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Optimising the utility of Military Injury Surveillance Systems: A Qualitative Study within the Australian Defence Force

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Injury prevention guided by robust injury surveillance systems (ISS) can effectively reduce military injury rates, but ISS depend on human interaction. This study examined experiences and requirements of key users of Australian Defence Force (ADF) ISS, to determine whether the operation of the ISS was optimal, any shortcomings, and if present, how these shortcomings might be addressed. Semi-structured interviews were conducted with eighteen Australian Defence Department participants located throughout Australia. Grounded theory methods were used to analyse data by developing an understanding of processes and social phenomena related to injury surveillance systems within the military context. Interviews were recorded and professionally transcribed and information contained in the transcripts was analysed using NVivo. Key themes relating to the components of an injury surveillance system were identified from the analysis. A range of processes and socio-cultural factors influence the utility of military ISS. These are discussed in detail and should be considered in the future design and operation of military ISS, in order to facilitate optimal outcomes for injury prevention.

1. Introduction

Injuries are a significant problem for military forces. They incapacitate large numbers of military personnel and so reduce the size of the force available for operational deployment on any given day. They contribute to force attrition when the levels of incapacity resulting from these injuries make individuals medically unfit for continued service. They are also costly to the institution. Clearly illustrating these points, data from the Australian Department of Veterans Affairs (DVA) and Department of Defence for the Australian financial year 2005-2006 [1,2] indicate that seven injuries, each severe enough to warrant claims for compensation, were reported in that 12-month period for every 100 serving Australian Defence Force (ADF) personnel. Further, during the same 12-month period five injuries described as resulting in a permanent impairment were also reported for every 100 ADF personnel[1]. In some instances, permanent impairment results in the injured personnel being assessed as medically unfit for continued service, and they are therefore discharged from the ADF, thereby contributing to force attrition. Figures available from 2004 [3] also show that, in that year, the financial liability of the Australian Government for injury-related compensation payments to serving and former military personnel stood at 1.9 billion dollars. On this basis, even small relative reductions in injury rates, achieved through injury prevention efforts, would result in significant improvements in military capability and reductions in costs, force attrition, and personal suffering.

Importantly, given the magnitude of this problem, injury prevention activities can achieve strong reductions in injury rates in the military context, particularly when informed and guided by comprehensive and robust injury surveillance systems (ISS). For example, in the ADF context, injury prevention efforts guided by such ISS have been responsible for reducing the incidence of pelvic stress fractures in female army recruits by 95% [4], and for detecting and eliminating a new source of Anterior Cruciate Ligament ruptures in army

[1] Some new injury claims in 2005-06 were also claimed as injuries resulting in permanent impairment in this period. However, the number of injuries resulting in permanent impairment in 2005-06 also included injuries sustained prior to 2005 that were reassessed in 2005-06 and determined to be resulting in permanent impairment.

recruits [5 6]. Similar successes have been reported in the US military context, leading Jones and colleagues to highlight the critical nature of robust ISS for military injury prevention [7 8].

The role of ISS in military injury prevention programs is to identify activities, venues, and other sources (e.g. equipment, substances) of high injury risks. This information can then be used to guide, prioritise and focus the more detailed and resource-intensive investigations and causal analyses that must generally underpin countermeasure development and implementation. A balance is required in ISS between gaining comprehensive data about injury incidents and ensuring that those reporting injury incidents are not deterred by excessive data requirements. Excessive requirements will reduce compliance in data provision and flow on to reduce the information available to guide further investigation and injury prevention. For this reason, most ISS operate on the basis of a 'minimum data set' [9], aiming to gather information that is deliberately restricted to factors that are critical to guiding, prioritising and focusing more detailed investigations. Such factors would include, for example, the place and activity in which the injury occurred, so that any subsequent investigation can be narrowed in focus to these places and activities and so be conducted efficiently. On this basis, ISS will usually not collect and supply all of the information that would be collected in a detailed investigation of injury causes and required as a basis for developing preventive interventions. However, ISS do provide an excellent starting point for such investigations by identifying important sources and factors associated with high risks or rates of injuries.

ISS involve three main elements, namely (1) data collection, (2) data analysis and interpretation and (3) information dissemination [9]. However, while it is valuable to consider these individual elements and factors that affect them, it is also important to consider the ISS as a whole, and the context within which they exist. This leads to consideration of *global* factors, which can affect some or all elements of ISS and the system as a whole. Such factors may include, for example, the organisational or cultural context or structure in which the system exists and operates, and its place in that context

or structure, which might in turn make it more or less effective. The range of global factors that might affect an injury surveillance system is very broad, and detailed discussion of them is beyond the scope of this report. Suffice to say that there is strong evidence that such factors can exert significant influence on the effectiveness of information systems [10]. Further information on such factors can be found in the extensive literature on this topic from the field of organisational psychology [10]. The current study considered factors related to the three specific elements of ISS and the global factors which impact systems as a whole.

