Chapter 1: The introduction of the BokSmart nationwide injury prevention programme in South Africa

THE INTRODUCTION OF THE BOKSMART NATIONWIDE INJURY PREVENTION PROGRAMME IN SOUTH AFRICA: INTRODUCTION AND BACKGROUND
Chapter 1: The introduction of the BokSmart nationwide injury prevention programme in South Africa

BACKGROUND

Regular participation in physical exercise offers numerous benefits, including health and enjoyment to the individual.[1,2] However, participation in physical activity also has a potential risk of injury to the individual – this risk varies by the amount and type of activity. [2,3]. Rugby Union (‘rugby’) is currently one of the most popular sports in the world. This popularity is increasing, worldwide. [4] Of all popular team sports, rugby has a particularly high risk of injury – higher than that of soccer (non-North American football) and cricket.[3-5] The high incidence of injury in rugby is related to the nature of the game – a field-based team sport that involves multiple contact situations over the 80 minutes of play. [6-8] Since rugby’s inception - speculated to have been between the start of the 1600’s and the mid 1800’s - the sport has always been regarded as a violent sport. [9] Indeed, the main motivations for the formation of the Rugby Football Union in 1871 were the introduction of laws to reduce the violence of the game. [9] The Laws of Rugby Union have developed exponentially in both number and complexity from these early days to present. The earliest recorded set of “laws”, created at the formation of the Rugby Football Union in 1871 were put in place to ensure a fair contest of possession. [9] Even more recently, many law changes have been made to increase player safety. [10]

However, some of these law changes have been to aid rugby in its competition with other popular sports for spectator support. [9] The earliest record of a law change to improve spectator enjoyment – made in in the early 1900’s was to reduce the number of players on the field from 300 to 30. [9] The result – a faster, more open, running game - is believed to have increased the injury risk due to the increased speed physical collisions. [11,12] This notion was even suggested in 1980 by the then President of the Rugby Football Union: “There is little doubt that Rugby Football at all levels...has become a more dangerous pursuit in the last ten years”. [11] Despite this injury risk, law changes and the nature of the game have resulted in rugby being one of the most watched and played games in the world, currently. [4]

Therefore, the epidemiology of rugby injuries has been of interest to researchers for some time now: the earliest scientific report on this topic being published in 1954. [13] Of all sports injuries, serious or catastrophic injuries are the most life-changing: for the sufferer, as well as for their immediate family and friends. As catastrophically
injured players are often also the “bread winners” of their family, there are often both emotional and financial consequences to the injury. Furthermore, the individual requires a shift in expectations as their life of physical activity and general good health will also be affected for their rest of their lives. [14] While media reports often associate rugby with catastrophic injuries, [15] these reports may exaggerate this association. [16] The United Kingdom’s Health and Safety Executive assesses certain day-to-day activities (such as driving a car or motorcycle) and diseases or adverse events (such as cancer or drowning) in terms of risk of serious injury or death. The number of deaths are normalised by the number of people at risk for a particular situation (exposure). These risks are rated in increasing magnitude: ‘negligible’, ‘acceptable’, ‘tolerable’ and ‘unacceptable’ risk. Risk of serious injury or death due to participating in rugby was classified as either ‘acceptable’ or ‘tolerable’ risk for all countries that had available data for the study. [16] Developing cancer and driving a motorcycle were examples of events/adverse activities that carried unacceptable levels of risk, while an event such as being struck by lightning carried negligible risk. While higher than most other popular sports, Fuller [16] classified rugby’s incidence of catastrophic injuries as ‘acceptable’ in this assessment. Furthermore, rugby’s rate of catastrophic injuries was less than sports such as horse-racing, gymnastics and ice hockey. [16]

Despite the assessment of rugby-related catastrophic injuries being classified as ‘acceptable’, the consequences of catastrophic injuries are so severe that even one catastrophic injury a year is one case too many. A recent account of those suffering catastrophic injury from the Chris Burger Petro Jackson Players’ Fund (CBPJPF) in South Africa illustrates the hardships that are experienced by the players and their families post-injury. [14] The CBJPF is a non-profit organisation that aims to financially assist players injured while playing rugby in South Africa. [14] The fund was begun in 1980 by former Springbok Captain Morne Du Plessis after his teammate and friend died a shortly after suffering a spinal cord injury during a rugby match where they were teammates. Owing to continued contributions and fund-raising activities the fund currently supports over 60 catastrophically injured rugby players.[14]
However, the most well documented example of an effort to prevent catastrophic injuries emerged from New Zealand. The sport of rugby is of “national prominence and importance” in New Zealand. [17] As a result, the country began the Rugby Injury and Performance Project (RIPP). This project’s aim was to scientifically develop and evaluate a rugby injury prevention programme. The ‘sequence of prevention’ model [2] was chosen as a framework for this proposed intervention. (Figure 1).

A series of six publications [17-22] assessed Step 1 and Step 2 of the four stage model of injury prevention (Figure 1). [2] Based on this information, and the success of the original nationwide SportSmart injury prevention education programme, [23] a nationwide injury prevention programme for rugby, RugbySmart, was launched in New Zealand in 2001 (Step 3). The programme strategy was to educate key rugby stakeholders - coaches and referees - on ‘safe’ rugby coaching, game and injury management – in an attempt to improve injury rates in players. This strategy was chosen based on the importance of these role players (coaches and referees) in determining player behaviour.[24] Thus, the coaches and referees are the actual...
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direct target (‘researcher intervention’) while players are the indirect targeted “health beneficiaries” of the intervention. [25] The effectiveness of this intervention was evaluated by examining changes in injury rates and player behaviour after the launch of the programme (Steps 4). [24,26] Five years after the introduction of RugbySmart, there was an observed reduction in the incidence of both general [24] and catastrophic [26] injuries in players, nationwide. As targeted player behaviour (practicing of safe techniques) had improved over the concomitant time period, [24] it was assumed that the improvement in player catastrophic injury rates were a result of this improvement in their behaviour. Since this evaluation, behaviour change in the target population has been recognised as a necessary requirement for the success of injury prevention programmes. [27,28]

Similarly to New Zealand, the sport of rugby is particularly popular in South Africa with an estimated 400 000 - 500 000 players and 40 000 – 45 000 coaches nationwide.[28] Despite the high level of participation, there have only been a few well-performed prospective epidemiological studies in rugby in South Africa. This is of concern considering that the CBPJPF has received reports of an average of 22 catastrophic injuries per annum since 2001 [29] As a result, the principles of the RugbySmart intervention were adapted, with their permission and support, for South Africa. The South African programme was named BokSmart, borrowing “Bok” from ‘Springboks’: the popular nickname of the national rugby team. Based on the programme’s success in New Zealand, the BokSmart manager, Dr Wayne Viljoen, predicted that BokSmart could reduce the incidence and severity of catastrophic head, neck and spine injuries in South Africa. [30] While the programme has other objectives, this is the main goal of the programme and will therefore be referred to as “internal goal” of the BokSmart programme. Although there were some preliminary discussions beforehand, the BokSmart injury prevention program was officially launched in South Africa in July 2009.

THE BOKSMART PROGRAMME

The BokSmart strategy is comprised of four ‘interventions’: 1. BokSmart rugby safety workshops (RSWs) aimed at coaches and referees, 2. BokSmart rugby medic programme (RMP) aimed at underprivileged communities, 3. BokSmart SpineLine
emergency number, 4. BokSmart website (www.boksmart.com) with freely available resources for coaches ranging from pre-participation screening forms to physical conditioning programmes [31] These interventions are used to achieve the internal goal of the programme.

Based on the principles of RugbySmart, all content and legislation of BokSmart is evidence-based. [31] The BokSmart manager has contracted and still contracts relevant experts on a needs basis to conduct literature reviews on specific topics of practical importance to the programme and encourages the expert to publish the work in a high impact peer-reviewed journal. For example, the “safe techniques for rugby” [32] that are advocated to coaches and referees in the RSWs as well as a modified scrum engagement law change that occurred in South Africa in 2013 [33] were both published in international sports medicine journals. A comprehensive list of the BokSmart related research is available at their website (http://boksmart.sarugby.co.za/content/boksmart-research/) [29]

**Intervention 1: BokSmart rugby safety workshops**

The rugby safety workshops are the main focus of the BokSmart programme and aim to educate all rugby coaches and referees in South Africa in safe, yet effective, rugby techniques and procedures. [31] The rugby safety workshops are facilitated by a SARU-appointed trainer who takes the attendees through an educational DVD. Trainers are well-respected coaches or referees who are nominated by their local regions (called ‘unions’ in South Africa) to SARU for this job. After a two day training process which involves rigorous screening, training and testing of the candidates, SARU chooses it’s BokSmart trainers. This is to ensure that all trainers are competent rugby safety workshop facilitators.

The rugby safety workshops content represents a summary and translation into everyday language for the attendees of the evidence-based articles described previously that are available on the BokSmart website, [29]. The topics covered in the RSW range from correct hydration and nutrition practices to serious injury management for rugby. The following topics were presented in the first rugby safety workshops in 2009:
Thus, this range of topics covers both primary (i.e. preventing an injury from occurring) and secondary (i.e. adequately dealing with an injury that has occurred to promote best possible outcome) aspects of prevention. Although English is only the fourth most spoken home language in South Africa according to the latest census results, [34] the language is widely spoken in the country. Therefore, SARU decided that the rugby safety workshops would be uniformly presented in English across the country.

At the end of the rugby safety workshops, attendees are provided with their own copy of the rugby safety workshops DVD as well as an accompanying manual that contains similar information to the DVD as well as a pitch-side concussion guide (all in English). It is SARU’s expectation that attendees will make use of the free resources once they return to their respective roles with players. Once attendees have sat through the entire rugby safety workshops, they are given a BokSmart card to certify that they have a current accreditation. This certification lasts for two years after which time the card expires and they have to redo the entire rugby safety workshop. SARU also renews the rugby safety workshop content (DVD and accompanying manual) every two years to ensure the information is current and also to incorporate relevant feedback from attendees from previous courses.

As the BokSmart programme is an injury prevention programme, it should address risk factors for injury. [35] The Meeuwisse model of injury causation describes the
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An athlete on a continuum, from healthy to injured, based on the interaction of various injury risk factors (Figure 2). An athlete may become predisposed to injury through intrinsic (internal) risk factors, which are inherent to an individual, such as age or sex. Once predisposed, the individual can become a susceptible athlete through exposure to extrinsic (external) risk factors, such as the equipment the athlete was using or the immediate playing environment. However, these two groups of risk factors alone may not necessarily result in an injury – an inciting event is a necessary extrinsic factor to cause an acute injury. [35]

![Figure 2. Adapted injury causation model. [34]](image)

To reduce the incidence of injuries in rugby, the course content of the rugby safety workshops would need to be designed to change behaviours that were risk factors for injury.[27] Therefore the content of the rugby safety workshops information book was divided into the specific intrinsic and extrinsic injury risk factors that each chapter addresses (Table 1). Due to the internal goal of the programme – to reduce the incidence and severity of catastrophic injuries, special note was made of content that had a focus on catastrophic injuries.

The intrinsic and extrinsic risk factors that were targeted by the content of the BokSmart rugby safety workshops were then applied to the Meeuwisse injury causation model in Figure 3. For the BokSmart programme to be effective, the content needs to be able to change behaviour associated with injuries, as well as the determinants of these behaviours, in all the key stakeholders involved in rugby in South Africa.
### Table 1. BokSmart Rugby Safety Workshops chapter content and associated injury risk factors.

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Content</th>
<th>Injury risk factor (I - Intrinsic or E - extrinsic)</th>
</tr>
</thead>
</table>
| 1. Eating and drinking right for rugby | Nutrition and hydration before, during and after training/match | Fatigue (I)  
Dehydration (I)  
Inadequate adaptation from training or match (I) |
| 2. Effective play and controlling the game | Inspection of playing conditions (on- and off-field) and pre-match briefing of players | Unsafe on- or off-field conditions (E) |
| | | Handling foul play | Foul play [C] |
| | | Handling the tackle situation (including foul play) | Incorrect technique (I) [C] |
| | | Coaching safe and effective techniques (scrum, tackle, being tackled, lineout, ruck and maul) | Incorrect technique (I) [C] |
| 3. Fair play and the BokSmart Code of Conduct | Agreement to uphold fair play agreement – safe environment | Foul play [C] |
Management of soft tissue injury – recovery from injury and adaptation  
Management of concussion – safe environment and recovery from injury  
Rehabilitation and return to play – recovery from injury | Incorrect on-field injury management (E) [C] *  
Previous injury (I) |
| 5. Physical preparation and recovery techniques | Effective warm-up – improve range of motion, body ready for contact situation, improve visual awareness, improve mental awareness  
Cool-down – improve recovery from match/training | Pre-game state (I)  
Inadequate adaptation (I) |
| 6. Pre-participation screening of players | Identify players predisposed to injury by previous injury or familial predisposition through questionnaire | Previous injury (I) [C]  
Familial predisposition (I) [C] |


*Table 1 continued on next page*
Table 1 (continued). BokSmart Rugby Safety Workshops chapter content and associated injury risk factors.

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<th>Content</th>
<th>Injury risk factor (I - Intrinsic or E - extrinsic)</th>
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| 7. Pre-season testing and the physical profiling of players | Awareness of players at risk by cardiorespiratory fitness or strength  
Improve cardio fitness and strength | Off-, pre- and in-season condition (I) [C] |
| 8. Protective equipment | Reduce impact of contact on body | Inadequate protective equipment (I) |
| 9. Safety in the playing environment | Improve on- and off-field conditions | Unsafe on- or off-field conditions (E) [C] |
| 10. Serious injury protocol | Dealing with a serious injury | Incorrect on- or off-field injury management (E) [C] |
| 11. Strength and conditioning for rugby | Ensure player is physically prepared for contact and cardiorespiratory demands of game  
Neck conditioning to reduce risk of serious injury | Off-, pre- or in-season cardiorespiratory fitness or muscle strength (I) [C] |


Figure 3. BokSmart content fitted to injury causation model [35]
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**Intervention 2: BokSmart rugby medic programme**
The *BokSmart* rugby medic programme is a parallel intervention to the rugby safety workshops although it was run on a needs-basis and for underprivileged clubs and schools and run on a far smaller scale to the rugby safety workshops. The rugby medic programme is a 6-8 hour practical course that focuses on secondary prevention as part of the catastrophic injury content of the RSW course and that is performed for no charge. Due to budget constraints, the rugby medic programme was stopped in 2011. However, this intervention is described for context.

Typically in South Africa, underprivileged clubs and schools have minimal access to trained medical professionals and equipment that are implicitly requisite for rugby training and matches. The aim of the rugby medic programme is to empower individuals involved in rugby in these underprivileged communities in the prevention of catastrophic injury.

*BokSmart* requires a rugby medic programme course representative from the school or club before a course will be run. The identification of this rugby medic programme course representative occurs through one of two processes. The main method is that SARU identifies leaders in known underprivileged rugby communities. Alternatively any member of a rugby community, who can prove that their club or school is underprivileged, can apply to SARU directly to be a rugby medic programme representative. Once SARU has confirmed a representative for the course, a qualified Emergency Medicine Specialist (EMS) will be sent to conduct the programme at the representative’s institution. Furthermore, if the EMS notices that the school or club is without any specialist equipment for managing a catastrophic injury – such as a stretcher or spider harness – these items are delivered to the school or club by SARU at no charge.

**Intervention 3: BokSmart Spineline emergency number**
This is a dedicated toll-free emergency hotline for all suspected rugby-related catastrophic injuries in South Africa. The line is operated by a private emergency medical service, *ER24*, and therefore can assist with both the management and transportation of catastrophically injured players. The number (0800 678 678) is discussed with coaches and referees during the rugby safety workshops and rugby medic programme and is also advertised widely outside of the course.
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**Intervention 4: BokSmart website (www.boksmart.com)**
The BokSmart website provides a variety of freely available content and resources:

1. Description of BokSmart, including details of the rugby safety workshops, rugby medic programmes and Spineline.
2. Medical protocols including concussion, eating and drinking right for rugby, pre-season testing, physical conditioning programmes (with and without access to training facilities), serious injury protocols.
3. “Safe six” prehabilitation programme.
4. Legislation and regulations for South Africa
5. Research – BokSmart-related content published in international peer-reviewed journals,
7. Up to date injury statistics
8. Coach and refereeing courses – International Rugby Board (IRB) courses and rugby safety workshops

**BOKSMART REPORTS**
The BokSmart content evolves in two-year cycles: cycle 1 began in July 2009 (BokSmart launch) and cycle 2 began in July 2011. The programme is currently in its third cycle. To keep the content of BokSmart relevant to its environment, SARU has various internal audits and reports (either annual or biannual). For example – because the number of scrum-related catastrophic injuries was increasing, SARU began investigating safer laws for scrummaging to reduce this injury risk. [33] SARU also uses the information gleaned from these reports to optimise the enjoyment of the RSW content. Six of the most important of these reports are detailed below.

