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The Need for Casualty Care Decision Support in Civilian and Defense Sectors

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Abstract

Trauma effects the lives of many people around the world; cases may include people involved in a car crash right through to military personnel injured on the battle field. Each situation requires different levels of care and the diagnosis and treatments administered play a large role in the recovery of the trauma victims. In such events it is vital to provide the correct level of care with high efficiency and with minimal errors. However these fast paced situations lead to stressful environments contributing to errors in patient care leading to detrimental consequences of morbidity. Computerized decision support systems have been introduced into the medical industry which have greatly improved patient recovery in trauma care, however such systems are primarily targeted for use in well-established medical facilities. The time it takes to transport an injured victim at the scene to a medical facility also plays an important role in the recovery process; by introducing optical head mounted display systems, remote off site field support can be provided which can enhance effective medical advice offered to both inexperienced through to properly trained medical staff prior, during transport and upon reception at a medical facility. This device is expected to greatly improve the recovery phase of trauma victims and reduce errors in patient treatment and diagnosis both in and out of hospital care.

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1. Introduction

Trauma is one of the greatest public health challenges of this period in time. About 5.8 million people die from injuries each year which accounts for 10% of the world's deaths; nearly one quarter of this figure is due to road traffic crashes which can cause a vast array of injuries and complexities [1] and this is expected to grow by the year 2030. Overall this number is 32% more than the number of fatalities that result from malaria, tuberculosis and HIV/AIDS

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combined [1] and yet still does not take into account the injuries due to combat and war. Fig 1. shows the break-up of the common injuries which lead to death. Overall there are a number of categories present which if treated correctly, can lead to a positive outcome on the patient's recovery.

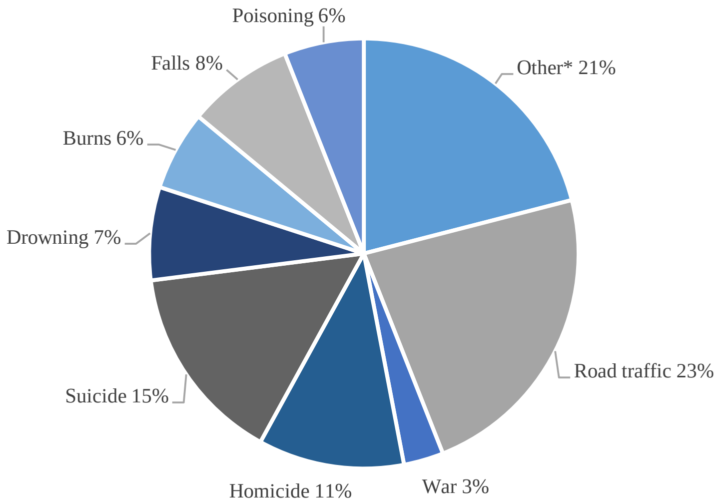

Fig 1. Breakup of the types of injuries which claim lives; *other includes smothering, asphyxiation, choking, animal and venomous bites, hypothermia and hyperthermia and natural disasters [1]

If any of the victims falling into one or more of these categories have been received for medical attention, it is vital they are treated with proper care in a timely efficient manner. Unfortunately cognitive errors will be inherent in any resuscitation situation. These errors can be classified as 'omission' due to taking no or only partial action to achieve a goal, and 'commission' errors which can cause harm or negatively affect the achievement of a goal [2]. In civilian setting's these errors equate to 0.75 per patient [3].

Errors can be due to a number of possible reasons, some examples include time pressure, reliance on memory, inexperience or multitasking [3]. These human limitations have been documented in a number of industries such as shipping, electrical power production, chemical manufacturing as well as in military environments due to battlefield settings and the unique challenges faced in an austere environment [4]. As a result in order to ensure the quick recovery of a trauma victim, it is essential that systems are put in place to prevent cognitive errors. Through the use of error prevention software, real-time information can be provided to the personnel at hand to provide the right level of advice to treat the patient.

The Problem-Oriented Medical Information System (PROMIS) was one of the earliest support systems in place to help medical staff in hospitals [5]. The system coupled medical knowledge with electronic medical records and was one of the first Electronic Health Record (EHR) systems. The ZOG system which was a rapid response, large network, menu selection system was later integrated into PROMIS to enable a man-to-machine communication interface [6]. The EHR system is now widely adopted in some form or another in the majority of all hospitals around the world. The simple diagnostic tool also served useful in supporting clinician led decision-making. However, the system was based on monitoring patient care and accessing medical records rather than being integrated in fast paced highly stressed environments commonly faced in pre-hospital trauma care and combat casualty care scenarios.