The main premise for the current study was that ISS are, at their most basic, simply a framework. It is through the introduction of human contributors that ISS become working processes that are able to effect positive outcomes. To date, the majority of research on ISS has focused on the technical design of the systems, examining the types of information that should be collected [9 11 12], case definition [13-16], coding frames [17-20], the use of narrative text [21-23], and the assessment of data quality [24-27]. Despite this technical understanding, many ISS continue to operate at sub-optimal levels, often due to human interaction with these systems [28-30]. The aim of the current research was to examine the experiences and requirements of users of several Australian military ISS, to inform future development and improvement of such systems internationally, particularly in areas pertaining to human interactions with the ISS. This understanding is also crucial in framing further research on this topic.

2. Method

2.1. *Research Approach*

A qualitative research approach was utilised in this study in order to provide a rich data set, drawn from the experiences of individuals involved in several ISS of the ADF. This approach was chosen based on the premise that understanding how these individuals interpret their experiences and the meanings they attribute to their experiences would provide new insight into how users perceive their interactions with ISS in this context, and thereby inform the future optimisation of aspects of ISS associated with human interaction. Information gathered from participants was synthesised to determine whether

the operation of ADF ISS was optimal, any shortcomings, and if present, how these shortcomings might be addressed, so that they could more effectively drive injury prevention action. Processes common to a grounded theory methodology were utilised in this research. Grounded theory methods are designed to generate theory through advancing understanding of social and psychological phenomena [31].

The study protocol was approved by the Australian Defence Human Research Ethics Committee and the Monash University Human Research Ethics Committee.

2.2. *Participants and ISS*

Semi-structured interviews were performed with 18 participants who had operational involvement with ISS within the ADF. Participant selection was based on broad experience with ISS within Defence and progressively guided by unfolding theorising and recommendations from early stage interviewees [32]. Participants were drawn from geographically dispersed locations with operational ISS throughout Australia. These ISS varied in design, based on unique system history and evolution, operational context (e.g. Service, deployment status) and driving needs. For example, some involved data reporting by injured personnel, some reporting by supervisors of injured personnel, and some reporting by health staff who managed the reported injuries. Some used databases to manage the data, and some simple spreadsheets. However, all of these ISS collected similar information, based on the minimum data set required by Australian occupational health and safety reporting regulations. Reporting formats from each of these systems varied, depending in part on intended audiences (eg regulators, commanders, health staff), but all reported similar content, based on the minimum data set.

Interviews were conducted with ten military personnel and eight civilian employees from the Department of Defence. Initial participants were chosen based on their depth and breadth of knowledge and experience of the array of main ISS of the ADF, in order to establish rich data that would provide direction for further theoretical sampling. Consequently, individuals with overarching knowledge of the array of main ISS in

Defence were chosen first, to broadly identify the range of information likely to be encountered.

The 18 participants included four military commanders who used data from ADF ISS, three civilian safety and injury prevention managers of military bases who each managed base ISS and used system data, five military injury prevention advisers of army brigades who managed brigade ISS and used system data, one civilian data entry operator of an ADF injury surveillance system, one civilian injury surveillance system data analyst and injury prevention adviser for the ADF, two senior directors (one military and one civilian) of ADF injury surveillance and safety and injury prevention programs, one physical training instructor who used injury surveillance system data to guide training injury prevention, and one physiotherapist who used injury surveillance system data and led military injury prevention at a military base.

2.3. *Interview Instrument*

A semi-structured interview instrument, incorporating a series of guiding topics and related questions, was developed prior to data collection, through a review of the literature. The instrument provided an initial point of departure for the interview-based data collection process. In keeping with the open and modifiable nature of grounded theory, topics of interest were reviewed and refined as interviews progressed and concurrent analysis was performed [33]. The instrument also acted as a static information tool, which was sent to all participants, up to three days prior to the interview. It introduced possible discussion topics, primed their thinking prior to interview, and reduced the explanation required to convey complex topics of interest [34].

2.4. *Data Collection & Management*

Interviews took approximately one hour to complete and were recorded with a digital voice recorder. All recordings were professionally transcribed and information contained in the transcripts was then analysed with NVivo Version 7.

2.5. *Data Analysis*

Thematic analysis of data was undertaken, directed by the tenets of grounded theory. The analysis adopted the following four key stages: (1) open coding whilst remaining flexible to the situation, (2) a process of collecting and analysing data simultaneously, altering the interview content as collection proceeds, (3) selective coding, utilising comparisons to develop related thematic entities, and (4) theoretical coding, creating a central theme, categories and sub-categories [35].

3. Results

The data analysis delineated the results into *global factors* impacting upon ISS and specific factors associated with one of the three main facets of ISS – *collection, analysis and interpretation*, and *dissemination* [9]. Due to the complexity of ISS there is considerable overlap between these factor categories but, for ease of understanding, they were demarcated in this way.