**Report 1. Knowledge, Attitude and Behaviour survey (annual)**
A Knowledge, Attitude and Behaviour (KAB) questionnaire was initially developed to evaluate junior and senior players’ behaviour as part of the RugbySmart evaluation in New Zealand. [24] BokSmart has been administering a comparable version of this questionnaire (Appendix I) at the national merit Rugby tournament for schoolboys and club (senior) players since 2008. SARU uses the results of these questionnaires to: 1. Assess if player behaviour is improving over time, and 2. Compare South Africa and New Zealand player behaviours.
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Report 2. BokSmart Rugby Safety Workshop (RSW)
While SARU felt that it was necessary to mandate coaches and referees attendance of BokSmart rugby safety workshops, they did not think it was fair to evaluate every attendee. The reasons for this were two fold: firstly, the course is already between 5-6 hours without an evaluation; secondly, with a variety of levels of attendees in both coaching expertise and socioeconomic status in the same course, SARU was concerned that some attendees would be made to feel inferior by a formal evaluation. Thus, there is no formal test or evaluation before you receive a BokSmart certification; only their attendance is required. However, before the course begins, attendees are required to complete a demographic information form (Appendix II). This form requires information such as the attendees’ union (region) affiliation, discipline (i.e. coach, referee, administrator, etc.), coaching/referees qualification and level of involvement in rugby (e.g. national, provincial, school, club, etc.). A biannual report keeps track of the number of these various demographics, but most importantly the number of coaches and referees who have attended the course.

For payment, SARU requires that the rugby safety workshop trainers ask three attendees of each course to assess the course they have just attended. The trainers are assessed with a standardised form (Appendix III) which requires the attendee (assessor) to rate the trainer on each of the following topics: each of the chapters, the welcome and introduction, course conclusion and summary, certification and hand-out process, overall presentation, communication skills, neatness and appearance, overall organisation, knowledge and understanding and overall impression. The assessors allocate a score between 0, for poor, and 5, for excellent, for each question. The three assessor’s scores are then averaged and this average presented in the report next to the initials of each trainer. This trainer assessment is not a validated method of evaluation and was not performed in RugbySmart. However, SARU decided to implement it as they thought it was critical to improving the accountability of the rugby safety workshop trainers.

Report 3. BokSmart Rugby Medic Programme (RMP) survey
When a rugby medic programme representative is appointed, SARU records information about the institution (club, school, etc.), location and role in rugby (coach, referee, manager, player, etc.) of the representative (Appendix IV). The
representative is required by SARU to assess the EMS trainer in terms of neatness, promptness, professionalism and content they taught (Appendix IV). The RMP representatives are also asked if the students enjoyed the workshop, if the institution has its own spinal immobilization equipment, and if the institution has been issued with equipment previously (Appendix IV). Depending on the institution’s catastrophic injury management equipment, SARU may allocate equipment to that institution. SARU records and reports on the details of the institution that received equipment. Owing to the termination of this intervention, this report is obviously no longer prepared.

**Report 4. BokSmart Spineline (0800 678 678) calls survey**
The emergency medicine company that runs Spineline, ER24, has a computer system that records the number of calls that are received, the time taken to answer the calls and the number of calls that were abandoned the caller stated their reason for calling to call centre professional. ER24 also records the time between answering the call and the EMS (Emergency Medical Services) arriving on the scene. Other information that ER24 records is: the type of injury (head, neck), the region where the injury occurred, the Triage classification of injury at the time of the call to the Spineline (Red, Yellow, Green or Blue), age of the injured player, mode of transport to hospital and whether or not the injured player had health insurance. The Spineline biannual report summarises these data that are captured by ER24.

**Report 5. SARU injury surveillance project**
In 2008 SARU began an injury surveillance project at all of their tournaments. There are six tournaments that are surveyed: four youth tournaments and one senior (adult) tournament. The four youth tournaments are in the under-13, under-16 and under-18 (two tournaments) level. The senior tournament is for adult teams with non-professional players. All five tournaments are national merit tournaments, whereby players need to qualify for their region and be selected for the representative team to participate. An injury collection form, based on the consensus statement for injury data collection in rugby union [36] is used to collect all injury information (Appendix V). An annual report is prepared by Professor Mike Lambert of the University of Cape Town for SARU on these five tournaments to keep track of injury rates and risk factors.
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**Report 6. Serious injuries report**
A Serious Injury Case Manager (SICM) was appointed by SARU in March 2008 to follow-up on rugby-related catastrophic injuries that occurred in South Africa. SARU’s definition of a catastrophic injury is: “Any head, neck, spine or brain injury that is life-threatening, or has the potential to be permanently debilitating [includes “near misses”] and results in the emergency admission of a rugby player to a hospital or medical care center.” SARU developed a questionnaire (Appendix VI) to investigate possible risk factors that may have contributed to the injury. Recently this questionnaire has been amended to include information that the IRB (International Rugby Board) requires each rugby-playing nation to submit about these injuries. The questionnaire is either sent through to the injured player in hospital or filled in by BokSmart’s Serious Injury Case Manager (SICM) in consultation with the injured payer. Descriptive information on the following is captured in the questionnaire: details of the level of the game (junior or senior), field conditions, weather conditions, event causing injury and the final diagnosis of the injured player.

**IMPLEMENTATION CONTEXT**
There are some obvious differences between South Africa and New Zealand and that posed logistical issues to the implementers of the BokSmart Programme - SARU. A prominent author in the field of rugby injuries in South Africa - Professor Tim Noakes - emphasised four differences that are important in considering injury prevention efforts between these two countries: [11]

1. **Greater number of rugby players in South Africa than New Zealand,**
2. **South African players come from more diverse social backgrounds than in New Zealand, with large disparities in social classes and education,**
3. **Large proportion of rugby in South Africa is played outside of the control official rugby bodies,**
4. **Large disparities between playing facilities and level of coaching in South Africa, with an assumed greater injury risk to those players at worse facilities and coaching input.**

Additionally, South Africa is made up of nine provinces with an estimated population of 49.9 million people. Within this population, there are four distinct race groups and 11 official languages. [34] English, the language in which the rugby safety
workshops are taught, is only the fourth most spoken home-language of the country. Administratively, rugby is divided into 14 regions or ‘unions’, which fall under the overarching governance of the South African Rugby Union (SARU).

Another difference between the two countries is the absence of a nationwide injury-recording database in South Africa. New Zealand’s comprehensive medical insurer, the Accident Compensation Corporation (ACC), records details of an injury that occurs within New Zealand borders. In this way, the researchers of RugbySmart were aware of the number and severity of injuries caused by rugby. Furthermore, through extensive registries, the New Zealand Rugby Union (NZRU) has accurate information on the number of coaches, referees and players in the country – this is not available in South Africa. Without an accurate idea of the number of players and a comprehensive injury registry, the BokSmart programme’s effectiveness cannot be assessed by comparing injury rates over time, as was performed in the RugbySmart evaluation. [24,26]

OBJECTIVES

Although the RugbySmart evaluation was an exemplary injury prevention evaluation at the time, [36] the knowledge and experience associated with implementing strategies to prevent or reduce injuries has advanced rapidly since 2008. [38] For instance, the Van Mechelen’s ‘sequence of prevention’ model has now been built upon and included into the Translating Research into Injury Prevention Practice (TRIPP) model (Figure 3). [39]

The TRIPP framework adds stages 5 and 6 to the established ‘sequence of prevention’ model as these stages focus on the actual intervention developed in Step 4 of the original Van Mechelen model. [2] Stage 5 seeks to understand the motivators/barriers to uptake of particular safety behaviours in the intervention target, while stage 6 seeks to understand how effective the intervention is in a real-world context.

In order to understand the motivators/barriers (TRIPP Stage 5), a public health evaluation framework such as RE-AIM, has been suggested for use in injury
prevention implementation studies. [38] RE-AIM is an acronym for five components of evaluation: Reach, Effectiveness, Adoption, Implementation and Maintenance. Obviously the Effectiveness component of RE-AIM also serves as Stage 6 of the TRIPP model and thus would be assessed in Stage 5 if the RE-AIM model were used. Besides using RE-AIM, there has also been a call by prominent authors for greater clarity in defining the intervention and the intervention’s target(s) [25] – this is provided in Table 2.

Figure 3. The TRIPP framework stages: 1 – 6 [38]
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**Table 2. BokSmart intervention and intervention target(s) definition**

<table>
<thead>
<tr>
<th>Evaluation question</th>
<th>Planned evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Who is the intervention target?</td>
<td>Intervention target: coaches and referees</td>
</tr>
<tr>
<td></td>
<td>Health beneficiaries: players</td>
</tr>
<tr>
<td>What is the intervention?</td>
<td>Researcher intervention: SARU trainers deliver RSW to coaches and referees</td>
</tr>
<tr>
<td></td>
<td>Injury prevention intervention: players</td>
</tr>
<tr>
<td>Who delivered the intervention</td>
<td>Coaches and referees: not under SARU or researcher control</td>
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Having defined the BokSmart intervention (Table 2), it is obvious that this injury prevention programme has two targets: (1) Coaches and referees (“researcher intervention”) and, (2) Players (“injury prevention intervention”).[25] Thus, the BokSmart-specific definitions for the RE-AIM framework (TRIPP stage 5) have separate definitions for these two different targets in Table 3.

**Table 3. BokSmart RE-AIM definitions (TRIPP Stage 5)**

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<td>Reach</td>
<td>All 40,000-50,000 coaches and referees attend RSW</td>
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<td>Acquire RSW knowledge</td>
<td>Reduction in catastrophic injury rates (SARU internal goal)</td>
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RSW – rugby safety workshop

THESIS OUTLINE

Seven research questions are proposed to answer the overall thesis question: “Evaluation of the effectiveness of BokSmart – a nationwide injury prevention programme for rugby union”. These research questions were necessary to satisfy each stage of the Translating Research into Injury Prevention Practice (TRIPP) framework (Table 4).
Chapter 1: The introduction of the BokSmart nationwide injury prevention programme in South Africa

Chapters 2, 3, 4 and 5 address both stages 1 and 2 of TRIPP: the incidence and severity of injuries; as well as the aetiology of these injuries. Chapter 2 investigates the incidence, severity and aetiology of injuries at four competitive youth tournaments. This study used data from the SARU injury surveillance project described under the “BokSmart reports” heading. Chapter 3 uses the same data that were used in Chapter 1 to investigate and often understudied injury severity measure: the economic burden of injuries. The data for these two chapters are described under the “SARU injury surveillance” heading in this chapter (“BokSmart reports” general heading). Chapter 4 investigates the incidence and severity of all catastrophic injuries in South Africa. The details of these injuries are recorded by the BokSmart serious injury case manager and this data collection process is described in detail under “Report 6” (“BokSmart reports” general heading) in this chapter. Chapter 5 investigates in more detail the risk of both general and catastrophic injury specific to the scrum phase of play (TRIPP stage 2), using the data from Chapters 2 and 4.

Chapters 6, 7 and 8 assess TRIPP stage five (which includes TRIPP stage six). Chapter 6 investigates the internal goal of SARU for the BokSmart programme: the effectiveness of the programme in reducing the catastrophic injury rates in South Africa. This investigation is performed using the data from the Serious injury report (“Report 6” under “BokSmart reports” general heading) in this chapter. Chapter 7 investigates player behaviour to see if it changed over the time that BokSmart had been implemented. This study was performed using data collected for the Knowledge Attitude and Behaviour survey, described in detail under “BokSmart reports” in this chapter. Chapter 8 is a qualitative study to investigate coaches and referees’ perceptions of BokSmart (“researcher intervention”). 
### Table 4. Thesis research questions

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Research Question</th>
<th>TRIPP* stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>What is the injury incidence and severity of rugby injuries in competitive youth players?</td>
<td>1 + 2</td>
</tr>
<tr>
<td>3</td>
<td>What is the economic burden of rugby related injuries in competitive youth players</td>
<td>1 + 2</td>
</tr>
<tr>
<td>4</td>
<td>What is the incidence and severity rugby-related catastrophic injuries in South Africa?</td>
<td>1 + 2</td>
</tr>
<tr>
<td>5</td>
<td>Are we underestimating the risk of scrum-related injuries to front-row players?</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>BokSmart evaluation I: Has the launch of the programme been associated with changes in catastrophic injury rates?</td>
<td>5 + 6</td>
</tr>
<tr>
<td>7</td>
<td>BokSmart evaluation II: Has the programme been associated with changes in player’s injury-preventing behaviours?</td>
<td>5 + 6</td>
</tr>
<tr>
<td>8</td>
<td>BokSmart evaluation III: What are coaches and referees (research intervention) perceptions of the programme?</td>
<td>5 + 6</td>
</tr>
</tbody>
</table>

*TRIPP – Translating Research into Injury Prevention Practice [39]

Thus, the BokSmart programme will be investigated for SARU’s internal goal of reducing catastrophic injuries in players as part of these six TRIPP stages. Irrespective of whether SARU achieved its goal of reducing catastrophic injuries, the rest of the TRIPP stages will help the authors to establish why the intervention is/isn’t working. Once this is known, suggestions can be made to improve the intervention. By documenting this process, barriers and facilitators to programme success may be established, thereby assisting the development of similar injury prevention programmes in future.

**REFERENCES**


Chapter 1: The introduction of the BokSmart nationwide injury prevention programme in South Africa


30. Viljoen W [personal communication]. Main internal goal of BokSmart.


Chapter 1: The introduction of the BokSmart nationwide injury prevention programme in South Africa


Chapter 2: Incidence and severity of injuries to South African Rugby Union (SARU) Youth Week tournament players

INCIDENCE AND SEVERITY OF INJURIES TO SOUTH AFRICAN RUGBY UNION (SARU) YOUTH WEEK TOURNAMENT PLAYERS

PUBLISHED AS:

ABSTRACT

Introduction and objectives: To determine the injury incidence densities (IIDs) and severity of SARU Youth Week tournament injuries, if the IID increases with age, and the types of injuries at the different age group levels, in 2011.

Methods: All match-related injuries presenting to the Tournament Doctor during these tournaments were recorded and classified for severity and type, using the injury collection Consensus Statement for Rugby. Injury incidence per 1 000 match hours and 95% confidence intervals were calculated using overall player exposure time.

Results: Match-related IIDs for ‘all’ (combined: 47.9 injuries/1 000 match hours) and time-loss injuries (combined: 23.1 injuries/1 000 match hours) were not significantly different by age group, despite a strong tendency to indicate differences. The absolute number of injuries per match increased with age. In general, there was a higher proportion of concussions at the GK16, AW18, and CW18 compared with the CW13 tournament(s).

Conclusions: Time-loss IIDs at SARU Youth Weeks are similar to other elite junior rugby data. The absolute number and type/classification of injuries per match may be more informative than IIDs alone for medical planning purposes.
INTRODUCTION

The participation by children and adolescents in organised sport is increasing globally for various reasons, including enjoyment, social interaction and health.[1] However, there is a risk of injury associated with participation in the activity, which varies depending on the type of activity.[2] During organised events involving physical activity an accurate quantification of the risk associated with a particular activity is important to both the participant, the medical support associated with the event, and to injury epidemiologists attempting to provide guidelines to reduce this risk.

Of all popular team sports, Rugby Union (henceforth referred to as ‘Rugby’) presents an above-average overall risk of injury (69 injuries per 1 000 hours exposure) to the player – greater than that of cricket (2 injuries per 1 000 hours exposure), soccer (28 injuries per 1 000 hours exposure) or even ice hockey (53 injuries per 1 000 hours exposure).[3] The high incidence of injury in Rugby is related to the nature of the game – a field-based team sport, with the match lasting 80 minutes (at senior levels), and characterised by short, intermittent bouts of high-intensity exercise with the 30 players having multiple contact situations throughout the game.[4] Risk of injury may increase with age and level/grade, which could be explained by greater speed,[5,6] increased competitiveness/aggression,[7,8] increased height and weight [9] and increased foul play [8] at higher levels of play. In Rugby League, a faster, but comparable version of Rugby, the incidence of injury may also increase with age, which has been attributed to a higher intensity of play at higher levels. [10]

Rugby is popular globally, with an estimated 96 countries currently participating worldwide,[4,11] and enjoys particular popularity in South Africa with an estimated 400 000 - 500 000 players nationwide. [12] The annual South African Rugby Union (SARU) youth tournaments, which began in 1964, are a showcase of the country’s elite schoolboy rugby players at the under-13, under-16 and under-18 (two tournaments) age groups. The best 22 players from each of the country’s 14 Rugby unions (as well as other invited teams, including neighbouring countries Namibia and Zimbabwe), compete for the title of unofficial winner of each tournament. For the under-18 Academy Week and Craven Week (AW18 and CW18) tournaments, there is an additional incentive to be selected for national representative teams. Given the
prestige associated with provincial union or national representation in South Africa, these tournaments are played at a high level that is thought to be associated with a high injury incidence, based on the aforementioned literature. Despite this, no accurate injury data have been collected at these tournaments since their inception in 1964.

Therefore, the aim of this study was to investigate the incidence and severity of the 2011 SARU Youth Week tournament injuries, to determine differences, if any, with increasing age. A secondary aim was to explore associated factors in injured players. Through the results of this investigation, it was hoped that injury prevention strategies may be enhanced at these age groups to prevent any unnecessary injuries at future tournaments.

METHODS
Written informed consent to analyse the recorded information was provided by the player, or by the player's parent or guardian if the player was younger than 18 years of age. If, in the former case, the player was unable to sign the form owing to the nature of the injury, verbal consent was received after explaining the nature of the study. All of the injured players’ information was recorded on a SARU database and the authors were subsequently granted access to this database for analysis in 2011 by SARU and the UCT Human Research Ethics Committee.