A number of industries have devised solutions to combat and minimise cognitive errors. One of the most recognised systems is the decision support system used in the aerospace industry. In most aircrafts, error and diagnostic prompts are provided continuously to the pilots in command so that action can be taken before the situation escalates to a stage beyond management. For example if an aircraft is approaching its stall speed, an immediate warning will appear in the flight command system. This triggers a series of visual, as well as audio prompts to inform the pilot what actions they must take; in the order of most to least important. This method has enabled the airline industry to maintain a high success rate in recovering from difficult unforeseen circumstances. Likewise, similar systems have started to emerge in the medical sector such as the Trauma Reception and Resuscitation (TRR©) system developed by the Alfred Hospital based in Melbourne and now integrated across a number of facilities worldwide. The system has been proven to reduce the number of errors made during trauma reception however further streamlining and expansion is needed. The Monash Institute of Medical Engineering, the Department of Mechanical and Aerospace Engineering and the National Trauma Research Institute (NTRI) are currently developing a Casualty Care Decision Support System (CCDS) which offers a complete hands-free optical head mounted display to further integrate into the existing TRR© system. Additionally the device is expected to also operate as a standalone component. This will utilise the computerised algorithm already proven successful in the TRR© system and allow people off-site (first responders) access to medical treatment data and in-situ medical assistance. This is expected to enhance trauma reception and ensure proper care and treatment is provided well before reception at a proper medical facility.

2. Trauma Reception and Resuscitation

The Trauma Reception and Resuscitation (TRR©) System developed by the Alfred Hospital in Melbourne provides a decision support software for use in the first 60 minutes of trauma reception and resuscitation. Patient data including vital signs, confirmed and/or unconfirmed diagnosis and treatments are entered into the TRR© system via a touchscreen by a trauma nurse leader. From the information entered, computerized algorithms prompt the Trauma Team in real time to confirm the state of the patient; assist in diagnosing injuries; whilst also prompting the use of required drugs or interventions. All of this information is provided live to a monitor for all staff to view whilst providing summarized reports, screen capture data and secured storage of information for later review/audit and training.

The current TRR© system contains more than 40 purpose-built, evidence-based medical algorithms covering five major subcategories of trauma resuscitation:

1. Airway management
2. Ventilation and chest decompression
3. Management of shock
4. Generic trauma
5. Specialty situations (e.g. thoracic trauma, neurotrauma, burns, spinal cord injury and orthopaedic trauma)

The interrelated algorithms were developed using a ‘branched tree logic’ structure allowing rapid processing of discrete constraints and real-time operator support. Trauma bays are fitted with audio-visual recording systems; which are activated on or before patient arrival and limited to 60 minutes worth of recording. The video audit tool also captures the LCD prompt display screen simultaneously, enabling auditors to compare patient treatment with the information displayed to the trauma care professionals.

The LCD screen displays critical patient information and management prompts. This was found to be an effective way for communicating information to hospital staff without overloading the amount of data presented. ‘Action Prompts’ are provided based on the patients’ physiological status and the information inputted into the system by the nurse scribe. The medical trauma team leader then responds to these computer-generated diagnostic and intervention prompts. If the team ignores a prompt, a menu appears with selections for why it has been ignored, thus ensuring that staff know that they have decided against that pathway. Note, these prompts serve as a guide and do not replace the medical staff’s expertise.

This system was the world’s first to demonstrate the introduction of concurrent computer-aided decision support for experienced trauma teams with proven results. Studies conducted in the Alfred Emergency and Trauma Centre showed shock management errors were reduced by 26% and the need for blood transfusion was significantly reduced [3]. Since its initial introduction the TRR© system has been well received by a number of hospitals around the world. Its simple display method and user-interface provides vital information to staff members during the critical stage of trauma.

Secondary input devices (in addition to that used by the nurse scribe) such as tablet interfaces may also be utilized by the medical trauma team. However this requires physical touch inputs or hand gestures; which can pose difficulty where the medical staff need to keep both hands free to attend to the patient. The current user interface is considered the single greatest hurdle in making the system more widely adapted. As a result there is a demand for an improved interface to further enhance usability.

3. Casualty Care Decision Support

As previously mentioned, highly stressful situations can often lead to poor decision making and result in commission and omission during treatment. This can negatively affect the recovery of the patient. The ‘golden hour’ is a term often used to characterize the urgent need for care of trauma patients. Hence implying that morbidity and mortality are affected if care is not instituted in the first hour after injury. Thus it is vital that some level of treatment and assistance is provided during this critical stage. Depending on the situation, location and injury, the personnel nearby may not be able to assist the injured due to inexperience. By giving the general public and medical staff on field access to decision support software available through easy to use devices, immediate care can be provided to the trauma patient prior to the arrival of medical professionals. This is expected to greatly improve the recovery of the patient.