3.1. *Global Factors*

3.1.1. *Military Culture & Injury Surveillance.* Environments such as the ADF inculcate an expectation of enduring physical hardship. This informal ethos of 'physical toughness' strongly influences the action of military personnel in active service [36]. Participants in operational and training units indicated that it is not uncommon for military personnel to carry injuries over several days before reporting these injuries and seeking medical treatment. This ethos may complement military endeavours, but the delays in reporting of injuries can hamper the effectiveness of ISS and, because of the resulting lack of guiding injury information, can also hamper injury prevention efforts.

3.1.2. *Organisational Placement of ISS.* The situation and control of ISS within the wider military organisation impact upon the financial, personnel and political resources available to these systems. These factors have a significant effect on the scope and effectiveness of the different ISS within the ADF. Participants commented on the internal debate regarding which organisational sub-entity would be best suited to control ISS. Various entities had sought to control ADF ISS, and this had resulted in inefficiencies,

particularly duplication of effort, as evidenced in the range of different ISS operating across the ADF context. According to participants, this internal debate had at times eroded harmonious relations between organisational sub-entities, and this had reduced the effectiveness of ISS in providing comprehensive information to guide and focus detailed investigations of injury causes and subsequent injury prevention activities.

3.1.3. *Communication.* A major concern raised by respondents related to communication. The requirement for increased communication was evident in two areas: 1) between entities responsible for components of injury surveillance (for example, feedback of outcomes to those responsible for data collection), and 2) between users of injury surveillance products (for example, safety managers, military commanders). Participants believed that increasing regular communication would result in greater cooperation between entities and more collaborative problem-solving. Through these means and the sense of mutual support they generated, participants thought that ISS would be more readily sustained. Respondents also conveyed the need for greater transparency of information disseminated from ISS and of subsequent injury prevention action taken. For example, they considered that military commanders should have visibility of the rates and sources of injuries experienced by military units other than those which they command, and of the actions that other commanders have taken to prevent injuries to their personnel which result from specific causes. They also believed that those who collect and enter data in the injury surveillance system should be privy to the reports generated from the data, to the ways in which this information is subsequently used to guide injury prevention activities in military units, and to the injury prevention actions that result. These factors were considered important in facilitating ongoing cooperation and motivation amongst individuals responsible for injury surveillance and for injury prevention. Seeing results is a powerful motivator for further action but, equally, having no visibility of results can rapidly lead to disenchantment and reduced engagement in respective roles within the injury surveillance system and injury prevention continuum. This, in turn, can impact severely on the success of injury prevention programs.

3.1.4. *Injury Surveillance versus Detailed Causal Analyses.* As discussed in the Introduction, ISS provide critical information to guide more detailed causal analyses and development of preventive interventions. However, they generally cannot provide all of the required information, and more detailed and focused investigations of injury causes must precede development of preventive interventions. Participants in this study who were less experienced in injury surveillance processes tended to assume that injury surveillance data would allow users to clearly identify injury problems, identify key causal factors, and thereby enable the immediate development of preventive interventions. When users were unable to realise this outcome, they often responded by recommending that the scope of the data collection instrument be expanded. However, two of the more experienced participants in this study recognised that such an approach would likely reduce compliance in injury reporting and data provision and, consistent with the approach discussed above, advocated the adoption of a two stage surveillance framework: broad injury surveillance from which data analysis would drive periodic secondary data collection (i.e. additional surveillance data, site visits, interviews, etc) on specific injuries and their causes. They pointed out that the ADF had, in several programs and contexts (for example, in its Defence Injury Prevention Program and some Service-specific safety programs), already adopted such an approach.

3.2. *Collection*

Several key issues relating to injury data collection were identified. These included: duplication of data collection activities, mode of data collection, level of injury detail collected and methods of ensuring cooperation amongst military personnel.

3.2.1. *Duplication of data collection activities.* Several participants suggested that military personnel would be more willing to perform high quality data collection for ISS if there was a rationalisation of information collection processes across the ADF that appear to capture similar content. As indicated earlier in this report, the ADF currently operates a range of ISS across its Services and operating contexts, for different purposes and audiences, and it is not unusual for staff of an ADF health facility (which often provide health care to personnel from a range of different units or Services) to be

required to supply injury data for 2 to 4 different ISS, in different formats and with different emphases, and often in relation to the same injury case or incident. Data exchange between these different systems is currently poor, and the resulting duplication of effort is a strong disincentive to comply with data provision requirements of any one injury surveillance system. Participants also indicated that military members would welcome any interaction of organisational personnel information systems with ISS to speed the process by pre-populating demographic data that would normally have to be re-entered for each occurrence of an injury. The ISS of the ADF at present generally do not interact with personnel information systems in this way, adding further to the data entry burden. While this duplication issue may be common across organisational information systems, it is particularly relevant in military ISS, where health, safety, compensation and command entities within the organisation may operate in relative isolation from each other and so generate duplication in effort, inadvertently.