Injury surveillance was conducted on the 1 804 players (82 teams with 22 squad members) at the four SARU Youth Week tournaments: Craven Week under-13 (CW13), Grant Khomo Week under-16 (GK16), Academy Week under-18 (AW18) and Craven Week under-18 (CW18), which took place during June and July 2011. A SARU-appointed tournament doctor (TD) was available at each tournament to assess any injury complaint that a player may have had. All injuries that happened before the official tournament matches were not included in the analyses.

Because of the compact schedule of these tournaments, the non-match training hours contributed relatively little to overall tournament exposure and non-match injuries were therefore not recorded. An injury collection form (Appendix V) was
designed based on the Consensus Statement for injury surveillance. [13] Demographic information of each injured player, such as the player’s team, body height, body weight, age, whether or not the player had medical aid (insurance), and protective gear at the time of the injury, was also collected. Unfortunately, this information was not available for players who were not injured. Exposure time was calculated based on the injury collection consensus statement for Rugby: [13]

$$N_M \times P_M \times D_M$$

(where is $N_M$ is the number of matches, $P_M$ is the number of players per match, and $D_M$ is the duration of the match in hours).

Owing to the fact that the injury surveillance was conducted on all the teams in the tournament, $P_M$ was calculated as 30 (15 players per team) for each match. It was also assumed that there were 30 players for the entire match, thereby ignoring the effects of yellow and red cards on match exposure. [13]

**Injury definition**

The injury definitions, described in the Rugby injury consensus statement, were adapted to the following to suit the needs of these tournaments: ‘Any physical complaint, which was caused by a transfer of energy that exceeded the body’s ability to maintain its structural and/or functional integrity, that was sustained by a player during a rugby match and required attention from the SARU Tournament Doctor (TD), irrespective of who decided this’.

**Injury severity**

Highly qualified paramedics and/or nursing staff were available at all tournament matches and therefore, for a player to consult with a TD, the injury would have to be one that the paramedics/nurses could not deal with. A time-loss injury was an injury (based on the aforementioned definition) that resulted in being absent more than one match in a tournament, or more than one day of normal/planned recreational activities after the tournament.

**Injury type**

The ‘type’ of injury categories were collapsed from the original definition for the SARU tournaments so that each injury was classified, according to the TD, as relating to one of the following: concussion, spinal cord, broken bone/fracture,
joint/ligament/tendon, muscle, bruise, laceration (including skin abrasion), other, unsure.

**Match days (Ms)**

Match days (Ms) are defined as days on which all teams played an official tournament match on the same day. For CW18, when only half the teams played in an alternating fashion for the first four days, one M would span two days to include all the team matches. However, for the purpose of comparing the daily load on the tournament medical staff, a tournament match day (TM) is defined as any day in which official rugby matches were played. A TM could also be a M. These terms should be contrasted to ‘rest days’ (Rs), on which teams were able to do what they wanted. Exposure was only calculated from Ms, and not Rs.

The recording of information was performed at all tournaments by either JB or SH to reduce internal inconsistencies. Owing to the short duration of these tournaments (4 - 5 days), only a small number of players were injured a second time (n=4) and therefore these second injuries were analysed with the first injuries. It has been suggested that only injuries severe enough to be considered time-loss injuries (see ‘Injury definitions’) should be reported for uniformity of injury comparisons.[13] However, because of the relatively short duration and corresponding low absolute injury numbers at these tournaments, which would make further analyses and interpretation difficult, ‘Medical attention’ and ‘Unsure’ injuries were also reported for this study. Suspected time-loss injuries were followed up either at the tournament or at weekly intervals after the conclusion of the tournament to confirm the severity of injury: when the player was able to return to normal sporting activities or stopped all treatment.

**Statistical analyses**

Exposure was calculated as the total number of team matches played (varied by tournament, Table 1) multiplied by the number of players per match (30 in each case) multiplied by the match duration in hours (varied by tournament, Table 1). [13] For clarity: when two teams were competing against each other, as occurred for every tournament match, this was considered one team match. Injury incidence densities (IIDs) and corresponding 95% confidence intervals (95% CIs) were calculated for the number of injuries (regardless of whether one person was injured more than once) per 1 000 hours of match play. [14] Incidences, including their 95%
CIs, which did not overlap were considered to be significantly different from each other.

RESULTS

Key tournament descriptive information for the four Youth Week tournaments is provided in Table 1. The match duration increased with age, from two 20-minute halves (total match duration = 40 minutes) at under-13 to two 35-minute halves (total match duration = 70 minutes) at under-18 level. Although CW18 was the only five-day tournament, this tournament structure was unique in that only half of the teams (10 teams, five matches) played per day, in an alternating fashion, until the final match day in which all 20 teams competed (10 matches). The other three tournaments (CW13, GK16 and AW18) had each team play every day, with a rest day before the final day of the tournament, in which all teams played. Therefore, CW13 had the greatest number of Ms (n=4), while the other tournaments had three. The number of teams at each tournament was also greatest at the under-18 tournaments, although, owing to CW13 having four Ms as opposed to the three in the other tournaments, the youngest age-group tournament also had the second highest number of overall matches. The under-18 tournaments had a greater overall exposure time because of the longer duration of their matches.

Table 1. Youth Week tournament structure, 2011

<table>
<thead>
<tr>
<th>Tournament</th>
<th>Teams (n)</th>
<th>Duration (min)</th>
<th>Matches (n)</th>
<th>Exposure (hours)</th>
<th>Structure</th>
<th>IID (95% CI)</th>
<th>Time-loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>CW13</td>
<td>18</td>
<td>40</td>
<td>36</td>
<td>720</td>
<td>M,M,R,M, M</td>
<td>43.1 (27.9 - 58.2)</td>
<td>15.3 (6.2 - 24.3)</td>
</tr>
<tr>
<td>GK16</td>
<td>18</td>
<td>60</td>
<td>27</td>
<td>810</td>
<td>M,M,R,M</td>
<td>45.7 (31.0 - 60.4)</td>
<td>9.8 (10.1 - 29.4)</td>
</tr>
<tr>
<td>AW18</td>
<td>26</td>
<td>70</td>
<td>39</td>
<td>1 365</td>
<td>M,M,R,M</td>
<td>50.5 (38.6 - 62.5)</td>
<td>24.9 (16.5 - 33.3)</td>
</tr>
<tr>
<td>CW18</td>
<td>20</td>
<td>70</td>
<td>30</td>
<td>1 050</td>
<td>TM,TM,T M, TM,R,M</td>
<td>49.5 (36.1 - 63.0)</td>
<td>28.6 (18.3 - 38.8)</td>
</tr>
</tbody>
</table>

CW13 – Craven Week under-13; GK16 – Grant Khomo under-16; AW18 – Academy Week under-18; CW18 – Craven Week under-18; M – match day; TM – tournament match day; R – rest day; IID – injury incidence density (injuries/1 000 hours exposure).
In total, there were 1,804 players at risk for 3,945 hours of match injury exposure (exposure based on consensus statement calculations [13]) for all of the SARU Youth Week tournaments (Figure 1). Of these players, 185 sustained an injury during a tournament match-related incident and were attended to by the TD. Four players suffered two injuries during the tournaments. Based on the TD’s estimation, 91 injuries were considered severe enough to be classified as time-loss injuries. The remaining 98 injuries comprised 87 medical attention injuries and 11 injuries for which the TD was unsure of the diagnoses and the players could not be followed up. The majority (81%) of the 91 estimated time-loss injuries were confirmed telephonically one week after each tournament.

<table>
<thead>
<tr>
<th>SARU Youth Week Tournaments - 2011</th>
<th>Injuries</th>
<th>Total Injury Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>CW13 396 players, 720 hours of Exposure</td>
<td>85 players injured once</td>
<td>87</td>
</tr>
<tr>
<td>GK16 396 players, 810 hours of Exposure</td>
<td>1 player injured twice</td>
<td></td>
</tr>
<tr>
<td>AW18 572 players, 1,365 hours of Exposure</td>
<td>85 players injured once</td>
<td>91</td>
</tr>
<tr>
<td>CW18 440 players, 1,050 hours of Exposure</td>
<td>3 players injured twice</td>
<td></td>
</tr>
<tr>
<td><strong>185 injured players</strong></td>
<td><strong>1,618 uninjured players</strong></td>
<td><strong>11</strong></td>
</tr>
</tbody>
</table>

*Figure 1. Flow diagram indicating the number of players injured at the 2011 SARU Youth Weeks according to the injury definitions. The severity of injury was estimated by the tournament doctor (TD) in each case; these were subsequently confirmed telephonically.*
The combined IID of time-loss injuries was 23.1 injuries per 1 000 match hours (95% CIs: 18.3 - 27.8) across all the tournaments, while the overall IID was 47.9 injuries per 1 000 exposure hours (95% CI: 41.1 - 54.7). CW13 had the lowest IID of time-loss injuries (15.3 injuries per 1 000 exposure hours; 95% CI: 6.2 - 24.3), whereas CW18 had the highest IID of time-loss injuries (28.6 injuries per 1 000 exposure hours; 95% CI: 18.3 - 38.8) (Figure 2).

The overall IID (all injuries), and the IID of time-loss injuries, tended to increase with age, although there were no statistically significant differences between tournaments for either overall or time-loss IIDs (Figure 2).

**Figure 2. Incidence (+/- 95% CIs) of time loss (white bars) and all (time loss are included in all) injuries at each South African Rugby Union (SARU) tournament in 2011. CW13 – Craven Week under-13; GK16 – Grant Khomo under-16; AW18 – Academy Week under-18, CW18 – Craven Week under-18.**

**Injuries per match, injury severity and type**
The oldest age-group tournaments (AW18 and CW18) had the highest absolute number of injuries per match (Table 2). These two tournaments also had the highest absolute number of time-loss injuries per match. Among the youngest age group (CW13), muscle injuries accounted for the greatest proportion of injuries, while joint/ligament/tendon injuries were consistently over-represented at the three older age tournaments (GK16, AW18 and CW18). There was a relatively high proportion
Chapter 2: Incidence and severity of injuries to South African Rugby Union (SARU) Youth Week tournament players

of lacerations/skin abrasions that led to time loss; two injuries to a mouth (one tongue laceration and one case of multiple tooth loss), three eye-lid lacerations and two deep head wounds.

**Medical insurance and protective equipment use**
Twenty-four per cent \( (n=41) \) of the 174 injured players who answered the question had no medical insurance for their injuries. Of the players who suffered a time-loss injury, 22\% \( (n=19) \) reported having no medical insurance. Only 57\% \( (n=107) \) of all injured players were wearing a mouth guard at the time of their injury. Similarly, of the players who suffered a time-loss injury, only 51\% \( (n=46) \) were wearing a mouth guard at the time of their injury.

**Table 2. Number of injuries per match in South African Rugby Union (SARU) Youth tournaments, 2011.** (The number of matches per day is indicated in parentheses after the tournament title. Time-loss (TL) injuries are reported separately and as part of the ‘all’ injuries category. The proportions of the different types of injuries, as diagnosed by the TD, are shown below the number of injuries per match.)

<table>
<thead>
<tr>
<th>Injury severity</th>
<th>CW13 ((n=9))</th>
<th>GK16 ((n=9))</th>
<th>AW18 ((n=13))</th>
<th>CW18 ((n=5\text{ or }10))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Injuries per match ((n))</td>
<td>TL</td>
<td>All</td>
<td>TL</td>
<td>All</td>
</tr>
<tr>
<td>Concussion</td>
<td>18</td>
<td>0.9</td>
<td>0.6</td>
<td>14</td>
</tr>
<tr>
<td>Contusion</td>
<td>9</td>
<td>26</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Fracture</td>
<td>18</td>
<td>6</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Joint/lig./ten.</td>
<td>18</td>
<td>19</td>
<td>44</td>
<td>31</td>
</tr>
<tr>
<td>Lacerations †</td>
<td>9</td>
<td>3</td>
<td>0</td>
<td>14</td>
</tr>
<tr>
<td>Muscle</td>
<td>27</td>
<td>29</td>
<td>6</td>
<td>14</td>
</tr>
<tr>
<td>Unsure/other</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>19</td>
</tr>
</tbody>
</table>

CW13 – Craven Week under-13; GK16 – Grant Khomo under-16; AW18 – Academy Week under-18; CW18 – Craven Week under-18; All – all injuries; TL – time-loss; Lig. – ligament; ten. – tendon.
† Includes skin abrasions.

**DISCUSSION**
The main finding of this paper was that the IIDs of injuries (overall and time loss) during the SARU Youth Week tournaments did not differ significantly by age in 2011, rejecting our initial hypothesis. However, there was a strong tendency for the absolute number and relative proportion of time-loss injuries to increase with increasing age group (proportion of time loss to all injuries: CW13 - 36%; GK16 -
Haseler et al. [15] reported similar time-loss injury incidences in age groups that were comparable with those investigated in the current study and lower than those at elite under-20 level. [9] Overall, muscle and joint/ligament/tendon injuries were the most common types of injuries, which is comparable with the elite under-20 level previously studied [9] and junior Rugby League, [10] but not community-level junior rugby. [15]

This lack of significant differences between age group IIAs, particularly those of the time-loss injuries, are in contrast to findings consistently reported in the literature. These conflicting reports are from early [5-8] and more contemporary literature, [9,15] collected and reported on using the Consensus Statement for injury surveillance in rugby. [13] Both contemporary studies [9,15] took place over a longer time period (former = three-week tournament; latter = nine-month season) than this study.

Despite the fact that the wearing of mouth guards was highly recommended in the team manager’s handbook, only 51% of players who suffered a time-loss injury were wearing a mouth guard at time of their injury. This phenomenon does not appear unique to South Africa as similarly low compliance has been reported in Northern Italy.[16] Although the literature on mouth guard effectiveness in injury prevention is equivocal about concussion, [17] there is evidence to suggest that dental claims can be reduced with improved compliance of mouth guard wearing.[18]

Because of the relatively small number of time-loss injuries in this study, further comparisons between tournaments for positions or phases of play (scrum, ruck, tackle) could not be facilitated, as Knowles et al. [14] stated that CIs become inaccurate and therefore of little use to the researcher when calculated on raw data of five or less. However, the proportion of concussions of all time-loss injuries at the tournaments of older groups (GK16, AW18 and CW18) was high and should be focused on in future years.

These youth tournament formats (Table 1) may not be unique internationally and, therefore, raise the question of whether the Consensus Statement, [13] suggested for all rugby injury surveillance studies, should consider broadening the definition of
injury that should be reported, particularly for short-format tournaments such as the ones presented in this study. Furthermore, injury incidence densities alone may not have as much practical relevance for prospective medical professionals involved in providing medical support and infrastructure at these type of rugby tournaments. Importantly, this study reports only one year of data collection and therefore may not be a true reflection of these tournaments, emphasising the importance of continued injury surveillance at future SARU tournaments.

Of concern is that 22% of the players who suffered time-loss injuries, had no medical aid cover for the on-going treatment of their injuries. Although financial situations vary by Rugby, all competing teams should attempt to ensure that all their players are covered by medical aid or have some financial support structure in place for their participating players in case of a medical emergency, prior to competing in future tournaments.

A limitation of our study was the large reliance on the TD’s clinical judgement for diagnosing severity and type of injury at each tournament; this could potentially compromise the level of comparability between tournaments. While all time-loss and ‘unsure’ injuries were followed up telephonically after the tournament, medical attention injuries were assumed to be accurately defined by the TD. Inaccurate diagnoses could have resulted in under-reporting of time-loss injuries. Secondly, although it would be in direct contrast to SARU’s player safety mandate, some teams may have ‘hidden’ injuries from the TD owing to the short nature of the tournaments. Also, players were less likely to report injuries to the TD on the final day of the tournament as they may have preferred to see their family physician (families on medical aid would not need to pay for these services). Thirdly, the lack of quantification of training time and injuries before and during the tournament was a further limitation, but was logistically difficult to measure.

**Practical implications**
The current article could be used as a reference for prospective TDs and support personnel involved in the medical planning and management of future SARU Youth Week tournaments, or any other tournaments with similar, compact structures. IIDds, in isolation, may be misleading for prospective TDs for planning purposes. For example, with reference to Figure 3A, which displays IIDds, prospective TDs could
interpret the medical management loads of the two under-18 tournaments to be comparable. However, Figure 3B accurately illustrates the greater TM medical burden placed on the AW18 compared with the CW18 TD, despite both teams having the same number of Ms ($n=3$) according to the definition. Despite the same number of Ms and a similar number of injuries per match (Table 2), the CW18 tournament structure is less compacted, has fewer overall teams and therefore less matches than AW18. As the first four days of CW18 only has half the teams participating, this adds to the reduced medical load on the TD. The data presented in the suggested consensus format alone do not accurately guide the infrastructure and personnel requirements for these tournaments. This could have huge practical implications regarding effective planning around budget spend, and medical staffing and infrastructure requirements for these tournaments. Therefore, for medical planning purposes, it is suggested that the data in Tables 1 (daily tournament format) and 2 (injuries per match) are used in combination to determine and cater appropriately for the estimated number, severity and types of injuries per day at each tournament.