3.1. Decision Support Systems

The trauma department of any medical facility is a fast paced environment. Multiple tasks need to be carried out by several people whilst also being able to keep track of diagnosis and treatments made. This may be an overwhelming situation which is often difficult to manage and keep track of. Through the use of decision support systems, diagnosis and treatments made can be automatically recorded into the system. Once integrated with a branch tree logic system, real-time analysis of the treatments can be made. This will bring up action prompts to the end user allowing for proper medical attention to the patient.

There is evidence that a standardized algorithmic approach reduces error and that real-time prompts increase compliance [7]. However although some systems offer some level of decision support, most have incomplete automation of data entry that activates the treatment algorithms. Usually a nurse scribe or a medical professional is required to enter clinical interventions and decisions made that drive the decision support software.

For the TRR© system, a nurse scribe is used to enter data manually at a terminal during resuscitation. Based on the data inputted, the computerized algorithms determine what interventions and decisions are displayed on the central LCD screen in the trauma bays. Although the system has already been proven to reduce errors in patient resuscitation, complete data entry automation is expected to greatly improve speed and efficiency of the decision support system. This is the next stage of development required to provide a streamlined intuitive system which can operate without much user involvement, hence allowing personnel to focus on their set tasks.

3.2. Pre-hospital Arrival

In addition to automating and monitoring patient response, systems need to be put in place to assist remote medical professional off-site using decision support systems. Smartphone technology and tablet devices have evolved significantly over the past several years. This has enabled medical professional’s access to various pools of information which can be remotely accessed. However, accessing this information diverts their attention away from the trauma patient and in addition requires physical touch input which may not necessarily be possible if only one person is available who requires both hands to treat the patient. As a result, a hands-free system is needed which will interact with existing decision support systems either through verbal commands or facial gestures. The emergence of smartglass technology offers a new method of delivering and analyzing decision support information both off-site as well as within medical facilities. The key challenge will be in developing the voice recognition software which is able to navigate between system information and record data spoken by the wearer. A number of off the shelf smart-glasses currently exist in the market. These devices incorporate a number of sensors such as Bluetooth, WiFi, accelerometers, gyroscopes, magnetometers as well as altitude and humidity sensors. Hence enabling the development and testing of the new hands-free interface. The majority of these smartglasses also include cameras. This can be used to record video and audio for later audit as well as be used to live-stream video from an off-site location to experience medical professionals for further instructions and advice. Overall the use of this technology is not expected to only assist trained medical staff but also anyone with a basic understanding of technology. Hence immediate care and attention can be provided to the trauma patient well before the arrival of paramedics. Additionally, medical staff will have more information on the type of injury prior to arrival of the patient; enabling them to be better prepared for the situation. Overall the system will reduce the lapse in time between patient injury and medical attention received. Thus ensuring more attention is provided within the 'golden hour' timeframe.

3.3. Hospital Assistance

The optical head mounted display system also known as smartglasses will initially be integrated into trauma facilities in a civilian environment. Peripheral devices such as heart rate and blood pressure monitors will be wirelessly linked to the decision support system. This will introduce the first level of data capture automation. The smartglass device is expected to be worn by the trauma team leader. Verbal inputs made by the team leader will automatically be captured by the voice command system which will then record the information under the correct field (e.g. diagnosis, treatment, patient information etc.). This is expected to reduce the burden on the nurse scribe who manually inputs information into the existing TRR© system. This will not only streamline the current setup but reduce the chances of mistakes made by the nurse scribe inputting the data. Based on the information and peripheral device recordings, the computerized decision support system will then determine whether a specific action must be taken by the medical staff.

3.4. Combat Casualty Care

One of the greatest advantage of the casualty care decision support system will be in the defense sector. In an analysis of 4596 battlefield fatalities, it was found that 24.3% were potentially survivable [8]. Common causes of potentially survivable death include compressible haemorrhage and compromised airways [9]. These areas present specific targets for remote damage control resuscitation [10]. Uncontrolled haemorrhage was found to be solely responsible for more than 80% of combat deaths during Operation Iraqi Freedom and Operation Enduring Freedom [9]. Hence in order to improve prognosis it is vital to provide some form of medical assistance within minutes. Hence through the use of the optical head mounted display system, personnel near to the injured can provide proper immediate assistance well before the arrival of medical staff located further away from the front line. The use of a hands free voice command system will enable personnel to continue with their tasks without the need for leaving their posts. Additionally the system can be further integrated with other communication interfaces such as contacting the command base, requesting air support and requesting for further medical assistance. Overall, defense is an area which is expected to greatly benefit from these casualty care decision support systems. Being able to provide medical assistance at the forefront of the battlefield will enable the best possible medical care to the troops on field.