3.2.2. *Mode of data collection.* Opinion toward mode of data collection varied according to previous experience with different modes. Electronic and paper based methods, each of which are used in different ISS of the ADF, were discussed in some detail. Many participants currently in paper-based systems of data collection suggested that a move to electronic data collection would be progressive. Different collection technologies were discussed, including personal digital assistants (PDA), Tablet PC, and touch-screen computers, and file transfer mediums such as infrared and Bluetooth. According to these participants, benefits would include improved data quality, a streamlined data collection process, quicker turnaround of electronic data from collection to analysis, and reduced personnel overhead and labour costs associated with injury data collection and entry. However, electronic data collection had noted shortcomings. Many technology options would be difficult for acutely injured personnel to use, leading to poorer data capture in such cases and so poor representation of acute injuries in injury surveillance system data sets. Limited computer literacy of soldiers and initial lack of familiarity with the collection technology were also identified by participants as possible obstacles. It was suggested that these factors would be likely to reduce data quality, sensitivity and representativeness.

Despite a general inclination toward electronic data collection, participants acknowledged that multiple modes may be required to cater for the variety of operational military environments, and that in some circumstances, paper-based systems might remain the approach of choice for some time to come and some technologies might not be viable. Injury prevention is as relevant during times of operational deployment as during regular domestic service. Consequently, the environment (either domestic or operational) and the resources available are extremely important and influence the viability and utility of different approaches to injury data collection and injury surveillance.

3.2.3. *Level of injury detail collected.* The scope of injury incident data collected by ADF surveillance systems was of interest amongst respondents. As discussed in the Introduction and in the section above on global factors, the authors' would argue that a smaller data set, like the minimum data set recommended by the World Health Organisation (WHO) [9], will ensure better data quality by reducing the data collection burden, and so provide a better guide for injury prevention efforts. In contrast, several data users expressed concern that the collection instrument did not capture sufficient detail about injury circumstances to ensure identification of injury issues. Most respondents were unable to suggest a way of effectively addressing these competing demands. Two respondents suggested the introduction of periodic sampling of specific cases of interest (e.g. all obstacle course injuries) over given time frames, to facilitate the identification of factors contributing to injury causation and countermeasure development. This method was also considered to be a way of reducing the data collection burden on injured personnel and health facility staff, thus maintaining a positive outlook toward injury surveillance amongst ADF personnel. The second, periodic sampling, element is not inconsistent with the 'detailed investigation' approach advocated by the authors in the Introduction.

The value of narrative data was discussed by a small number of participants in terms of its ability to expand upon coded data and potentially provide a heightened understanding of injury circumstances, sources and causes.

3.2.4. *Ensuring cooperation amongst military personnel.* Participants identified that injury data collection in ISS of the ADF is heavily dependent upon health staff participation. Respondents involved with this facet of injury data collection suggested that regular consultation and demonstrations of appreciation of health staff by managers of the ISS would do much to ensure the continued goodwill of health staff. Ongoing consultation and opportunities for staff training were considered by participants to provide to health staff a sense of acknowledgement of the importance of their roles and contributions in ISS and injury prevention efforts. Another avenue of engaging health staff was the introduction of a feedback loop within the wider surveillance system. Feedback regarding the quality of the data collected, how the information had been used, and the outcomes of its use for injury prevention would illustrate a purpose in the data collection and so increase the perceived value of injury data collection amongst health centre staff.

In military units where injury data collection had experienced some degree of success (for example, the Army Recruit Training Centre [5]and a particular army brigade), participants highlighted that commanding officers had invested time and effort into reinforcing the value of injury data collection to soldiers. This aimed to ensure that personnel reported all significant injuries to health staff as early as feasible, to ensure that they were both appropriately managed and recorded and that injury data collection became an expected part of the health care process for soldiers.

3.3. *Data Analysis*

The two key themes to emerge from interviews with participants regarding injury surveillance data analysis were in relation to direct access to data and benchmarking, and the analytical methods applied to injury data.

3.3.1. *Data access and benchmarking.* Participants responsible for injury prevention were interested in having direct access to injury data electronically. Perhaps the greatest attraction was the ability to compare crude injury rates and issues across military units. It

was suggested that, by knowing similar issues affect other military units, military staff could choose to collaborate with these units in addressing injuries. Successful interventions within other units might also convincingly illustrate the benefits of injury surveillance and specific interventions. At a governance level, the provision of comparison groups creates a degree of accountability for injury problems amongst commanders. However, respondents did note that the interpretation of these comparisons needs to be contextualised, given the varying roles of military units (for example, paratrooper vs. mechanic) and the associated variations in injury risks. It was also noted that, currently in the ADF, a primary reason for collection of injury data is to enable the organisation to respond to Australian occupational health and safety legislative reporting requirements. This primary focus on organisational reporting compliance has meant that the resources devoted to providing military commanders with access to injury data to guide injury prevention activities have generally been very limited, making this lack of access a concern of commanders and injury prevention and safety practitioners, alike.