The tournament should be planned based on the known absolute number of injuries per match (Table 2), with particular reference to time-loss injuries that tend to require longer treatment and diagnostic times. For example, the recommended assessment and treatment of a concussion using the Sports Concussion Assessment Tool (SCAT2) card\textsuperscript{21} takes approximately 30 minutes for the TD to administer properly. With two, or three, concurrent matches being played at the under-18 age groups, the TD would become overwhelmed and would potentially compromise optimal treatment. A simple practical guide for future planning of these tournaments would be to allocate one TD per time-loss injury per match. Therefore, the under-18 tournaments would require one TD per match, while the TDs of the under-13 and under-16 age groups could cope with one TD, with two matches being played concurrently.
Figure 3. (A) Injury incidence density (IID) (+/- 95% CIs); and (B): Injuries per match day (M) of all injuries (medical attention, time-loss and unsure) and time-loss injuries only (white area) at each South African Rugby Union (SARU) tournament in 2011. (CW13 – Craven Week under-13; GK16 – Grant Khomo under-16; AW18 – Academy Week under-18; CW18 – Craven Week under-18. Tournament match days - CW13: 4; GK16: 3; AW18: 3; CW18: 5. Note that CW18 has three M, but five actual tournament match days (TM).)
CONCLUSION

The injury incidences of both all and time-loss injuries were not significantly different between age groups at the 2011 SARU tournaments. This finding is contrary to contemporary literature and our initial hypothesis, but is probably explained by the short duration of the SARU tournaments. However, the SARU tournament structures/formats may not be unique, and therefore the consensus statement for injury collection should be adapted to include reporting of a broader definition of injuries. Furthermore, while injury incidences of time-loss injuries may be scientifically comparable, in isolation they may be misleading from a medical planning or evaluation perspective. Presenting absolute numbers of injuries (both time-loss and medical attention) per match, in conjunction with injury incidences, [13] may satisfy more stakeholders in gaining practical application from injury surveillance reports.

REFERENCES


Chapter 2: Incidence and severity of injuries to South African Rugby Union (SARU) Youth Week tournament players


THE ECONOMIC BURDEN OF TIME-LOSS INJURIES TO YOUTH PLAYERS PARTICIPATING IN WEEK-LONG RUGBY UNION TOURNAMENTS

PUBLISHED AS:

Chapter 3: The economic burden of time-loss injuries to youth players participating in week-long rugby union tournaments

ABSTRACT

Introduction and objectives: Rugby Union ("rugby") is a popular sport with high injury risk. Burden of injury is described by the incidence and severity of injury. However reports have ignored the monetary cost of injuries. Therefore the aim of this study was to describe the monetary cost associated with youth rugby injuries.

Methods: This descriptive study quantified medical treatments of injured players at the South African Rugby Union Youth tournaments in 2011/2012 and the days of work parents missed as a result of the injuries. A health insurer used these data to calculate associated costs. Legal guardians of the 421 injured players were contacted telephonically on a weekly basis until they returned to play. Treatments costs were estimated in South African Rands based on 2013 insurance rates and converted to US$ using purchasing power parities.

Results: Of the 3652 players, 2% (n=71) sought medical care after the tournament. For these players, average treatment costs were high (US$731 per player, 95% CI: US$425 – US$1096), with fractures being the most expensive type of injury. Players with medical insurance had higher costs (US$937, 95% CI: US$486 – US$1500) than those without (US$220, 95% CI: US$145 – US$302).

Conclusions: Although a minority of players sought follow-up treatment after the tournaments, the cost of these injuries was high. Players without medical insurance having lower costs may indicate that these players didn’t receive adequate treatment for their injuries. Injury prevention efforts should consider injuries with high costs and the treatment of players without medical insurance.
Chapter 3: The economic burden of time-loss injuries to youth players participating in week-long rugby union tournaments

INTRODUCTION

Participation in physical activity has numerous health benefits for children. [1] However, physical activity can also pose the risk of health detriments, such as injury, the likelihood of which may vary depending on the mode of physical activity. [2] This potential burden of injury may discourage participation in a particular sport, unless preventative measures are introduced effectively. [2] Of all international sports, Rugby union (“rugby”) is arguably amongst the most popular, for all age groups, including youth. [3]

To better understand the injury problem, both the incidence and severity of a particular sport-related injury need to be accurately quantified. [2] The incidence of injury can be described by calculating the number of new injuries that occur taking into account the participation levels of that sport. [4] “Severity” could be described using six criteria: (i) nature of sports injury, (ii) duration and nature of treatment, (iii) sporting time lost, (iv) working time lost (of the injured individual or injured individual’s parent/legal guardian), (v) permanent damage and (vi) monetary cost. [4] In general, rugby carries a higher incidence and severity of injury to the participant, [5] in comparison to other popular sports. [6] Although other sports, [7-9] including rugby league, [10-12] have reported on injury-related monetary costs, this analysis is yet to be performed in rugby union.

Besides being an important descriptor of severity, the monetary cost of injury provides valuable information to drive and evaluate the effectiveness of preventative measures. [8] In South Africa, the BokSmart programme is responsible for implementing injury prevention strategies in rugby union [13] and information on the costs of injuries is therefore essential for guiding future policies emanating from this nationwide programme. Therefore, the aim of this study is to describe the monetary cost of rugby-related injuries in a youth cohort.

METHODS

The population studied included the combined attendees of the South African Rugby Union (SARU) Youth Weeks in 2011 and 2012, and, depending on the tournament,
players ranged between the ages of 12 and 18 years old. These tournaments showcase the most talented players in each age group, and have been described in more detail elsewhere. [14] Written informed consent was provided by the player or by the player’s parent/legal guardian if the player was younger than 18 years of age. All information was recorded on a SARU database to which the authors were granted access by SARU and the UCT Human Research Ethics Committee. In total, 3652 players attended the four elite national Youth tournaments: Craven week under-13, Grant Khomo under-16, Academy Week under-18 and Craven Week under-18 in 2011 and 2012 (Figure 1). Although preliminary analyses indicated no differences in injury rates, the tournaments were analysed separately by age group for the purposes of this study: “under-13” (Craven Week under-13 tournament), “under-16” (Grant Khomo under-16 tournament) and “under-18” (combination of Craven Week and Academy Week under-18 tournaments). Of these players, 12% (421 players) received medical attention from the SARU tournament Doctor and accounted for a total of 436 injury events. Of the 421 injured players, 17% (n = 71 players) sought further treatment after the tournament. The data collection process has been discussed previously. [14] Briefly, SARU collected data on all 421 injured players that were attended to by the tournament medical doctors in 2011 and 2012. The injury definitions, including that of what constituted a “time-loss” (TL) injury were consistent with the consensus statement for injury surveillance in rugby union [15] with slight adjustments for these tournaments. The injury definition was:

“Any physical complaint, which was caused by a transfer of energy that exceeded the body’s ability to maintain its structural and/or functional integrity, that was sustained by a player during a rugby match and required attention from the SARU Tournament Doctor, irrespective of who decided this”.

Therefore, a time-loss (TL) injury was an injury that resulted in the player being absent from more than one match in a tournament, or more than one day of normal/planned recreational activities after the tournament. After the tournament ended and the injured players returned home, the responsibility of the treatment and
rehabilitation of their injuries resided with the players’ parents/legal guardians. Players that were confirmed or suspected by the tournament medical doctors to have suffered a TL injury at the tournaments were followed up telephonically (Figure 1). Costs were estimated from the perspective of the medical insurer in South Africa.

![Figure 1. A flow diagram illustrating the number of players that were considered for this study. Although there were 3652 players at these tournaments, only 2% (n = 71) sought follow-up treatment after the tournament conclusion.](image)

An “old” injury was one in which the player answered “yes” to the following question, asked by the tournament Doctor, or data capturer, or both: “Have you ever had this injury before?”. If the player answered “no” to the question, the injury was classified as “new”.

The consensus statement severity of injury categories\[15\] of slight, minimal and mild, were grouped together as “mild”, and compared to “moderate” and “severe” categories due to a lack of statistical power.

The parents/legal guardians of all players with confirmed and suspected time-loss (including “unsure” diagnoses) injuries (n = 190) were contacted a week after the completion of the tournament (Figure 1). Of these 190 injured players, 7% (n = 14 of 190) could not be followed up due to incorrect contact details or no response to these follow-up calls (“no contact” in Figure 1) and 3% (n = 5 of 190) were re-classified as medical attention injuries, leaving 171 time-loss injuries. [14] Of the 171 injured players that were contacted, 42% (n = 71) sought follow-up treatment after the tournament (“follow-up injuries”). Only the medical treatments that were sought
after the tournament (i.e. excluding the Tournament Doctor’s treatment) were included in these analyses.

Medical treatments/services and the time that the injured player’s parent/legal guardian were away from work were quantified using a cost diary used previously, [8] and which was adapted for use in South Africa. The South African version was adapted from the original version to provide a semi-structured guide for the telephonic interviewer to capture total quantity and type of medical service sought (Appendix VII).

Direct costs (medical care quantification) were initially estimated in South African Rand (R) for all medical treatments. Indirect costs could not be calculated due to the wide range in average salaries in South Africa. Thereafter, costs were converted to US dollars (US$) based on purchasing power parities (PPP’s), as suggested for economic evaluations. [16] To convert R to US$, the R value should be divided by a factor of 5.48: this factor was obtained from the most recent World Bank estimates, which were last provided in 2012. [17]

Discovery Health Insurance, one of the largest private medical insurance companies in South Africa, provided cost estimates for medical consultations. This approach was adopted due to South Africa not having any national standard medical care costs available at the time of the study. Inferred costs were calculated based on the medical insurance company’s 2013 data even though the actual treatments occurred in 2011 and 2012.

Discovery Health based their care cost estimates on historical data of the medical insurance company for a given region within a specific diagnosis-related group. These rates were based on 2006 national rates (the last time standard rates were available) and included inflation adjustments, time factors, difficulty in receiving treatment, and thousands of claims factored into the estimation. Medical care costs may vary depending on the type of injury and initial consultations sometimes differ in price from the follow-up treatments (rehabilitation).

Surgeries were assumed to be conditions without major complications – e.g. basic shoulder/clavicle injury with basic reduction and repair. Therapy (Physiotherapy, Occupational Therapy, Biokinetics) costs were based on the most likely modalities
related to the particular injury type (e.g. muscle strain or ligament tear). For radiology costs, the x-rays and scans were assumed to be uncontrasted (i.e. basic evaluations). Dental cases were considered to be basic examinations as not enough information was available.

Total costs were calculated based on the initial rate for a particular medical service and medical service provider and multiplied by the frequency of these visits. The parents’ missed work could not be converted into a financial cost due to the large rates of unemployment and variance in average wages in South Africa.

As costs were not normally distributed, mean differences in costs and associated 95% Confidence Intervals were obtained by bias corrected and accelerated bootstrapping (2000 replications). All analyses were performed with IBM SPSS statistical software (Version 21). Differences in costs were compared between categories using 95% confidence intervals. [15]

RESULTS

The overall injury rates (Table 1) were not significantly different between the various age groups (under-13 to under-18), with a combined rate of 54.6 injuries per 1 000 hours (95% CIs: 49.5 – 59.8 injuries per 1 000 hours) of tournament play resulting from 436 injury events in 7 945 exposure hours. Of the 436 injury events, the most common injury was a joint/ligament/tendon injury which accounted for 31% of all injuries. The joint/ligament/tendon injuries were the most common at all age groups except for under-13 where bruises/contusions were the most common type of injury (31%). Of the 421 players who received medical attention and agreed to answer the question (n = 388), 25% (n = 97) did not have medical insurance.

The overall confirmed time-loss injury rate was 21.4 injuries per 1 000 hours (95% CIs: 18.2 – 24.6). Similarly to all injuries, joint/ligament/tendon injuries accounted for the highest proportion (36%) of all TL injuries, overall. This was consistent for all the age groups.
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Of the 71 players that sought and received treatment once returning home (Table 1), the largest proportion was from the under-18 age group (n = 48; 68%). Overall, 26% (n = 18 of 69; 2 did not answer) of these players did not have medical insurance. The highest proportions of these injured players with no medical insurance were at the under-18 age group (61%, n = 11 of 18).

Table 1. The injury rate (per 1 000 hours of tournament play), type of injury and proportion of injured players with medical insurance for the 2011 and 2012 tournaments (n = 3652).

<table>
<thead>
<tr>
<th></th>
<th>Under-13</th>
<th>Under-16</th>
<th>Under-18</th>
<th>Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ALL INJURIES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(n = 436)</td>
<td>64.6</td>
<td>54.4</td>
<td>52.1</td>
<td>54.6</td>
</tr>
<tr>
<td>Injury rate (95% CIs)</td>
<td>(51.5 – 77.7)</td>
<td>(43.3 – 65.4)</td>
<td>(45.7 – 58.6)</td>
<td>(49.5 – 59.8)</td>
</tr>
<tr>
<td>Injury type - % (n = 436)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concussion</td>
<td>9% (n=8)</td>
<td>13% (n=12)</td>
<td>11% (n=27)</td>
<td>11% (n=47)</td>
</tr>
<tr>
<td>Bruise/contusion</td>
<td>31% (n=29)</td>
<td>13% (n=12)</td>
<td>18% (n=45)</td>
<td>20% (n=86)</td>
</tr>
<tr>
<td>Broken bone/fracture</td>
<td>8% (n=7)</td>
<td>2% (n=2)</td>
<td>4% (n=9)</td>
<td>4% (n=18)</td>
</tr>
<tr>
<td>Joint/Lig./Ten.</td>
<td>22% (n=20)</td>
<td>32% (n=30)</td>
<td>33% (n=83)</td>
<td>31% (n=133)</td>
</tr>
<tr>
<td>Laceration/abrasion</td>
<td>4% (n=4)</td>
<td>15% (n=14)</td>
<td>12% (n=31)</td>
<td>11% (n=49)</td>
</tr>
<tr>
<td>Muscle strain/cramp</td>
<td>19% (n=18)</td>
<td>12% (n=11)</td>
<td>14% (n=36)</td>
<td>15% (n=65)</td>
</tr>
<tr>
<td>Unsure/other</td>
<td>8% (n=7)</td>
<td>13% (n=12)</td>
<td>8% (n=19)</td>
<td>9% (n=38)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Under-13</th>
<th>Under-16</th>
<th>Under-18</th>
<th>Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TL INJURIES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(n = 171)</td>
<td>22.2</td>
<td>22.2</td>
<td>21.1</td>
<td>21.4</td>
</tr>
<tr>
<td>Injury rate (95% CIs)</td>
<td>(14.5 – 29.9)</td>
<td>(15.2 – 29.3)</td>
<td>(17.0 – 25.2)</td>
<td>(18.2 – 24.6)</td>
</tr>
<tr>
<td>Injury type - % (n = 171)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concussion</td>
<td>19% (n=6)</td>
<td>29% (n=11)</td>
<td>27% (n=27)</td>
<td>26% (n=44)</td>
</tr>
<tr>
<td>Bruise/contusion</td>
<td>19% (n=6)</td>
<td>11% (n=4)</td>
<td>6% (n=6)</td>
<td>9% (n=16)</td>
</tr>
<tr>
<td>Broken bone/fracture</td>
<td>22% (n=7)</td>
<td>5% (n=2)</td>
<td>8% (n=8)</td>
<td>10% (n=7)</td>
</tr>
<tr>
<td>Joint/Lig./Ten.</td>
<td>22% (n=7)</td>
<td>39% (n=15)</td>
<td>40% (n=40)</td>
<td>36% (n=62)</td>
</tr>
<tr>
<td>Laceration/abrasion</td>
<td>3% (n=1)</td>
<td>5% (n=2)</td>
<td>6% (n=6)</td>
<td>5% (n=9)</td>
</tr>
<tr>
<td>Muscle strain/cramp</td>
<td>16% (n=5)</td>
<td>5% (n=2)</td>
<td>8% (n=8)</td>
<td>9% (n=15)</td>
</tr>
<tr>
<td>Unsure/other</td>
<td>0% (n=0)</td>
<td>5% (n=2)</td>
<td>6% (n=6)</td>
<td>5% (n=8)</td>
</tr>
</tbody>
</table>

Under-13 – Craven week under-13, Under-16 – Grant Khomo under-16, Under-18 - Academy Week under-18 + CW18 – Craven Week under-18 combined, CIs – confidence intervals, IID – injury incidence densities, TL – Time-Loss, Med. – medical, Lig. – ligament, Ten. – tendon
The most expensive unit costs of medical treatment (Supplemental table – at end of Chapter) were the hospital/surgery costs which ranged from US$1 066 (per day) for the Intensive Care Unit (ICU) to US$8 421 for surgery to the lower extremities. Other large costs included MRI/CT scans of various joints (range US$393 – US$1 038).

In total, there were 390 treatments that amounted to an estimated total cost of US$80 228. Of the 390 medical treatments (Supplemental Table), the most common category of treatment was “consultations and rehabilitations” (87%, n = 340 of 390), of which General Practitioner consultations accounted for the largest proportion (18%, n = 60). Despite accounting for the largest proportion of treatments (87%), this category of “consultations and rehabilitations” only accounted for 26% of the total costs of all treatments. In contrast, the “hospital/surgery” category only accounted for 3% (n = 11 of 390) of all treatments sought, yet accounted for 66% of the total treatment costs (US$52 787 of US$80 228).

