grouping the respondents

Cluster analysis was used to cluster respondents with similar opinions against statements. Statements used in the cluster analysis were selected based on the factor analysis. Statements with the highest loading with the factors were used as a representative variable of the factors. In that sense all 19 statements were used in the cluster analysis. In (Table 2) final cluster centers (i.e. cluster means of statements using scale 1=Strongly agree, 5=Strongly disagree) are given. Number of clusters was chosen as two. This was done because of small sample size.

The first cluster (n=6) respondents tended to agree "I received sufficient training for the use of the application", "RFID-tag reading was mostly successful" and "Application and device functioned well together" and agree with other three statements. On the other hand respondents of the second cluster (n=4) tended to agree with "I received sufficient training for the use of the application" and "Application and device functioned well together". Average attitude against "RFID-patient triage took longer because of the technology" was neutral. Attitudes against "RFID-tag reading was mostly successful", "RFID-tag reading was difficult" and "RFID-patient triage was labour intensive" were typically negative.

Conclusion

This paper evaluated the implementation of the mobile triage in a military field exercise.

This system has many benefits over the current paper-based paper triage. The medics whom were unfamiliar to RFID triage quickly learned how to use it, and found it be easy-to-use. Where this kind of equipment is used in disaster relief efforts, equipment should be quick and easy to repair and hands-on training should be routine [10]. The training on site was effective and helped the use of the equipment.

While using the mTriage in the field medics did not find triage to be labour intensive, it was quick and reliable. The users in the field felt that the application and the device functioned well together while they were performing the casualty triage. The mTriage system also made it possible to change casualties triage category when needed, which is often done at the secondary triage point or during the transportation.

Mobile triage has the potential to contribute to the management of mass casualty situations; it also has potential for improving the quality of medical care. New information technologies, such as mTriage, will improve triage and patient tracking on the field. The mTriage has potential not only for the military medicine use in the future. The system could also be adapted without any difficulties by the civilian sector. It could be used for management of mass casualty disasters; such as earthquakes, storms and mass casualty incidents.

All new technologies have limitations as well as capabilities. The RFID tags would need some sort of human readable element (similar to the color coding on traditional triage cards) to simplify the work of transport and field personnel who are not equipped with RFID readers [13].

Due to nature of emergencies more studies need to be done on user satisfaction to evaluate the usability of the RFID triage in the field.

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