3.3.2. *Analysis methods and timeliness.* Greater sophistication of injury data analyses was mentioned by several study participants as a feature they would like the ADF's ISS to possess, particularly the ability to perform real-time data analysis as it is collected. Currently, analysis of data from the ADF's ISS occurs periodically, typically some months after the data has been collected, and often this analysis is quite labor-intensive, rather than being automated. However, real time analyses depend on the technology acquired for the collection and analysis phases of surveillance. Real time analysis would allow injury issues to be addressed as they occurred or emerged, rather than military units enduring preventable injuries for extended periods of time, due to rigid and lagging reporting time frames. The automation of analyses might also reduce staff workload in manually trawling data for injury patterns. This would free specialist staff to assist in a greater way in designing and implementing injury countermeasures, rather than spending so much time on data analysis. Several unit-based military personnel also expressed a desire for greater specialist interpretation of data, to facilitate identification of injury issues and help develop prevention initiatives.

3.4. *Dissemination*

Knowledge management was the dominant issue amongst dissemination topics raised by participants in the current study. This issue was typified by a perceived need for greater transparency in injury data dissemination and heightened communication amongst entities involved in both injury surveillance and prevention activities.

3.4.1. *Knowledge management.* Better knowledge management was discussed by numerous respondents. Respondents tended to operationalise their perception of knowledge management as a central electronic information repository. The services they proposed should be provided by this repository included:

- Direct access to injury surveillance data for commanders, safety managers and injury prevention practitioners, from their respective desktops, via the organisation's intranet or via the internet
- Information to assist in the identification of injury causes and the development and planning of injury countermeasures
- Reports of the results of evaluations or trials of injury countermeasures, previously conducted
- Organisation-level injury surveillance reports, non-standard reports and presentations covering special topics, and any other associated information.

The flow-on effects of the increased availability of injury surveillance data and injury prevention information in the proposed central electronic repository would include, most importantly, heightened transparency with regard to injury rates and patterns amongst military units. Some participants felt that greater transparency may create a stronger sense of accountability amongst military personnel responsible for addressing the organisation's injury problems.

3.4.2. *Communication and cooperation.* A central shared information repository was also expected by participants to facilitate increased communication and cooperation amongst units in defining and addressing injury concerns. There is a large degree of commonality in the physical nature of service required of military personnel from different units and

roles. Therefore, military units could gain from the experiences of other units by being aware of their successes and failures in addressing local injury issues. Furthermore, given the competitive nature of the military environment, participants believed that transparent reporting and shared communication would promote unit comparisons, which might in turn facilitate greater scrutiny and action. In this environment, units would be encouraged to adopt successful interventions from other units rather than perpetuate unnecessary injury problems or waste resources in duplicating intervention development, evaluation and refinement.

One of the more consistent themes to emerge from the analysis was the requirement for greater communication amongst entities contributing to the injury surveillance system and injury prevention process. Respondents proposed that the data itself and appraisal of the quality of the data collected should be fed back to collection staff, both immediately if quality concerns were obvious or at the end of a standardised collection period (i.e. 3 months). This would strengthen collection procedures within the respective collection environments and provide a sense of ownership by data collectors of this crucial element of the process.

4. Discussion

This study revealed a range of factors involving the interaction between military ISS and their human users that were considered important by the study's participants for the effective operation of ISS, but lacking in current ISS of the ADF and in previously-published literature on this topic. This new knowledge can usefully inform development of military ISS of any nation, and supplement general guidance on injury surveillance system design and operation provided by organisations like the WHO [9]. Several socio-cultural and organisational ('global') factors were implicated by participants as important in the effective ongoing operation of military ISS, along with a range of factors related to each of the more commonly considered, specific injury surveillance system processes of data collection, data analysis and interpretation, and information dissemination.

One important *global factor* identified was military culture. Military environments such as the ADF, which inculcate an expectation of enduring physical hardship, can be perceived as running counter to the aim of injury prevention. The reporting of injuries that is critical to gaining comprehensive and representative data in military ISS can be hampered in military contexts by a pervading ethos of perseverance and toughness, which is rightly valued. However, it must be recognised that it is in such environments that robust injury risk management is most useful, though risk aversion cannot and will not be tolerated. Injury prevention and public health practitioners must work hard in this type of environment to ensure that it is recognised that their efforts are designed to reduce risk of injury while not impairing but rather enhancing achievement of military operational objectives. These goals of military injury prevention and ISS can be made explicit to military personnel and commanders, in order to positively influence the military culture towards effective injury risk management and injury reporting. Well-designed ISS are pivotal in the achievement of these goals, as they guide investigations of injury causes and development and implementation of viable preventive interventions.

It was also evident that the positioning and resulting priority and resourcing of a military ISS within the organisation are further important global factors influencing the effectiveness of the ISS. While this is true of any organisational information system, the unique division between military personnel and civilian staff that commonly exists in defence departments and the range of individual Services and other sub-entities that comprise the military force and defence department introduce additional considerations. In the ADF, for example, the current proliferation of ISS has resulted from these divisions and the desire of each sub-entity to have access to and ownership of meaningful injury incident data, for their own purposes. To overcome this problem, and reduce the duplication in ISS and data collection requirements highlighted in the current study, military forces and defence departments should carefully consider the positioning and control of ISS within the organisation and the access, priority and resourcing that will result from this positioning of the ISS. It is likely that the best situation will be one that can readily support all relevant sub-entities and command or provide the required priority and resources.