Follow-up injuries cost the 71 players, on average, US$731 per follow-up injury (95% CIs: US$425 – US$1 096) (Table 2). These follow-up costs would be, on average, US$ 123 per injured player or US$ 14 per tournament player (Table 2). While the younger under-13 and under-16 age group had a tendency to be more expensive than the under-18 age group, these average costs were not significantly different from one another (Table 2). Injuries of “mild” severity (US$217, 95% CIs: US$122 - US$ 321), cost on average, significantly less than injuries with a “severe” severity (US$ 1 551, 95% CIs: US$655 - US$2 696). Injuries to the lower extremities (US$ 278, 95% CIs: US$217 - US$342) cost significantly less than those to the upper extremities (US$1 242, 95% CIs: US$446 - US$2 269), on average, and injuries to the head/face (US$822, 95% CIs: US$168 - US$1 825) and to the neck/cervical/back regions (US$480, CIs could not be calculated) fell between the costs to the lower and upper extremities. On average, fractures (US$2 609, 95% CIs: US$864 - US$4 605) were the most expensive type of injury to treat. This treatment cost was significantly greater than the cost of treating muscle injuries (US$261, 95% CIs: US$134 - US$426), on average. Also, players with medical insurance had significantly greater treatment costs (US$937, 95% CIs: US$486 - US$1 500) than those players without medical insurance (US$220, 95% CIs: US$145 - US$302).
In total, n = 13 parents/guardians reported missing work to ensure their child received follow-up treatment. In total, these parents missed 26 work days (8 hour work day) at a median of 0.5 days (Minimum: 0.1 day – Maximum: 9 days) per parent.

**DISCUSSION**

The main finding of this paper was that the monetary cost to players seeking follow-up treatment was, on average US$731 (95% CIs: US$425 – US$1 096). These high costs were incurred by a relative minority of players: 17% (n = 71 of 421) of injured players and 2% (n = 71 of 3 652) of the total tournament players. If these costs were divided by all the tournament players (n = 3 652) instead of just those that sought follow-up treatment, the costs would be less of a burden (US$14 instead of US$731, on average). Furthermore, the highest costs were for injuries of “severe” nature (based on time-loss definition), upper extremity injuries, fractures and for players who had medical insurance (in comparison to those that did not).

The average cost per tournament player of the present study (US$14) is, as expected, far less than the annual medical costs reported for a high school population of athletes in 1999 (US$187 per registered athlete). [7] However, only players with time-loss injuries who actively sought medical treatment above and beyond what was already provided at the rugby tournament were included in the present study, so this finding was not surprising. Also, the average cost per follow-up injury in the present study (US$731) was about ten times less than moderate to serious injuries reported for rugby league between 1999 and 2007 (US$7 100), [18] although the rugby league study included players of all ages, not just youth.

The finding that the injuries with the longest periods of recovery (more than 28 days = “severe”) were also the most expensive was expected and is consistent with findings in a population of high school sports participants in the United States. [7] Severe injuries in the present study (US$1 551) also cost much less than in the study of high school sports (US$35 336). [7] The very different study designs could explain the discrepancies between the two studies. Nonetheless, the findings of the present study indicate an additional burden of injury that has not been identified in a
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youth rugby union cohort before, i.e. the economic burden of injury of player’s that seek follow-up treatment. For player’s seeking follow-up treatment this was, on average, US$731 and a median of 0.5 missed work days per injury for the parent/legal guardian.

The higher average costs of upper extremity injuries in comparison to lower extremity injuries was unexpected and in contrast to what has been found in rugby league players of all ages, [18] but was not dissimilar to general physical activity and sport injuries in children aged 10-12 years. [8] The costs for both of these sites (upper and lower extremity) were greater in the present study than in that of rugby league players that involved all ages and both sexes. However, injury sites were not corrected for the possible confounding effect of injury type – therefore we cannot exclude the possibility that the significantly higher average cost of fractures (Table 2) could have influenced the mean cost of injury sites in the present study. The finding of higher average costs of fractures, in comparison to other injury sites in the present study was also in contrast with a rugby league report of all ages [18] and study on knee injuries in Swiss youth sports. [19] The average cost of fractures in the present study (US$2 609) was also over 5 times greater than in the rugby league study (US$469). [18]

The relatively low average cost of head/neck injuries and, specifically, concussions in the present study (US$358) (Table 2) is surprising and in less than 70 times the cost in the rugby league study of all ages in New Zealand (US$25 347). [18] Rugby league has comparable rates of concussion to rugby union and thus this difference could not be explained by injury rates between the two sports (Table 1). [20] Of concern is that the low treatment costs associated with concussions in the present study could indicate that players did not consult a medical doctor or follow the correct return-to-play guidelines, which are considered “best-practice” [21] and are strongly advocated by BokSmart/SARU for players with concussion. [13] In fact, only 14% of all concussions (n = 7 of 50) received any form of follow-up treatment. Another explanation could be that the first-line medical professionals involved in assessing the concussed players both with medical aid, and especially those concussed players without medical aid, might also not be appropriately versed in the
current scientific literature and medical protocols for correctly identifying, suspecting, diagnosing, treating and managing concussed players for safe return to play. [22]

This potential phenomenon of inadequate medical care could partially explain the finding that players with medical insurance had, on average, higher treatment costs than those players without medical aid: it is possible that those players without medical insurance did not receive optimal care for their injuries. In South Africa, access to medical insurance is linked to socioeconomic status and determines how one deals with a manageable disease such as hypertension. [23] It is also possible that players with medical insurance could have received more treatment than was necessary for a particular injury. Thus, it is further possible that the absence or presence of medical insurance could have affected follow-up treatment-seeking behaviour.

Although there were no significant differences in mean costs sustained in the different age groups (Table 2), this was expected due to the similar injury rates of the three age groups (Table 1). These findings support a study of high school sports participants in North Carolina, where age was also not considered a risk factor for the cost of injury albeit that age was categorised differently to that of the present study which based its categorisation on tournaments. [7] Similarly, there was no significant difference in mean costs for players who did, or did not, mention having previously had the injury they were treated for - this phenomenon was also observed in the North Carolina High School study. [7] However, comparable costs indicate that the costs for the present study might be greater than that of the North Carolina high school study in general. For example, the average medical cost of football-related injuries was $577 in the North Carolina high school study, while the comparable cost per injury for the present study was $731.

A possible limitation of the present study was that only the 190 players who suffered what the tournament doctor predicted to be a “time-loss” injury were followed-up. This decision was made for logistical reasons as it would have been difficult to accurately follow-up all medical attention injuries telephonically. However, it is unlikely that many medical attention injuries required follow-up treatment. The cost estimations were based on numerous assumptions by the medical insurance
company due to the unique situation in South Africa in which there is no prescribed standard rate for medical treatment costs. Thus, although the present method is subject to potential inaccuracies as a result of these assumptions, the authors contend that any method of calculating costs in South Africa would require many assumptions. This approach of using an insurer to estimate costs also meant that the raw data were not available for conducting sensitivity analyses, which may limit the comparability of these findings to other countries although the unit cost and frequency of care (Supplementary Table 1 – at end of chapter) should provide some allowance for comparison. Owing to the large discrepancy in average wage in South Africa, the authors were unable to estimate an indirect cost for the loss of the working time of the parents who had to take time off work to accompany their children to the health care practitioner. The classification of “old” or previous injury was also highly subjective, although it was difficult to implement a repeatable objective assessment in the circumstances in which these data were collected. Mean injury costs should have been corrected for different proportions of types of injuries (e.g. fractures, strains, etc.) in the different tournaments, but the study was statistically underpowered to be able to perform these analyses. Finally, comparisons between the present findings and other studies were limited due to a paucity of economic studies that investigated male youth athletes.

CONCLUSION
Although the estimation of costs associated with the medical treatments described in the present study involved many assumptions due to the circumstances in which they were collected, this study is the first to quantify and compare monetary cost as an indication of injury burden in youth rugby union. In particular BokSmart, the national injury prevention programme in South Africa, [13] should consider the high monetary costs of fractures and upper extremity injuries, in addition to injuries of large severity which have previously been identified. [14] Furthermore, this study indicated the potential to significantly reduce the direct burden of injury to injured players, by dividing predicted injury costs amongst all players attending these tournaments, instead of just the relative minority who suffered an injury requiring follow-up treatment. This proposed model could potentially alleviate and offset
individual injury costs at these types of tournaments, regardless of medical insurance status.

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Table 2. Mean costs for the 71 players seeking treatment after the four tournaments; divided according to age group, injury sites, injury types, injury severity, injury nature and medical insurance status (n = 71).

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean cost (US$*)</th>
<th>95% confidence interval</th>
</tr>
</thead>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Lower</td>
</tr>
<tr>
<td>Costs per population</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Costs per player</td>
<td>3 652</td>
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<tr>
<td>Costs per injury</td>
<td>421</td>
<td>123</td>
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<tr>
<td>Costs per follow-up injury</td>
<td>71</td>
<td>731</td>
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<td>Under-18</td>
<td>48</td>
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<td>Injury Severity</td>
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<tr>
<td>“Mild”</td>
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</tr>
<tr>
<td>Head/face</td>
<td>14</td>
<td>822</td>
<td>168</td>
</tr>
<tr>
<td>Neck/cervical/back</td>
<td>7</td>
<td>480</td>
<td>-</td>
</tr>
</tbody>
</table>

* Costs per player, costs per injury and costs per follow-up injury were all significantly different from each other.

**Mild” severity significantly different to “severe” severity category.

Lower extremity injuries significantly different to upper extremity injuries.

Fracture injuries significantly different to muscle injuries.

Injured players without medical insurance (“No”) significantly different to players with medical insurance (“Yes”).

Conversion: local currency (ZAR)/5.48 to obtain US$ at purchasing power parity (PPP) rate: obtained from World Bank in March 2014 [17]
Chapter 3: The economic burden of time-loss injuries to youth players participating in week-long rugby union tournaments

Table 2 (continued). Mean costs for the 71 players seeking treatment after the four tournaments; divided according to age group, injury sites, injury types, injury severity, injury nature and medical insurance status (n = 71).

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean cost</th>
<th>95% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(US$*)</td>
<td>Lower</td>
</tr>
<tr>
<td><strong>Injury type</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concussion</td>
<td>7</td>
<td>358</td>
<td>-</td>
</tr>
<tr>
<td>Contusion</td>
<td>3</td>
<td>240</td>
<td>-</td>
</tr>
<tr>
<td>Fracture</td>
<td>11</td>
<td>2 609</td>
<td>864</td>
</tr>
<tr>
<td>Joint/ligament/tendon</td>
<td>29</td>
<td>522</td>
<td>232</td>
</tr>
<tr>
<td>Laceration</td>
<td>5</td>
<td>65</td>
<td>-</td>
</tr>
<tr>
<td>Muscle strain</td>
<td>9</td>
<td>261</td>
<td>134</td>
</tr>
<tr>
<td>Unsure/Other</td>
<td>7</td>
<td>311</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Injury nature</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New injury</td>
<td>51</td>
<td>786</td>
<td>372</td>
</tr>
<tr>
<td>Old injury</td>
<td>19</td>
<td>608</td>
<td>214</td>
</tr>
<tr>
<td><strong>Medical Insurance</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>51</td>
<td>937</td>
<td>486</td>
</tr>
<tr>
<td>No</td>
<td>18</td>
<td>220</td>
<td>145</td>
</tr>
</tbody>
</table>

* Costs per player, costs per injury and costs per follow-up injury were all significantly different from each other.

b “Mild” severity significantly different to “severe” severity category.

c Lower extremity injuries significantly different to upper extremity injuries.

d Fracture injuries significantly different to muscle injuries.

e Injured players without medical insurance (“No”) significantly different to players with medical insurance (“Yes”).

*Conversion: local currency (ZAR)/5.48 to obtain US$ at purchasing power parity (PPP) rate: obtained from World Bank in March 2014 [17].
**Supplemental Table 1. Unit costs, frequency and total costs of medical services sought for the 71 injured players in both years (2011 and 2012). The services are categorised into four types: “consultations and rehabilitation”, “chemist/pharmacy”, “radiology” and “hospital/surgery” costs.**

<table>
<thead>
<tr>
<th>Medical service provider and type</th>
<th>Unit Cost (US$*)</th>
<th>Frequency</th>
<th>Total Cost (US$*)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Consultations and rehabilitation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General practitioner</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consultation/Check-up</td>
<td>53</td>
<td>60 (18%)</td>
<td>3 199</td>
</tr>
<tr>
<td>Physiotherapist</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consultation for muscle strain/tendon injuries</td>
<td>77</td>
<td>17 (5%)</td>
<td>1 309</td>
</tr>
<tr>
<td>Consultation for ligament strains/joints</td>
<td>78</td>
<td>25 (7.%)</td>
<td>1 949</td>
</tr>
<tr>
<td>Rehabilitation for muscle strain/tendon injuries</td>
<td>57</td>
<td>61 (18%)</td>
<td>3 456</td>
</tr>
<tr>
<td>Rehabilitation for ligament strains/joints</td>
<td>58</td>
<td>87 (26%)</td>
<td>5 012</td>
</tr>
<tr>
<td>Dentist – general visit</td>
<td>102</td>
<td>4 (1%)</td>
<td>409</td>
</tr>
<tr>
<td>Orthodontist – general visit</td>
<td>125</td>
<td>5 (2%)</td>
<td>622</td>
</tr>
<tr>
<td>Ophthalmologist – general visit</td>
<td>55</td>
<td>6 (2%)</td>
<td>332</td>
</tr>
<tr>
<td>Sports physician – consultation</td>
<td>79</td>
<td>5 (2%)</td>
<td>398</td>
</tr>
<tr>
<td>Orthopaedic surgeon – consultation</td>
<td>55</td>
<td>41 (12%)</td>
<td>2 269</td>
</tr>
<tr>
<td><strong>Occupational therapist</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consultation</td>
<td>91</td>
<td>1 (0%)</td>
<td>91</td>
</tr>
<tr>
<td>Rehabilitation</td>
<td>59</td>
<td>2 (1%)</td>
<td>118</td>
</tr>
<tr>
<td><strong>Neurosurgeon – consultation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consultation</td>
<td>93</td>
<td>7 (2%)</td>
<td>652</td>
</tr>
<tr>
<td>Rehabilitation</td>
<td>62</td>
<td>17 (5%)</td>
<td>1 047</td>
</tr>
<tr>
<td><strong>Chemist/pharmacy</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moonboot for foot fractures</td>
<td>324</td>
<td>2 (20%)</td>
<td>649</td>
</tr>
<tr>
<td>Elbow crutches – adjustable</td>
<td>71</td>
<td>1 (10%)</td>
<td>71</td>
</tr>
<tr>
<td>Compression socks – below knee</td>
<td>43</td>
<td>1 (10%)</td>
<td>43</td>
</tr>
<tr>
<td>Transact patches (for inflammation)</td>
<td>33</td>
<td>1 (10%)</td>
<td>33</td>
</tr>
<tr>
<td>Anti-inflammatories (e.g. Cataflam/Voltaren)</td>
<td>12</td>
<td>1 (10%)</td>
<td>12</td>
</tr>
<tr>
<td>Painkillers (e.g. Mybulen/Mypaid/Myprodol) – 30 pills</td>
<td>16</td>
<td>4 (40%)</td>
<td>64</td>
</tr>
<tr>
<td><strong>Radiology</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X-rays</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X-ray ankle (per unit)</td>
<td>63</td>
<td>3 (10%)</td>
<td>189</td>
</tr>
<tr>
<td>X-ray foot (per unit)</td>
<td>53</td>
<td>1 (4%)</td>
<td>53</td>
</tr>
<tr>
<td>X-ray shoulder region (per unit)</td>
<td>60</td>
<td>6 (21%)</td>
<td>357</td>
</tr>
<tr>
<td>X-ray complete cervical (per unit)</td>
<td>144</td>
<td>2 (7%)</td>
<td>287</td>
</tr>
<tr>
<td>X-ray lumbar (per unit)</td>
<td>143</td>
<td>1 (4%)</td>
<td>143</td>
</tr>
<tr>
<td>X-ray hand (per unit)</td>
<td>58</td>
<td>2 (7%)</td>
<td>117</td>
</tr>
<tr>
<td>X-ray ribs (per unit)</td>
<td>91</td>
<td>1 (4%)</td>
<td>91</td>
</tr>
<tr>
<td>X-ray sternum (per unit)</td>
<td>80</td>
<td>1 (4%)</td>
<td>80</td>
</tr>
<tr>
<td>X-ray hip (per unit)</td>
<td>60</td>
<td>1 (4%)</td>
<td>60</td>
</tr>
<tr>
<td>X-ray lower leg (per unit)</td>
<td>56</td>
<td>1 (4%)</td>
<td>56</td>
</tr>
<tr>
<td>X-ray knee (per unit)</td>
<td>63</td>
<td>2 (7%)</td>
<td>126</td>
</tr>
</tbody>
</table>

*Conversion at local currency (ZAR)/5.48 to obtain US$ at purchasing power parity (PPP) rate - obtained from World Bank in March 2014 [17]*
Chapter 3: The economic burden of time-loss injuries to youth players participating in week-long rugby union tournaments