4. Optical Smart Head Mounted Display System

A number of smartglass systems can be adopted for the initial trial of these decision support systems. The ODG-R7 smartglasses manufactured by the Osterhout Design Group, the EPSON BT-300, the Lumus DK-50 and the CHIPSIP SiME smartglasses all offer the hardware required for testing. All of these devices are run on Android OS. The innovation in this technology lies in the software interface. A native java application is currently under development running on a minimum API level of 14. This will enable compatibility on more than 95.2% of android devices. Software has already been developed with the voice activated hands free setup working. The software is able to recognize whether the wearer of the device is having a conversation with other personnel or whether it is being instructed to record or display particular information. This eliminates the need for any touch inputs to initiate an action and hence offering a truly hands free interface. Verbal commands are picked up by the microphone and analyzed by the on-board computer within the glasses. If the verbal command has been programmed into the software's library, the desired action is then automatically initiated.

4.1. System Integration

The computerized algorithm responsible for providing the management prompts already exists in current Trauma Reception and Resuscitation (TRR©) systems. This will be integrated into the smartglass software whereby information will be analyzed in real-time to determine whether or not certain parameters fall outside of tolerable limits. As previously mentioned, the system will also facilitate the use of wireless peripheral devices such as heart rate, blood pressure and oxygen saturation monitors. Real-time integration of these multiple data sets into the TRR© algorithms system results in user alerts of critical information relating to the casualty status. As a result this will allow the user to focus on attending to the casualty rather than constantly monitoring vital signs. In addition real-time action prompts will provide a series of autonomous instructions based on input of diagnosis and treatments conducted by the care provider, Fig 2 shows an example of the operation and integration of the smartglass platform to the existing TRR© system. Testing is required on whether the processing required by the computerized algorithms can be done on-board of the device or from a remote server.

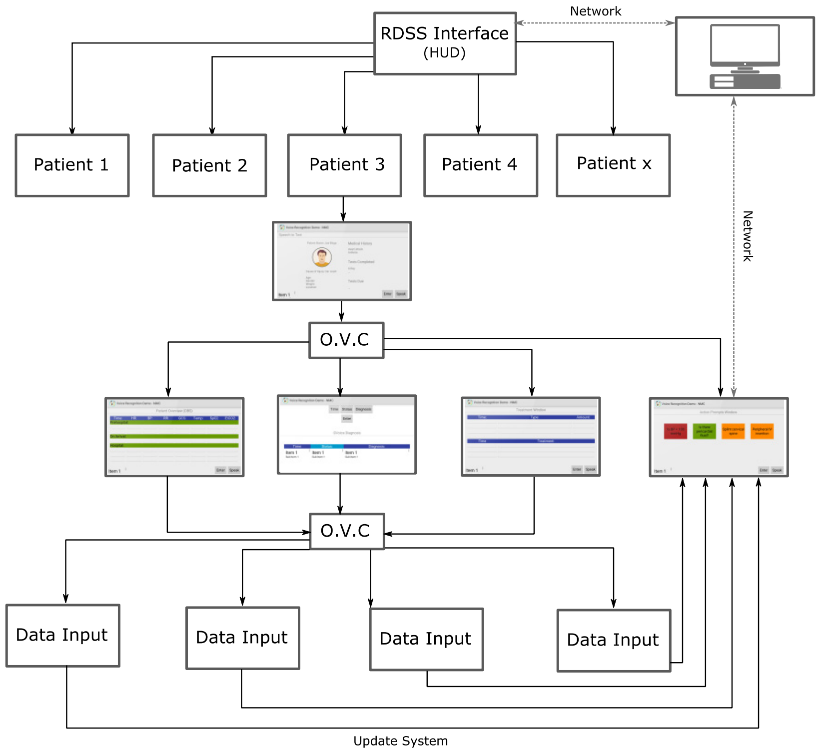

Fig 2 Branch tree diagram highlighting an overview of the hands-free smartglass platform; O.V.C (Open Voice Command)

From Fig 2, there are essentially four key categories identified. These include patient identifier and mechanisms of injury, physiological parameters which can be directly recorded through the smartglasses, diagnosis made from time of reception, and finally the interventions that have been performed. The software layout and categories can also be redesigned based on the industry and field it is used in.