The need for ongoing communication, facilitated by better knowledge management, was a further global factor identified by study participants to be important in the success of military ISS. While this again applies to other types of information systems, across organisations, once again there are unique characteristics of the military context that must be considered. One of these is the unique mix of military and civilian staff that typically comprise the users of military ISS. Another is the range of Services, units and roles that operate in the military context under separate commands, and the range of support entities that typically exist in defence departments to support these operational entities. Each of these characteristics presents challenges for the communication across staff groups, entities and commands that is required for optimal operation of ISS in support of military injury prevention programs. These issues require special consideration by military forces and the defence departments within which they exist.

Within military contexts like the ADF, communication of injury issues identified by ISS through a transparent, accessible and shared electronic information and data repository would likely promote unit comparisons of injury problems, sharing of information between units, and collaboration in solving injury problems. Greater transparency may cause greater scrutiny of the actions commanders of units and staff responsible for injury prevention take to combat injury issues within their units. This increased scrutiny may thereby promote a greater sense of accountability and action. Moreover, by disseminating information relating to the development and evaluation of prevention measures - both successes and failures - units and their commanders may learn from the experiences of others. This, in turn, will conserve valuable resources and enable earlier and more effective prevention of injuries. Heightened communication may also benefit the injury surveillance process itself. Increased communication may facilitate the creation and maintenance of a shared understanding of roles and responsibilities. From a performance perspective this will likely (i) facilitate transmission of knowledge, (ii) simplify coordination, and (iii) avoid potential conflicts; thereby improving performance.

Participants in this study also identified several facets of the design and operation of injury *data collection* elements of ISS that they consider to be important. These include the rationalisation of like ISS across sub-entities of the organisation, the adoption of electronic data collection methods where feasible, engaging health centre staff to support injury data collection through ongoing communication (for example, data quality feedback, highlighting prevention activities), and identifying an optimal amount or format of data to be collected by the ISS. These elements have synergies – if one changed the impact would be felt across other elements. This may be suggestive of a holistic approach being needed to resolve these issues.

Further work is required to identify the optimal data elements and collection format (for example, quantitative vs. qualitative) to elicit high quality data that is also effective in providing an understanding of factors associated with injury. Through the adoption of electronic infrastructure, there is also potential to link fragmented electronic health and personnel systems and better coordinate public health surveillance efforts.

A two-step approach to injury surveillance would be effective in meeting any legislative reporting requirements and providing a useful process for understanding injury factors. Step one would be a minimum data collection of information pertaining to all injuries. Based on the analysis and prioritisation of injury issues from step-one, periodic sampling of specific injury types, personnel groups, places or activities would be conducted, to inform in-depth investigations of injury causes. This second step ideally provides a more in-depth understanding of the factors associated with causation of specific injuries [37 38]. This framework appears to represent an effective structure in balancing data needs, available resources and perceived respondent survey burden, and would be particularly useful in the military context, where personnel are often already stretched for time and tasks must be prioritised and efficiently completed.

In military ISS, injury data analyses performed by military personnel with little data analysis training are likely to result in suboptimal interpretation and understanding of injury issues. Greater sophistication of analyses through real-time automated analyses

may be a useful method to realise the full benefits of ISS of the ADF and other military forces. This would allow injury issues to be addressed as they occurred, rather than in accordance with fixed and often lagging reporting time frames. Deviation detection and statistical process control charts are methods of analysis which have demonstrated utility in related fields [39-42]. However, the initiation of more sophisticated analyses is dependent upon the existence of robust technological infrastructure for data collection and analysis in military ISS, and skilled personnel to perform and interpret the analyses. Sophisticated analysis of injury surveillance data may also suggest potential refinements for the data collection instrument.

Injury surveillance dissemination was also a concern of participants, who viewed this as limited and ad-hoc in the ADF context. Robust knowledge management was considered central to optimising information dissemination processes. Respondents desired a centralised electronic information repository which provided a variety of information services. These services focussed on providing assistance to end-users of the data to identify injury problems within units and develop, implement and evaluate countermeasures. This may seem beyond the traditional scope of military and civilian ISS, but within a self sustaining environment such as that of a military force there is an internal responsibility to actively bridge the divide between information dissemination and action. Arguably, this perceived divide has historically stifled the proliferation of injury prevention within military forces like the ADF, and the broader civilian community.

The study results suggest that a range of issues should be addressed if military ISS are to be optimised, and a number of these factors require additional consideration in the military context than would be required in other organisations. Importantly, though, it should again be noted that ISS and the information they produce are not a panacea and will not solely provide all of the required information regarding injury causation. Injury surveillance is crucial in defining problems and guiding and prioritising further investigations, but should be a catalyst for further causal analyses. The comprehensive implementation of a two-stage injury surveillance framework is suggested. A move away

from the historical emphasis on solely defining the problems is needed, and a greater emphasis should be given to understanding the mechanisms that cause injury and defining interventions aimed at their eventual prevention [43]. Injury surveillance should not be seen as an end in itself.