**Supplemental Table 1 (continued). Unit costs, frequency and total costs of medical services sought for the 71 injured players in both years (2011 and 2012). The services are categorised into four types: “consultations and rehabilitation”, “chemist/pharmacy”, “radiology” and “hospital/surgery” costs.**

<table>
<thead>
<tr>
<th>Medical service provider and type</th>
<th>Unit Cost (US$*)</th>
<th>Frequency</th>
<th>Total Cost (US$*)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MRI</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MRI shoulder scan (per unit)</td>
<td>1 038</td>
<td>1 (4%)</td>
<td>1 038</td>
</tr>
<tr>
<td>MRI cervical/neck scan (per unit)</td>
<td>713</td>
<td>3 (10%)</td>
<td>2 138</td>
</tr>
<tr>
<td>CT scan</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CT scan ankle (per unit)</td>
<td>393</td>
<td>1 (4%)</td>
<td>393</td>
</tr>
<tr>
<td>Ultrasound</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ultrasound upper limb/shoulder (per unit)</td>
<td>140</td>
<td>2 (7%)</td>
<td>280</td>
</tr>
<tr>
<td>Sonar</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sonar/US scan</td>
<td>140</td>
<td>1 (4%)</td>
<td>140</td>
</tr>
<tr>
<td>Hospital/Surgery</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intensive Care Unit (per day)</td>
<td>1 066</td>
<td>2 (18%)</td>
<td>2 132</td>
</tr>
<tr>
<td>Knee Procedures</td>
<td>5 790</td>
<td>1 (9%)</td>
<td>5 790</td>
</tr>
<tr>
<td>Shoulder/Elbow/Forearm</td>
<td>4 972</td>
<td>3 (27%)</td>
<td>14 914</td>
</tr>
<tr>
<td>Hand/Wrist</td>
<td>3 413</td>
<td>1 (9%)</td>
<td>3 413</td>
</tr>
<tr>
<td>Lower Extremity &amp; Humerus (excl. hip/knee/foot/femur)</td>
<td>8 421</td>
<td>2 (18%)</td>
<td>16 843</td>
</tr>
<tr>
<td>Facial bone procedures (excl. major head/neck)</td>
<td>7 703</td>
<td>1 (9%)</td>
<td>7 703</td>
</tr>
<tr>
<td>Injuries and other eye disorders</td>
<td>1 992</td>
<td>1 (9%)</td>
<td>1 992</td>
</tr>
</tbody>
</table>

*Conversion at local currency (ZAR)/5.48 to obtain US$ at purchasing power parity (PPP) rate - obtained from World Bank in March 2014 [17]*
INCIDENCE OF RUGBY-RELATED CATASTROPHIC INJURIES (INCLUDING CARDIAC EVENTS) IN SOUTH AFRICA: 2008 – 2011

PUBLISHED AS:

ABSTRACT

Introduction and objectives: To establish an accurate and comprehensive injury incidence registry of all catastrophic events that occurred in rugby union ('rugby') in South Africa between 2008-2011. An additional aim was to investigate correlates associated with these injuries.

Methods: Rugby related catastrophic injury data have been recorded since 2008 in South Africa at all levels of play (amateur and professional). There are an estimated 529 483 junior and 121 663 senior players (population at risk). Injuries were categorised by type: cardiac events, traumatic brain and acute spinal cord injuries; and outcome: full recoveries - fatalities. Position and event (phase of play) were also assessed.

Results: The average annual incidence of Acute Spinal Cord Injuries (ASCIs) and Traumatic Brain Injuries (TBIs) combined was 2.00 per 100 000 players (95% CI: 0.91 – 3.08) from 2008-2011. The incidence of ASCIs with permanent outcomes was significantly higher at senior (4.52 per 100 000 players, 95% CI: 0.74 – 8.30) than junior (0.24 per 100 000 players, 95% CI: 0 – 0.65) level during this period. The hooker position was associated with 46% (n = 12 of 26) of all permanent ASCI outcomes, the majority of which (83%) occurred during the scrum phase of play.

Conclusions: The incidence of rugby-related catastrophic injuries in South Africa between 2008-2011 is comparable to that of other countries and to most other collision sports. The higher incidence rate of permanent ASCIs at the senior level could be related to different law variations or characteristics (e.g. more regular training) compared to junior level. The hooker and scrum were associated with high proportions of permanent ASCIs. The BokSmart injury prevention programme should focus efforts on these areas (senior level, hooker and scrum) and use this study as a reference point for the evaluation of the effectiveness of the programme.
INTRODUCTION

While catastrophic events rarely occur in sport [1] the long-term consequences and implicit severity of these events make them the most devastating of all injuries to the player, their family and friends.[2] Up until the third decade of life, sport is associated with a large proportion of all catastrophic spinal injuries. Of all sports, collision games such as American Football, Ice Hockey and Rugby account for a large proportion of these sport-related catastrophic events.[3-5] Furthermore, Rugby Union (henceforth “Rugby”) is currently the most popular collision sport worldwide [6] and has an enormous participant base with 118 active international Unions (www.irb.com).

Despite these participation levels, a recent review concluded that the level of risk of suffering a catastrophic injury while playing Rugby in the United Kingdom was “acceptable” (0.8 per 100 000 participants). Furthermore, this annual incidence was not higher than that of other collision sports such as Rugby League (1.9 per 100 000 participants), Ice Hockey (4.1 per 100 000 participants) or American Football (1.0 per 100 000 participants). [1] For South Africa in 2007, the average annual incidence of rugby-related permanently disabling spinal cord injury was estimated to be lower (0.6 per 100 000 participants) than other rugby-playing nations such as New Zealand, Ireland and Australia.[1,7] Despite these “endorsements” of the relatively low risk of catastrophic injury associated with rugby, an early South African study [8] concluded that 56% of all rugby-related spinal cord injuries reported, could potentially have been prevented. It is these predictable and preventable catastrophic injuries that are the priority focus for injury prevention strategies.[5,9]

As a result, New Zealand’s RugbySmart programme (http://www.nzrugby.co.nz/the_game/safety/rugbysmart) was developed and proved successful in reducing catastrophic injuries. [1,9-11] Based on this success, the South African Rugby Union (SARU) developed their own programme, BokSmart (www.boksmart.com) [12,13] modelling it on a comparable intervention approach to New Zealand with additional components to suit the South African rugby landscape, making it an example of a National Sports Organization intervention.[14] Other catastrophic injury prevention strategies for rugby include Rugbyready (IRB), Smartplay (Australia) and Tackling Safety (England).[1] To evaluate the
effectiveness of the BokSmart programme, one first needs to establish the incidence and severity of catastrophic events.[15]

Therefore, the primary aim of this paper was to establish an accurate and comprehensive injury incidence registry of all rugby union-related catastrophic events in South Africa between 2008-2011. An additional aim was to investigate correlates associated with these injuries.

METHODS

Data for this study were collected through the BokSmart program, which is a joint initiative between the South African Rugby Union (SARU) (www.sarugby.co.za) and the Chris Burger/Petro Jackson Player’s Fund (CBPJPF) (www.playersfund.org.za). The CBPJPF is a non-profit public benefit organization (PBO), developed to aid players who have been permanently disabled while playing rugby in South Africa.[16] Permission to analyse the data was obtained, with SARU’s and the CBPJPF’s permission, by the UCT Human Research Ethics Committee. This is a descriptive study in which injury incidences are described from data that were collected prospectively. Risk factors between players that suffered catastrophic events and those that did suffer these events were not investigated. The following definitions were adopted for this manuscript (a more detailed description of the game of rugby union is available elsewhere [17]):

*Catastrophic injury*

BokSmart and the CBPJPF use the following definition for recording catastrophic injuries:

“Any head, neck, spine or brain injury that is life-threatening, or has the potential to be permanently debilitating and results in the emergency admission of a rugby player to a hospital or medical care center.”

An event that satisfied the above definition, but was established to be a cardiac-related injury (not head, neck, spine or brain) was also recorded and classified as a “cardiac event”. Injuries (includes cardiac events) represented both amateur and professional levels. Catastrophic injuries were classified into three different groups: 1. Acute Spinal Cord Injury (ASCI), 2. Traumatic Brain Injury (TBI) and 3. Cardiac
events. ASCIs were further grouped into outcomes, listed in order of increasing severity: Near miss (full recovery expected, ambulant), Neurological deficit (some deficit remains, may walk with or without the requirement of assistive devices), Quadriplegic, and Fatal. TBI outcomes were divided into, with increasing severity: fully recovered, disability (remaining neurological deficit), and fatal. ASCIs and TBIs were further grouped into “non-permanent” (near misses/fully recovered) and “permanent” (residual disability, including fatalities). Non-fatal Permanent injuries - Neurological deficit (ASCI), Quadriplegia (ASCI), residual disability (TBI) – would be classified as morbidities and all Fatalities would be classified as mortalities.

The outcomes presented are the hospital-confirmed diagnoses within one month after the initial injury date as this time frame was thought to be able to provide a more accurate diagnosis.

**Incidence**
The numerator was calculated as the number of catastrophic injuries and the denominator was the population at risk (total number of rugby players in South Africa). These player numbers were obtained from the International Rugby Board’s (IRB’s) website (www.irb.com/unions/index.html). Incidences were presented as an annual average (over the four years) per 100 000 players.

**Age group**
This term distinguished between juniors and seniors. “junior”, which is synonymous with “schoolboy” in the South African context (under-7 to under-19), and included “pre-teen” and “teen” males and females (as per IRB website). “senior”, was comprised of anyone who was not in the definition for “junior” for males and females (older than under-19) and also included both amateurs and professionals. This term was used to describe the age group of match where the injury event occurred, regardless of whether the player was legitimately participating in that age group at the time.

**Event**
This term described the phase of play where the injury occurred and included scrum, ruck, tackle (this included both ball-carriers and tacklers) and collisions (an unintentional or intentional clash - which is distinct from a “tackle”).
Positional grouping
Owing to small sample sizes, the fifteen general positions were grouped into nine positional groupings as per Durandt et al.[18] prop (loose-head and tight head prop; = 2 positions), hooker (= 1 position), lock (left and right lock; = 2 positions), loose-forward (open-side flank, blind-side flank and eighth man; = 3 positions), scrumhalf ( = 1 position), flyhalf ( = 1 position), center (inside and outside center, = 2 positions), wing (left and right wing; = 2 positions), and fullback ( = 1 position).

Statistics
Incidences with 95% confidence intervals were calculated using standard formulae [19] suggested for rugby union injury studies.[20] Incidences were considered significantly different if the 95% confidence intervals (CIs) did not overlap. Any negative lower 95% confidence limits were presented as “0”. To confirm these comparisons using 95% CIs, p-values were also calculated for comparisons of junior and senior groups using VRP injury statistics software [8,21]. If a P-value was less than 0.05, the difference between groups was considered significantly different, even if overlap existed between 95% CIs.[22] All presented proportions were calculated after excluding missing data (if present) for a particular section - the denominator is always indicated to remove ambiguity.

RESULTS
Since 2008, there have been 54 catastrophic injuries (24 in juniors and 30 in seniors) recorded in total in South Africa (Table 1), the majority of which (n = 45) were Acute Spinal Cord Injuries (ASCIs). In juniors, the highest number of injuries occurred in 2009 (n = 8), while for Seniors the highest number (n = 9) occurred in both 2009 and 2010. Owing to small changes in numbers per year, incidences were calculated on the annual average of injuries over the four-year period (Table 1).

With an estimated 651 146 players at both levels (junior: n = 529 483; senior: n = 121 663) in South Africa, the average annual incidence for all catastrophic injuries (TBI, Cardiac events and ASCIs) was 2.07 per 100 000 players (95% CI: 0.97 - 3.18). Senior players had a significantly higher incidence of these events (6.16, 95% CI: 1.75 – 10.58) than junior players (1.13, 95% CI: 0.23 – 2.04) (P = 0.03). The average annual incidence for all TBIs and ASCIs combined (excluding cardiac events) was also significantly higher at senior (5.96, 95% CI: 1.62 – 10.30) than
junior (1.09, 95% CI: 0.20 – 1.97) level (P = 0.03) (Combined = 2.00 per 100 000 players, 95% CIs: 0.91 – 3.08) between 2008 and 2011. In combination, permanent TBIs and ASCIs occurred significantly more often at the senior (5.14 per 100 000 players, 95% CIs 1.11 – 9.16) than at the junior level (0.33 per 100 000 players, 95% CIs: 0 – 0.82) (P = 0.02) between 2008 and 2011 (combined: 1.23 per 100 000 players; 95% CIs: 0.38 – 2.08).

The incidence of TBIs was 0.19 per 100 000 junior players (95% CI: 0 – 0.56) and 0.62 per 100 000 senior players (95% CIs: 0 – 2.01). The incidence of cardiac events was 0.05 per 100 000 junior players (95% CIs: 0 – 0.23) and 0.21 per 100 000 senior players (95% CI: 0 to 1.01). The point estimates calculated for TBIs and cardiac events should be interpreted with caution due to low number of these events (Table 1). Half of the TBIs in junior players (50%, n = 2 of 4) had full recoveries, while all outcomes in senior players (100%, n = 3) were fatal. Both cardiac events to date (n = 2) had fatal outcomes. Owing to the low numbers of cardiac and TBI outcomes (n = 9), subsequent analyses only focus on ASCIs.

**Correlates of Acute Spinal Cord injuries (TBIs and cardiac events excluded): 2008-2011**

All of the ASCIs occurred to males. Seven % of the ASCIs (n=3 of 42) were fatal, 26% (n=11 of 42) resulted in Quadriplegia, 31% (n=13 of 42) resulted in neurological deficit and the remaining 36% (n=15 of 42) were classified as “Near Misses” (outcome not provided in n = 3 cases) (Table 1). Henceforth for further comparison, outcomes of ASCI were also grouped as either “Permanent” (Neurological Deficit, Quadriplegia, Fatal) or Non-Permanent (Near Miss).

The senior level accounted for 58% (n = 26 of 45) of all ASCIs. Considering the population at risk numbers, the average annual incidence of all ASCIs (including “not provided” outcomes) was significantly higher at the senior (5.34 per 100 000 players, 95% CI: 1.24 – 9.45) compared to junior level (0.90 per 100 000 players, 95% CI: 0.09 – 1.70) (P = 0.04) between 2008 and 2011 (Table 2).
Table 1: Absolute numbers of serious/catastrophic injuries in junior and senior rugby levels in South Africa by year, between 2008 and 2011 (4 years, inclusive).

<table>
<thead>
<tr>
<th>Type of injury</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>TOTAL</th>
<th>Annual Average*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute Spinal Cord Injury (ASCI) [n = 45]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;Near miss&quot; (full recovery/ ambulant)</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>0</td>
<td>12</td>
<td>3.00</td>
</tr>
<tr>
<td>Neurological deficit</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>0.75</td>
</tr>
<tr>
<td>Quadriplegics</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>0.50</td>
</tr>
<tr>
<td>Fatal</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0.75</td>
</tr>
<tr>
<td>Not Provided</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>0.50</td>
</tr>
<tr>
<td>Traumatic Brain Injury (TBI) [n = 7]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Fully recovered</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>0.50</td>
</tr>
<tr>
<td>Disability</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0.25</td>
</tr>
<tr>
<td>Fatal</td>
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<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0.25</td>
</tr>
<tr>
<td>Cardiac events [n = 2]</td>
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<td></td>
<td></td>
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<td>4</td>
<td>8</td>
<td>9</td>
<td>24</td>
<td>6.00</td>
</tr>
</tbody>
</table>

*Average is calculated for the four years that data has been collected.
Table 2: Average annual incidences (based on IRB estimated numbers) of acute spinal cord injury (ASCI) from 2008 – 2011 in South Africa (4 years, inclusive). Incidences include 95% confidence intervals (CI). Acute Spinal Cord injuries (ASCI’s) are divided into outcomes

<table>
<thead>
<tr>
<th>ASCI outcome</th>
<th>Junior Incidence (95% CI)</th>
<th>Senior Incidence (95% CI)</th>
<th>Combined Incidence (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permanent (ND + Quad. + Fatal)</td>
<td>0.24 (0 – 0.65)</td>
<td>4.52 (0.74 – 8.30)</td>
<td>1.04 (0.25 – 1.82)</td>
</tr>
<tr>
<td>Neurological deficit (ND)</td>
<td>0.14 (0 – 0.46)</td>
<td>2.05 (0 – 4.60)</td>
<td>0.50 (0 – 1.04)</td>
</tr>
<tr>
<td>Quadriplegics (Quad.)</td>
<td>0.09 (0 – 0.36)</td>
<td>1.85 (0 – 4.27)</td>
<td>0.42 (0 – 0.92)</td>
</tr>
<tr>
<td>Fatal</td>
<td>0 (–)</td>
<td>0.62 (0 – 2.01)</td>
<td>0.12 (0 – 0.38)</td>
</tr>
<tr>
<td>Non-permanent (&quot;Near miss&quot;)</td>
<td>0.57 (0 – 1.21)</td>
<td>0.62 (0 – 2.01)</td>
<td>0.58 (0 – 1.16)</td>
</tr>
<tr>
<td>Not Provided*</td>
<td>0.09 (0 – 0.36)</td>
<td>0.21 (0 – 1.01)</td>
<td>0.12 (0 – 0.38)</td>
</tr>
<tr>
<td>Total ASCI’s</td>
<td>0.90 (0.09 – 1.70)</td>
<td>5.34 (1.24 – 9.45)</td>
<td>1.73 (0.72 – 2.74)</td>
</tr>
</tbody>
</table>

*Specific diagnosis not available/supplied, but confirmed as ASCI
ASCI – Acute Spinal Cord Injury
Bold text indicates value is significantly different from junior level
In senior players, 85% (n = 22 of 26) of all ASCIs had permanent outcomes (neurological deficit, quadriplegia or fatal) in comparison to 26% (n = 5 of 19) in junior players. When considering the different numbers for the populations at risk, permanent ASCIs occurred significantly more often in senior (4.52 per 100 000 players; 0.74 – 8.30) than junior players (0.24 per 100 000 players; 0 – 0.65) (P = 0.04) (combined: 1.04 per 100 000 players, 95% CI: 0.25 – 1.82) between 2008 and 2011 (Table 2).