Note that if the user wishes to update or input further information into the system, a series of questions will be asked with a follow-up confirmation prompt asking the user whether the recorded information is correct and to finally sign off with their name. This process will eliminate the possibility of incorrect data being uploaded to the system which may trigger false action prompts. Fig 3 shows an example of data-input into the system with a follow up prompt. Overall the successful integration will be dependent on a number of factors including requirement analysis, design specifications, software scripting, unit testing and system testing.

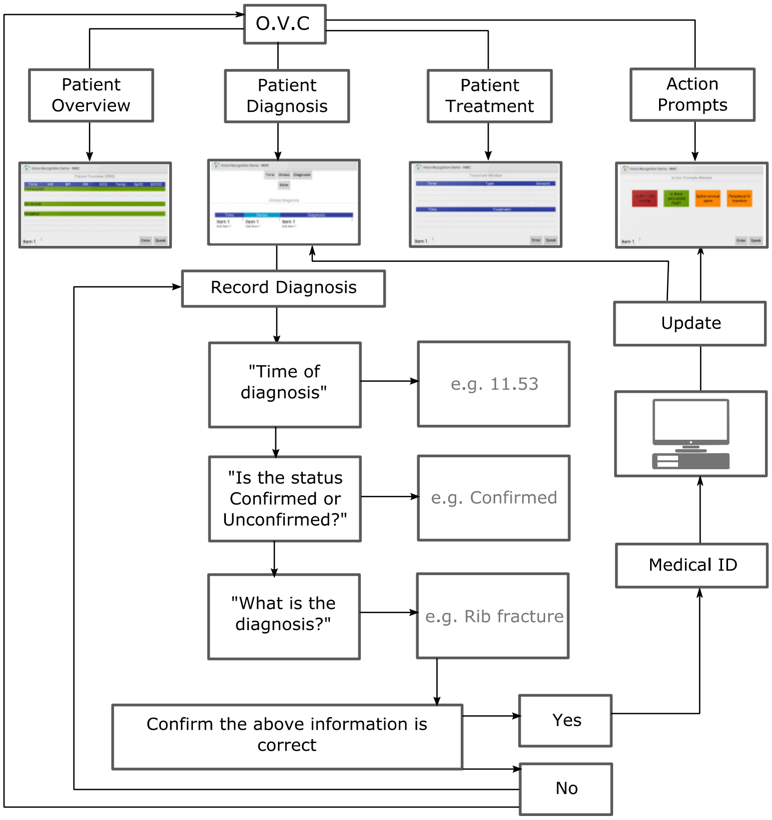

Fig 3 Branched tree diagram highlighting an example of an interaction achieved during input of a diagnosis

4.2. Development and Clinical Trials

In order to see the widespread use of such new technology. The Casualty Care Decision Support System will be demonstrated by rigorous bench testing. A number of casualty care scenarios will be run on the smartglass device. This will also include clinical trials with a variety of end users ranging from paramedics and possibly military medics through to first responders located at the scene. All information and performances will be audited while user feedback will be gathered using a qualitative questionnaire. Simulated casualty care scenarios will also be performed in the Australian Centre for Health Innovation (CHI). This will also allow for further debugging, beta testing and performance testing of the smartglass interface. Ultimately through the rigorous bench testing stage of this project, clinical trials will be run in the Alfred Trauma Centre (which has already hosted TRR© trials) and AV MICA Helicopters. The main aim of the system is to improve trauma care both within and out of hospital environments.

5. Conclusion

The introduction of decision support systems have helped industries regulate and manage difficult and unforeseen circumstances. Regular training of employees helps ensure they are fit for the job when certain tasks are called upon, however a lapse or delay in training can often result in errors. In the medical field, these can lead to detrimental consequences which may ultimately lead to loss of life. Highly stressful environments added with limited time to administer proper treatments have led to the development of the TRR© system. This system has been proven to reduce errors in hospital environments. However the expansion of the current system to a more mobile platform such as a hands-free optical head mounted smartglass system will enable further streamlining within hospital trauma bays and offers new levels of assistance to medical staff on field such as a AV MICA paramedics, combat care medics as well as to first responders. The development of the hands-free software interface followed by rigorous bench testing and network integration will be a vital stage in the development of these devices. Once complete, proper clinical trials can commence, eventually leading to the widespread use of the device in civilian and defense sectors.

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