5. Study Strengths and Limitations

Two key limitations within this research potentially undermined the classical tenets of a grounded theoretical approach to qualitative analysis. The data collection phase, specifically the theoretical sampling, was effected by a sample frame bias, notably through 'gatekeeper bias' and logistical concerns. Gatekeeper bias was introduced, as the researcher relied on participants' recommendations in identifying and accessing additional interviewees. Participants likely had a greater propensity to recommend individuals that they had worked with and potentially sharing similar views. This may have reduced the overall variance in responses obtained throughout the interview process. Furthermore, access (i.e. permission from military commands) and logistical difficulties eliminated the possibility of including some individuals.

The aim of the current research was to examine the experiences and requirements of users of several Australian military ISS, to inform future development and improvement of such systems internationally, particularly in areas pertaining to human interactions with the ISS, and to assist in framing further research on this topic. The study did not endeavour to measure the effectiveness of ADF or other military ISS, which has been considered elsewhere [5 6]. On this basis, the study design was appropriate and adequate, and the range of interviewed participants was representative of key users of military ISS.

6. Conclusion

This research offers unique insight into the socio-cultural, organisational, and procedural factors which impact ISS within a military environment. These factors can be considered and addressed in military ISS to optimise their design and operation within the context of injury prevention programs. The extent to which these factors readily apply to the civilian ISS is uncertain and warrants future research.

The current research explores in detail the collection, analysis and dissemination of injury data in a holistic manner that is useful for injury surveillance system optimisation. By understanding and incorporating the procedural elements identified, military ISS can be optimised. Moreover, this work illustrates that further research is particularly required to identify new and useful forms (for example, automated forms) of injury data analysis, and establish a better understanding of user requirements regarding information dissemination for injury prevention.

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References

1. Department of Veterans' Affairs. Annual Report 2005-2006. In: Commission MRaC, editor. Canberra: Australian Government, 2006:1-23.
2. Department of Defence. Annual Report 2005-2006. Canberra: Australian Government, 2006:1-512.
3. Department of Defence. Financial Statements. Canberra: Australian Government, 2006.
4. Pope R. Prevention of pelvic stress fractures in female army recruits. *Military Medicine* 1999;164(5):370-373.
5. Pope RP. Case Report: injury surveillance and systematic investigation identify a rubber matting hazard for ACL rupture on an obstacle course. *Military Medicine* 2002;167(4):359-362.
6. Pope R. Rubber Matting on an Obstacle Course Causes Anterior Cruciate Ligament Ruptures and Its Removal Eliminates Them. *Military Medicine* 2002;167(4):355-358.
7. Jones BH, Amoroso PJ, Canham ML, Schmitt JB, Weyandt B. Conclusions and Recommendations of the DoD Injury Surveillance and Prevention Work Group. *Military Medicine* 1999;164(8 Suppl):9-26.
8. Jones BH, Perrotta DM, Canham-Chervak ML, Nee MA, Brundage JF. Injuries in the Military: A Review and Commentary Focused on Prevention. *American Journal of Preventive Medicine* 2000;18(3 Suppl):71-84.
9. Holder Y, Peden M, Krug E, Lund J, Gururaj G, Kobusingye O, editors. *Injury Surveillance Guidelines*. Geneva: World Health Organization, 2001.
10. Seliem A, Ashour A, Khalil O, Millar S. The Relationship of Some Organizational Factors to Information Systems Effectiveness: A Contingency Analysis of Egyptian Data. *Journal of Global Information Management* 2003;11(1):40-71.
11. Graitcer PL. The Development of State and Local Injury Surveillance Systems. *Journal of Safety Research* 1987;18:191-198.
12. Stone DH, Morrison A, Ohn TT. Developing injury surveillance in accident and emergency departments. *Archives of Disease in Childhood* 1998;78(2):108-110.

13. Driscoll T, Harrison J, Langley J. Injury Surveillance. In: McClure R, Stevenson M, McEvoy S, editors. *The Scientific Basis of Injury Prevention and Control*. Melbourne: IP Communications, 2004:87-109.
14. Orchard J, Newman D, Stretch R, Frost W, Mansingh A, Leipus A. Methods for injury surveillance in international cricket. *Journal of Science and Medicine in Sport* 2005;8(1):1-14.
15. Carroll LJ, Cassidy D, Holm L, Kraus J, Coronado VG. Methodological issues and research recommendations for mild traumatic brain injury: the WHO collaborating centre task force on mild traumatic brain injury. *Journal of Rehabilitation Medicine* 2004;Suppl. 43:113-125.
16. Isolani L, Bonfiglioli R, Raffi GB, Violante FS. Different case definitions to describe the prevalence of occupational carpal tunnel syndrome in meat industry workers. *Internation Archives of Occupational and Environmental Health* 2002;75:229-234.
17. World Health Organisation. *The International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Australian Modification (ICD-10-AM)*. Fourth ed. Sydney: National Centre for Classification in Health, 2004.
18. Ribbeck BM, Runge JW, Thomason MH, Baker JW. Injury Surveillance: A method for Recording E Codes for Injured Emergency Department Patients. *Annals of Emergency Medicine* 1992;21(1):37-40.
19. ICECI Coordination and Maintenance Group. Internation Classification of External Causes of Injuries (ICECI) Version 1.2: Consumer Safety Institute, Amsterdam and AIHW National Injury Surveillance Unit, Adelaide, 2004.
20. National Occupational Health and Safety Commission. Type of Occurance Classification System, Version 3 (TOOCS 3.0). Canberra: National Occupational Health and Safety Commission, 2004.
21. Williamson A, Feyer A-M, Stout N, Driscoll T, Usher H. Use of narrative analysis for comparisons of the causes of fatal accidents in three countries: New Zealand, Australia, and the United States. *Injury Prevention* 2001;7:15-20.