Matches, as opposed to training, were associated with 88% (n = 38 of 43) of all ASCIs (information not available for n = 2 cases). The training injuries occurred either in a scrum (n=2), tackle (n=2) or ruck (n=1). Owing to the low numbers of training injuries and the fact that their mechanisms were similar to those that occurred in matches, these injuries were combined with match injuries for further analyses (Figures 1 and 2).

The scrum was involved in 42% (n=19 of 45) of all ASCIs. Sixty-three % (n=12 of 19) of scrum-related ASCIs occurred to senior players, which equates to an incidence of 2.47 injuries per 100 000 senior players (95% CI: 0 - 5.26) between 2008 and 2011. Together, the scrum and tackle accounted for 80% (n=36 of 45) of all ASCIs for both levels combined (junior and senior) (Figure 1A). Eighty-two % (n=14 of 17; outcome “not provided” for n=2) of scrum related injuries had permanent outcomes compared to 50% of tackle injuries (n=8 of 16; outcome “not provided” for n=1) (Table 1B). The 14 scrum-related permanent ASCI outcomes equated to an average annual incidence of 0.54 permanent scrum ASCIs per 100 000 players (95% CI: 0 – 1.10) between 2008 and 2011.

The senior age group accounted for 79% (n=11 of 14) of the permanent scrum injuries and 88% (n=7 of 8) of the permanent tackle injuries. Of all the scrum injuries, scrum engagement and a collapsed scrum contributed to 56% and 39% of cases, respectively (n=10 and 7 of 18, respectively; n=1 case was attributed to popping out, and information was not provided for n=1 case). The tackle events were evenly split between tackler and ball-carrier (n=8 for each).
For further analyses, only n=40 cases were considered because four cases occurred in positional groupings that are not conventional 15-a-side rugby (n=3 “seven-a-side”, n=1 mini-rugby) and the event responsible was “unclear” for one case.

The hooker and loose-forward positional groupings were associated with 38% (n = 15 of 40) and 25% (n=10 of 40) of all ASCIs (Figure 2A). Eighty % of all ASCIs to the hooker position were permanent injury outcomes (n=12 of 15). Together, the hooker, prop, and lock positional grouping (tight five) accounted for all the scrum
injuries. The tackle injuries were shared between all positional groupings except prop and scrumhalf.

Figure 2. [A] The positional grouping, and the phase of play (tackle, scrum, ruck or collision) that accounted for all ASCI (n = 40) and [B] permanent ASCI (n=27) outcomes. All segments, in combination, add up to 100%.

*L-F = Loose-Forward; SH = Scrumhalf, FH = Flyhalf

When examining permanent ASCIs in isolation (Figure 2B), only the forwards positional groupings were represented (prop, hooker, lock and loose-forward). Of
these permanent outcomes, the hooker alone accounted for 46% (n=12 of 26) of all injuries, 83% of which (n=10 of 12) were as a result of the scrum. The loose-forward positional grouping accounted for 31% (n = 8 of 26) of all permanent outcomes, 63% (n = 5 of 8) of which came from the tackle.

DISCUSSION
In South Africa, we found that the average annual incidence of all rugby-related catastrophic outcomes (excluding cardiac events) was 2.00 per 100 000 players (95% CI: 0.91 – 3.08) between 2008 and 2011. This is comparable to the rate reported for Argentina (1.90 per 100 000 players) [23], between 1977 and 1997 and Ireland (0.89 per 100 000 players) [5] between 1995 and 2004. These are the only rugby-related catastrophic injury papers that included “near miss” outcomes and the incidences were only subsequently estimated by a recent review article [1]. While the current consensus statement for rugby injury data collection recognizes the importance of calculating incidences for comparability across playing nations [20], it still does not include “near miss” outcomes in the definition of catastrophic injury. The small difference between non-permanent and permanent outcomes and therefore the epidemiological importance of including these outcomes has been stated by various authors in the past [3,24] and was clearly illustrated in a recent UK study of spinal injuries in junior players [25].

For comparative purposes, the average annual incidence of permanent ASCIs and TBIs was 1.23 per 100 000 players (95% CI: 0.38 - 2.08) between 2008 and 2011. On a Health and Safety Executive scale [1] which categorises risk in ascending order, from “negligible” (0.001 – 0.1 cases/100 000 population) to “acceptable” (0.1 – 2.0 cases per 100 000 population); “tolerable” (2.0 – 100.0 cases per 100 000 population); and “unacceptable” (> 100 cases per 100 000 population), this incidence would be classified as “acceptable”. This average incidence is also comparable to the rates reported in a review of rugby-related permanently disabling head and spinal injuries [1] in the UK (0.48 – 1.50 per 100 000 players), but was on the lower end of rates reported for other countries (0.89 – 13.00 per 100 000 players) in the same review. However, although this aforementioned review [1] intended to include both permanent TBIs and ASCIs, the majority of studies that were included only investigated the latter type of injury.
Therefore, the average annual incidence of permanent ASCIs in the present study (1.04 per 100,000 players, 95% CI: 0.25 – 1.82) is the more comparable incidence to those presented in the review [1]. The incidence of permanent ASCIs in the present study is also similar to that reported for comparable outcomes in Australia between 1997 and 2002 (3.2 per 100,000 players) [26] and New Zealand before and after the introduction of RugbySmart (between 0.8 and 1.7, per 100,000 players, per year) [10]. The incidence data of New Zealand is particularly believable and accurate due to their comprehensive no-fault insurance system [27]. The annual average incidence of the present study is also greater than the estimated incidence of permanent spinal cord injuries for South Africa between 2001 and 2005 (0.6 per 100,000 players) [7], although the earlier study had a different method of data collection to that of the present.

For further comparison, the annual average incidence of non-fatal permanent ASCIs (excluding near misses and fatalities), for the present study was 0.92 per 100,000 players (95% CI: 0.18 – 1.66) which is significantly lower than the rate reported for comparable outcomes (ASIA scale A – D, excluding fatalities) in Australia between 1995 and 2003 (6.8 per 100,000 players, 95% CI 4.0 – 10.7) [28], but comparable to France before (2.1 per 100,000 players, per year) and after the introduction of modified Laws and guidelines for the scrum (1.4 per 100,000 players, per year).

The main finding of the present study was the higher incidence of catastrophic injuries at the senior, in comparison to the junior level. This associated factor, along with other relevant factors are described in the following section.

**Senior (as opposed to junior) level**
The novel conclusion of the present study is that the annual average incidence of all (including “near misses”) and permanent ASCI outcomes between 2008 and 2011 was significantly higher at the senior than junior level. Although incidences at senior level have previously not been statistically compared with those at junior level, preceding literature in Australia [26] and France [29] have indeed also reported higher incidences in senior compared to Junior age groups. The best comparison to the present study was an American Football study [30] that investigated a comparable range of all ASCI outcomes per 100,000 players: fatal to serious, with
full recovery outcomes (equivalent to “near miss” in the present study). This American Football study had similar annual average incidences per 100 000 high school and college players respectively to the present study: 1.10 (present study: 0.90 per 100 000 players, 95% CI: 0.09 – 1.70) and 4.72 (present study: 5.34 per 100 000 players, 95% CI: 1.24 – 9.45). It was interesting to note that this study presents the first documented incidence of catastrophic injury in mini rugby [1], although this injury had a “near miss” outcome.

The reason for higher incidence rates at senior level may, in part, be related to more stringent law variations, in particular with respect to the scrum, at Junior levels [31]. Under 19 law variations, for the scrum, include, but are not limited to: not being able to push a scrum more than 1.5 metres and not being allowed to wheel a scrum [32]. These law changes decreased numbers of spinal cord injuries in New Zealand [33]. However, the consistent finding that all (non-catastrophic as well as catastrophic) injury incidences rates are higher at senior than junior level [34-36] suggest that this finding is not unexpected. Studies investigating general injuries have suggested that increased speed [36] and increased competitiveness and aggression [34,35] may be responsible for the differences in incidences at these levels. Other factors such as “weekend warriors” (adults only playing sport on the weekend, without sufficient training, coaching and conditioning) and the low numbers of players at the senior level which could force players to play in unfamiliar positions, are potential contributing factors, although these require further investigation.

**Hooker positional grouping**

While the many positional groupings of rugby does not allow for statistical comparisons, the hooker positional grouping accounted for the highest proportion of all ASCIs (38%) in the present study, which is alarming considering the small proportion (7%, n = 1 of 15) that this position represents in a traditional 15-man starting line-up. Furthermore, this finding and comparison has been made in previous research in South Africa [7] and other countries [2]. Moreover, this position also accounted for the majority of all permanent ASCIs (46%) in the present study, regardless of age group, and 83% of these (n = 10 of 12) were in the scrum. While the findings could not be investigated statistically, common-sense would argue that the large proportion of ASCIs attributed to this one specific playing position represents an alarming and concerning finding.
The Hooker’s role and position in the scrum could place this player at more risk of suffering a scrum-related ASCI than any other positional groupings. During engagement, the hooker has each arms bound around a prop, and is driven into the gap between the opposition hooker and prop by his/her team-mates. During this period, and the subsequent shove, there are a number of forces experienced by the front-row including lateral, vertical and compressive. Depending on the level, the compressive forces can be between 8.7 and 16.5 kiloNewtons [37]. At these large impulsive forces, and with the hooker unable to adjust his/her position due to the scrum structure, a slight miscalculation or deliberate foul play could result in a catastrophic event to this player.

Scrum (as opposed to any other phase of play)
The scrum alone accounted for a rate of 0.73 ASCIs per 100 000 players and for 42% of all ASCIs. The high proportion of scrum-related catastrophic injuries has previously been shown in South Africa [7] and other countries [2] [1]. Additionally, there was a higher proportion of scrum-related catastrophic injuries in the present study (42%) in comparison to other studies which also included “near misses”, e.g. in Ireland (17%, 2 of 12) [5].

However, studies that only investigated permanent outcomes found that the scrum accounted for 37% (68 of 183) of all cases in South Africa, 51% (19 of 37) of all cases in France, and 61% of all cases in Argentina [23], which were comparable in proportion to that of the present study (52%). Independently, a higher proportion of scrum- compared to tackle-related ASCIs resulted in permanent outcomes (82% vs. 50%). Considering that scrums occur relatively infrequently in comparison to tackles and rucks [38], these findings are noticeably understated.

While, the hooker, prop, and lock positional grouping (tight five) accounted for all the scrum-related permanent ASCIs, the tackle-related injuries were shared between all positional groupings except prop and scrumhalf, which represents the more generalised risk in the latter phase of play. While the incidence was not significantly different between age groups, 79% of all permanent scrum-related ASCIs occurred at the senior rather than the junior level. The engagement sequence accounted for the largest proportion of scrum-related injuries (56%) in the present study, which is consistent with previous findings [2,39] and has been attributed to the high forces
experienced by the front row during this phase of the scrum [29] [40]. The high forces (and thus acceleration) during engagement would exacerbate any predisposing risk factor.

The premature degeneration of the cervical spine, particularly in front row players [10,41], mismatches in size between front-row players [2,12], and high impact forces [40,42] have been mentioned as potential factors for the relative overrepresentation of scrum-related injuries in previous literature, but other factors such as refereeing experience, coaching experience, scrum laws, technical preparation, appropriate player selection and specific conditioning of players should also be scrutinized more carefully. While the four phase “crouch, touch, pause, engage” (CTPE) refereeing sequence has been shown to have some positive effect on injury incidences [39], the results of the present study warrants considering further Law changes with potentially greater effect, especially for the amateur game. The modification of scrum laws/regulations in amateur rugby in France: removal of the high impact on engagement, and linking the two packs together before the scrum commences, and a “rugby passport” license to certify capacity of front-row players, significantly reduced scrum-related catastrophic cervical spine injuries, including those to the front-row and hooker positions [29]. Furthermore, the exemplary nationwide injury prevention program of New Zealand, RugbySmart, had a significant reduction in scrum-related spinal injuries [10] and it is hypothesized that the BokSmart program can produce a similar effect over time [12]. This paper serves as a reference point for the BokSmart program going forward.

Although all ASCIs occurred to males in the present study, this may simply be an artefact of disproportionate participation levels: there are only 17 917 females in comparison to 633 229 males (www.irb.com/unions/index.html). The average annual incidence of cardiac death rates in the present study in junior players (0.05 per 100 000 players) is less than rates published previously for competitive athletes younger than 18 years of age [42]. There were no prospective incidences available for adult/senior populations.

Limitations
Player numbers were assumed to remain constant over the four years of investigation. While they may have fluctuated between years, it is unlikely that
Chapter 4: Incidence of rugby-related catastrophic injuries in South Africa: 2008 - 2011

numbers have declined appreciably, thereby ensuring that incidences were not under-estimated. The estimation of player numbers (population at risk) may also be open to error. However, due to the fact that these rare events are shown as an incidence per 100 000 players, the inaccuracy would have to be enormous to affect the results presented in the current study. Furthermore, errors in numbers would probably be consistent at both levels (junior and senior) and should not drastically affect between-level comparisons.

It is plausible to suggest that some catastrophic events might not be reported to BokSmart and the CBPJPF. However, the Serious Injury Protocol, and the potential benefit of financial assistance that is associated with reporting injuries in South Africa would make this possibility very small. Information dissemination via social media and other more formal communication channels regarding catastrophic rugby injuries would generally pick up any shortfall potentially missed.

CONCLUSION
In conclusion, the rates of all (including near-miss) and permanent (excluding near-miss) rugby-related ASCIs in South Africa from 2008 to 2011 are comparable to that of most other countries and to rates in other collision sports such as American Football. Despite this finding, three factors were strongly associated with catastrophic injury and warrant further attention for prevention strategies: Senior players, hooker playing position and the scrum phase of play. This four year registry will serve as reference point for the evaluation of the BokSmart injury prevention program going forward.

REFERENCES


Chapter 4: Incidence of rugby-related catastrophic injuries in South Africa: 2008 - 2011


Chapter 5: Are we currently underestimating the risk of scrum-related neck injuries in rugby union front-row players?

5

ARE WE CURRENTLY UNDERESTIMATING THE RISK OF SCRUM-RELATED NECK INJURIES IN RUGBY UNION FRONT-ROW PLAYERS?

PUBLISHED AS:

Chapter 5: Are we currently underestimating the risk of scrum-related neck injuries in rugby union front-row players?

ABSTRACT

Introduction and objectives: Of all rugby-related injuries, those to the head and neck carry the most concern for medical professionals. Each rugby team of 15 is comprised of eight ‘forwards’ and seven ‘backs’ – each of which have position-specific roles in the team. The phase of play that is most well-regulated by the referee is the scrum, yet this phase has a high propensity to result in injury. Injury rates are typically calculated by dividing the number of injuries by the total exposure. Depending on the study design, this exposure can either be the total number (catastrophic injuries generally) or amount of time (non-catastrophic injuries generally) of participants potentially at risk of suffering a particular injury. In rugby epidemiology, exposure for scrum-related injuries is conventionally calculated based on the eight forwards as they are the only players involved in this activity. However, injuries in all injury epidemiology it is generally only the three front-row forwards (hooker and two props) that are at risk of suffering a scrum-related neck injury. Thus, the authors intend to show through re-calculating previous data, that the scrum-related neck injury rate to front-row forwards has been underestimated.

Methods: The data from two publications was re-calculated with only the front-row forwards in the exposure calculation. One publication which examined catastrophic injury rates used total number of players in the exposure. The other publication, which used total amount of time as the exposure, was an investigation of general (all) injuries. Injury point estimates and 95% confidence intervals were re-calculated using on the injuries and exposure for the front-row positions and these values were compared to the previous calculations.

Results: For catastrophic injuries, the rate can be up to five-fold higher than has been reported previously when all eight forwards were considered to be exposed to scrum-related injury risk. Similarly for general injuries, the scrum-related injury rate was significantly greater in the three front-row forwards than the other eight forwards.

Conclusions: These finding of this study have implications for risk communication to administrators, medical personnel, coaches, referees, parents and most importantly players. Depending on the research question, future studies should consider the calculations adopted in this article or at least consider the players at risk of suffering scrum-related neck injuries in their calculation only.
Chapter 5: Are we currently underestimating the risk of scrum-related neck injuries in rugby union front-row players?