22. Bondy J, Lipscomb H, Guarini K, Glazner JE. Methods for Using Narrative Text from Injury Reports to Identify Factors Contributing to Construction Injury. *American Journal of Industrial Medicine* 2005;48:373-380.

23. Stout N. Analysis of narrative text fields in occupational injury data. In: Feyer A-M, Williamson A, editors. *Occupational injury: risk, prevention and intervention*. Londond: Taylor and Francis, 1998.

24. German RR, Westmoreland D, Armstrong G, Birkhead GS, Horan JM, Herrera G, et al. Updated Guidelines for Evaluating Public Health Surveillance Systems. *Morbidity and Mortality Weekly Report* 2001;50(RR13):1-35.

25. Ezenkwele UA, Holder Y. Applicability of CDC guidelines toward the development of an injury surveillance system in the Caribbean. *Injury Prevention* 2001;7:245-248.

26. Macarthur C, Pless IB. Sensitivity and representativeness of a childhood injury surveillance system. *Injury Prevention* 1999;5:214-216.

27. Macarthur C, Pless IB. Evaluation of the Quality of an Injury Surveillance System. *American Journal of Epidemiology* 1999;149(6):586-592.

28. Marson R, McD Taylor D, Ashby K, Cassell E. Victorian Emergency Minimum Dataset: Factors that impact upon the data quality. *Emergency Medicine Australiasia* 2005;17:104-112.

29. De Lusignan S. The barriers to clinical coding in general practice: A literature review. *Medical Informatics and the Internet in Medicine* 2005;30(2):89-97.

30. Gambel JM, Drabick JJ, Martinez-Lopez L. Medical surveillance of multinational peacekeepers deployed in support of the United Nations Mission in Haiti, June-October 1995. *International Journal of Epidemiology* 1999;28:312-318.

31. Higginbottom G. Sampling issues in qualitative research. *Nurse Researcher* 2004;12(1):13-20.

32. Tuckett AG. Qualitative research sampling: the very real complexities. *Nurse Researcher* 2004;12(1):47-62.

33. Glaser BG. The Future of Grounded Theory. *Qualitative Health Research* 1999;9(6):836-845.

34. DeGrace BW. The everyday occupation of families with children with autism. *The American Journal of Occupational Therapy* 2004;58(5):543-550.

35. Glaser BG, Strauss AL. *The discovery of grounded theory: strategies for qualitative research*. New York: Aldine, 1967.

36. Gould M, Greenberg N, Hetherton J. Stigma and the Military: Evaluation of a PTSD Psychoeducational Program. *Journal of Traumatic Stress* 2007;20(4):505-515.

37. Lund J, Bjerkedal T, Gravseth HM, Vilimas K, Wergeland E. A two-step medically based injury surveillance system - experiences from the Oslo injury register. *Accident Analysis and Prevention* 2004;36:1003-1017.

38. Auer AM, Andersson R. Canadian Aboriginal communities: a framework for injury surveillance. *Health Promotion International* 2001;16(2):169-177.

39. Rigau-Pérez JG, Millard PS, Walker DR, Deseda CC, Casta-Vélez A. A deviation bar chart for detecting dengue outbreaks in Puerto Rico. *American Journal of Public Health* 1999;89(3):374-378.

40. Wolkin AF, Patel MP, Watson W, Belson M, Rubin C, Schier J, et al. Early Detection of Illness Associated With Poisonings of Public Health Significance. *Annals of Emergency Medicine* 2006;47(2):170-176.

41. Kahn MG, Bailey TC, Steib SA, Fraser VJ, Dunagan WC. Statistical Process Control Methods for Expert System Performance Monitoring. *Journal of the American Medical Informatics Association* 1996;3(4):258-269.

42. Quesenberry CP. Statistical process control geometric Q-chart for nosocomial infection surveillance. *American Journal of Infection Control* 2000;28(4):314-320.

43. Finch C. A new framework for research leading to sports injury prevention. *Journal of Science and Medicine in Sport* 2006;9:3-9.