INTRODUCTION

To understand the risk of incurring a particular rugby injury, and to identify risk factors related to this injury, it is necessary to know both the injury counts and the time that the players are exposed to the risk of sustaining that injury. The latter poses an interesting debate with respect to the scrum as there are various ways in which the exposure can be expressed. While not the only two methods, “exposure” in sports injury epidemiology has often been calculated as either: the “Athlete at risk” and the “Athlete participation” method:

“**Athlete at risk**” = number of athletes involved in a game X number of games X average duration of game.

“**Athlete participation**” = total number of athletes who could possibly have been at risk for a particular injury.

The “athlete participation” method is sometimes the only way to calculate injury incidence rates for certain investigations, such as for catastrophic injury risk, in which data are mainly collected retrospectively. However, this method typically underestimates injury rates as the exact time at risk is not quantified. Where match time is recorded, the current consensus statement for the surveillance of injuries in rugby union provides a formula for the calculation of match exposure. This consensus statement, which defines terms and preferred methodology, has significantly advanced the quality of research on injuries associated with rugby union by offering guidelines for a standardised approach, enabling universal comparison of injury risk and risk factors. For the majority of rugby union epidemiological studies, it is assumed that within one team (Team A) 15 players (the number of players per team on the field at one time) are at risk for Y minutes (80 minutes for senior level) over Z number of matches during a season/tournament.

This exposure calculation assumes that all 15 players of the team are at equal risk of injury during this time: Y (minutes of match) x Z (number of matches). However, the 15 players are comprised of two broad positional groupings: eight forwards and seven backs. Rugby union involves activities, such as scrummaging, that are position specific, and therefore do not involve all 15 players. Furthermore, players
are not at risk for the full match time as the ball is typically in play for far less time than the full 80 minutes. [6] Outside of this “ball in play” time there is no injury risk to players. Also, certain activities, such as scrummaging, occur for a small percentage of the total match time: at international level, players only physically scrum for 1 minute and 16 seconds per match, on average. [6] Thus, the calculated incidence rate, based on the assumed exposure of 15 players at risk for the full match time (80 minutes, in most cases), would be a gross underestimation of the actual incidence rate of activity-related injuries when measured against the incidence rate calculated using the time of “ball in play”. Reporting incidence rates separately for forwards and backs[1] may reduce some, but not all of the inaccuracies of this calculation. For example, if only the three front-row positions (loose-head prop, hooker and tight-head prop) are mainly at risk of injury during the scrum, the current exposure calculation is overestimated, and the incidence rate is underestimated by the order of five players that are not at risk of injury. This point is even more pertinent for catastrophic scrum injuries which occur almost exclusively to the front row.[3,7-8]

Scrummaging is not the only event that may have an underestimated injury risk because of its specificity during a match. Other examples of events that are more related to certain playing positions than others due to the position-specific nature of the game are lineouts, kicking, ball carries, tackles, mauls and rucks. However, scrums are a well-structured and controlled event, governed by numerous safety Laws which referees have to enforce. Thus, the authors felt this specific aspect of play, was the most suited to practically demonstrate the underestimated injury risk per event, in this case for scrum-related injuries in the front row playing positions.

METHODS
Two worked examples, based on data from previously published manuscripts, [7,9] are presented to illustrate this potential underestimation in the calculation of non-catastrophic (Worked example A) and catastrophic (Worked example B) injury rates. Incidences with 95% confidence intervals were calculated using formulae[10] frequently used in rugby union injury studies:[1,5] incidence rates were considered significantly different from each other if their respective 95% confidence intervals (CIs) did not overlap at all.
RESULTS

Worked Example A: evaluation of non-catastrophic injury rates using “athlete at risk” method

Teams followed across two rugby seasons (with 15 players per team) participating in a total of 420 matches that are each 80 minutes in length, have an overall exposure time of 8400 player hours. There are 91 scrum-related neck injuries to the front-row players (various severities, including medical attention injuries) during these 420 matches. Depending on the number of players that one considers to be “at risk” during the scrum, there are typically three methods to calculate risk exposure, each of these exposure calculations produces notably different incidence rates:

(i) Consider all 15 players (Figure 1 – all players); \((91 \div 8400) \times 1000\) = an incidence rate of 10.8 scrum-related injuries per 1 000 player hours (95% confidence intervals: 8.6 to 13.1). As mentioned previously, this is highly inaccurate since not all 15 players participate in a scrum.

(ii) Consider only the eight forwards (Figure 1 – forwards only); \([91 \div (8400 \times \frac{8}{15})]\) \times 1000 = an incidence rate of 20.3 scrum-related injuries per 1 000 forward hours (95% confidence intervals: 16.1 to 24.5), which is significantly greater than the incidence rate for all 15 players. This method has been suggested by Brooks and Fuller [1] and Gianotti et al. [12] previously, but does not feature in the current consensus statement [4] and is not applied ubiquitously.

(iii) Consider only the three front row players who are at risk of suffering a scrum-related injury (Figure 1 – front-row only); \([91 \div (8400 \times \frac{3}{15})]\) \times 1000 = an incidence rate of 54.2 scrum-related injuries per 1 000 front-row hours (95% CIs: 43.0 to 65.3), which is significantly greater than both the incidence rates for all 15 players (i) and for all eight forwards only (ii). Given previously recorded scrum injuries, this calculation, may be closer to a true reflection of the injury incidence rate during the scrum.

Moreover, scrummaging accounts for a small amount of total activity: it only accounts for 2% of total match time (1 minute 16 seconds of 80 minutes) [6] and 6% of total events/activities (1447 of 22842 events).[11] Thus, points (ii) and (iii), which
assume that the exposure to scrum injury risk is for the entire 80 minutes of a senior match, also overestimate the exposure, and underestimate the risk. However, quantifying the amount of time spent scrummaging and ball-in-play time, may be more logistically challenging, particularly for non-elite or community levels of the game.

An alternative approach to evaluating risk would be to disregard time completely and to calculate injury counts per event – i.e. 10 scrum injuries per 92 scrums. This method has previously been performed for a prospective cohort study [11] and showed the scrum to have the highest propensity to cause injury. Should the primary measure be scrum injuries only, due to the small number of scrums in a match, this method could still be practically feasible.

**Figure 1. The same number of scrum-related injuries produces three different injury incidence rates, depending on the number of players that are considered to be “at risk” in the exposure time (player hours). The injury incidence rate for all players is significantly less than for the three front-row forwards only. (CIs – confidence intervals)**
Chapter 5: Are we currently underestimating the risk of scrum-related neck injuries in rugby union front-row players?

**Worked Example B — evaluation of catastrophic injury rates using the “athlete participation” method**

The following raw data were used from a previous publication [7] which investigated the incidence rate of catastrophic injuries in South Africa between 2008 and 2011. The raw data are used here purely for illustrative purposes. To calculate the national incidence rate of injuries, the “athlete at risk” method would be logistically difficult. Therefore, the “athlete participation” method was used for this particular investigation.[7]

Table 1 provides the estimated player number exposure hours for calculation of relative match-related catastrophic acute spinal cord injury (ASCI) average incidence rates associated with the scrum (4.8 injuries per year) between 2008 and 2011 in South Africa. Hookers (n = 13), props (n = 5) and locks (n = 1) incurred scrum-related catastrophic ASCI. There were an estimated 651 146 active players at the time of the study.

**Table 1. The estimated total number of South African rugby players [7] at risk is provided, and the respectively calculated forwards, front-row players (loose-head prop, hooker and tight-head prop), props (loose-head prop and tight-head prop) and hooker position only.**

<table>
<thead>
<tr>
<th>Total player numbers</th>
<th>“Forwards” population*</th>
<th>“Front-row” population^</th>
<th>“Prop” population^</th>
<th>“Hooker” population&amp;</th>
</tr>
</thead>
<tbody>
<tr>
<td>651 146</td>
<td>347 278</td>
<td>130 230</td>
<td>86 820</td>
<td>43 410</td>
</tr>
</tbody>
</table>

* Calculated by multiplying total player numbers by the fraction of 8/15.
^ Calculated by multiplying total player numbers by the fraction of 3/15.
& Calculated by multiplying total player numbers by the fraction of 1/15.

On the assumption that all 15 playing positions were represented proportionally, if one then multiplied this total number of players by the fraction of forwards that comprise a starting team (8/15), one would have a gross estimate of the forwards population at risk (347 278 players -Table 1). This method has been described and used previously for assessing scrum law changes.[12] Furthermore, with the same assumption made as per the above, by then multiplying the total number of players...
by the fraction of front-row forwards (loose-head prop, hooker and tight-head prop) that are at risk for a catastrophic injury during a scrum ($\frac{3}{15}$), one would have a gross estimate of the front-row forward population at risk (130 230 players). Similarly, one could multiply the total number of players by a fraction of $\frac{2}{15}$ and $\frac{1}{15}$ to get a gross estimate of the number of props (86 820) and hookers at risk (43 410). Intuitively, accurately recording the exposure time for such a large amount of players would be impractical and therefore the “athlete participation” method remains the most feasible for catastrophic injury studies.

Using the “athlete participation” method, and therefore player participation numbers, scrum-related catastrophic injury incidence was calculated in a variety of ways using the respective player numbers at risk (i.e. all players, forwards, front-row players, props, and hookers only) and represented as injuries per 100 000 players. Similarly, only the scrum injuries that occurred to the front-row ($n = 18$: 4.5 injuries per year) were considered for the “front-row” calculation, only injuries that occurred to props were considered for the “props” calculation ($n = 5$: 1.3 per year), and only injuries that occurred to the hooker ($n = 13$: 3.3 injuries per year) were considered for the “hooker” calculation.

Using methods common to sports epidemiology research,[1,10] injury incidence rates for the front-row (3.7 injuries per 100 000 players, 95% CIs: 0.4 – 7.0) would not be statistically different to the incidence rate for all players (0.7 injuries per 100 000 players, 95% CI’s: 0.1 – 1.4), despite this representing a five-fold difference (Figure 2). Similarly, hookers (7.5 per 100 000 players, 95% CI’s: 0.0 – 15.6) had a five-fold greater injury rate than props (1.4 per 100 000 players, 95% CI’s: 0.1 – 4.0), although this would also not be statistically significant due to the overlap of these two confidence intervals. As catastrophic events are rare occurrences, the calculation of a relative rate,[13] using a clinically relevant threshold for a “meaningful” difference, could be a more practical method to assess if the two rates were different. Even though the difference is statistically not significant, the hooker position, from a clinical relevance point of view, would be at far greater risk of catastrophic injury than other positions in the scrum. The definition of “clinical relevance” would depend on the particular research question.
DISCUSSION AND CONCLUSION
The current consensus statement for injury surveillance in rugby union [4] has improved epidemiological rigour within the rugby injury field. However, considering the relatively small number of players at risk of scrum-related injuries, [7,14] and without acknowledging the reduction in relative exposure, we are in danger of masking the real risk of injury to the front-row, and more specifically the hooker playing position in the scrum. This “masking” effect is evident when data from previous publications [7,9] are recalculated with only those players that are at risk of injury in the scrum (front-row) being considered in the exposure calculation (Figures 1 and 2). While the incidence of spinal cord injury in rugby is generally small, and while the calculated overall risk of a scrum-related catastrophic injury would probably still remain relatively small, it is important not to underestimate this risk.
Furthermore, with this “masking” effect, it is possible that changes in scrum injury incidence rates as a result of the modified scrum Laws that SARU [15] and, more recently, the International Rugby Board (IRB) have mandated [16] could be overlooked. Any injury prevention intervention needs to be accurately evaluated before and after the problem was identified.[17] With the large confidence intervals that would result from reducing the scrum-related exposure to the fraction of the front-row and positional grouping numbers, any statistical effect of the Law changes might indeed be missed. A relative rate change with a clinically relevant threshold or using a Poisson regression, as employed by Quarrie et al.,[18] to assess the effect of RugbySmart on neck and spinal injuries, may offer alternative approaches to consider.

The authors propose that future epidemiological studies should, where possible, attempt to more accurately quantify the actual player exposure when assessing scrum-related injury risk. At the very least, this exposure should be changed based on the assumption that only three players – the loose-head prop, hooker and tight-head prop - are effectively at risk for suffering a scrum-related injury (general or catastrophic). Although there is a chance that the lock positions could also be injured during the scrum, the authors contend that this chance is very low, based on only one isolated injury to date that the authors are aware of.[7] Furthermore, although using fractions to recalculate the “forward” and “front-row” populations for catastrophic injuries in the “athlete participation” method may be based on many assumptions, the authors contend that this recalculated exposure is more accurate than calculating an injury rate based on the total playing population, as is currently performed. This would align risk estimates in catastrophic injury epidemiological reports with the majority of non-catastrophic epidemiological reports, which only consider the forwards in the exposure calculation. Similarly, with non-catastrophic scrum injuries included in the “athlete at risk” method, calculating the adjusted player exposure hours using only the three front row players, or using the injuries per event approach, would provide a better representation of the true injury incidence per scrum event than is currently provided.
Chapter 5: Are we currently underestimating the risk of scrum-related neck injuries in rugby union front-row players?

REFERENCES


Chapter 5: Are we currently underestimating the risk of scrum-related neck injuries in rugby union front-row players?


THE EFFECTIVENESS OF THE NATIONWIDE BOKSMART RUGBY INJURY PREVENTION PROGRAMME ON CATASTROPHIC INJURY RATES

PUBLISHED AS:

Chapter 6: The effectiveness of *BokSmart* - a nationwide injury prevention programme on rugby-related catastrophic injury rates

**ABSTRACT**

**Introduction and objectives:** Rugby union ("rugby") participants have a higher than average risk of injury compared to participants of other popular team sports. *BokSmart*, a nationwide injury prevention programme was launched in South Africa in mid-2009, with the goal of reducing catastrophic head/neck (serious) injuries in players. The programme provides injury prevention information to coaches and referees. This study investigated if *BokSmart* has been associated with a reduction in these injuries.

**Methods:** The *BokSmart* programme collected data on all South African rugby-related CIs since 2008. Using a Poisson regression CI numbers were compared pre-*BokSmart* (2008/9) to the years post-implementation (2010-13). Player numbers were assumed to be constant throughout this evaluation: junior = 529,483; senior = 121,663.

**Results:** In junior players, the 'post-*BokSmart'* period had 2.5 less annual serious injuries than 'pre-*BokSmart'* (IRR: 0.6, 95% CI: 0.5 – 0.7, p<0.0001). In contrast, there was no significant difference in these periods in seniors.

**Conclusions:** The *BokSmart* programme was associated with a reduction in serious injuries in the four years post-implementation. The absence of effect in seniors may be a result of fewer players or of differences in effectiveness of the intervention in this group - future studies should investigate these questions.
Chapter 6: The effectiveness of BokSmart - a nationwide injury prevention programme on rugby-related catastrophic injury rates

INTRODUCTION

There are numerous benefits associated with being physically active.[1] However, being physically active also presents a level of risk of injury to the individual - the incidence and severity of which is dependent on the type of physical activity.[2] [3] Of all popular sports, Rugby Union (henceforth “rugby”) is associated with a relatively high incidence of injuries.[4,5] Rugby is also currently the most popular collision sport worldwide,[6] has an enormous participant base with 118 active international Unions, and enjoys particular popularity in South Africa with more than 600,000 players nationwide.[7]

Although catastrophic injuries in rugby are rare, and the risk of their occurrence has been classified as “acceptable,”[8] when they do occur they are tragic and have profound effects on the player, their family and friends.[9] In South Africa [7] the average annual incidence of rugby-related permanently disabling spinal cord injury was estimated to be comparable (1.0 per 100 000 participants) to other rugby-playing nations such as New Zealand, Ireland, Australia and the United Kingdom – thereby classifying the level of risk of these injuries in South Africa as “acceptable”.[8] However, an early South African study [10] concluded that 56% of all rugby-related spinal cord injuries were preventable.[10] South Africa is not the only country to have reported “preventable” rugby-related catastrophic injuries [11].

As a result, various preventive programmes have been introduced in various unions to reduce the rate of catastrophic injuries.[12-14] RugbySmart of New Zealand, is a notable example of a nationwide catastrophic injury prevention programme that was associated with a significant reduction in scrum-related spinal injuries.[15] Based on the success of this programme, the South African Rugby Union (SARU) adapted and developed it’s own programme, BokSmart, which was launched in July 2009.[16-17] The two programmes (RugbySmart and BokSmart) have recognisable similarities, such as their programme structures which educate coaches and referees in an attempt to prevent catastrophic injuries in players. However, the two countries present very different environments to the implementers of these respective programmes (New Zealand and South African Rugby Unions), with South Africa still classified as a “developing nation” with huge socioeconomic disparity.
among players, coaches and referees.[18] For example, English is only the fourth most spoken language in South Africa, [19] yet the BokSmart educational programme is taught in this language. Attendance of the BokSmart educational course became compulsory for any active coach or referee in January 2010, and SARU estimated that between 70 and 95% of active coaches had a current BokSmart certification in 2012 (Viljoen W. Personal communication). Referees are supposed to check that all coaches have proof of attending the course before any match begins, regardless of the level of play. In the follow-up of any catastrophically injured player in South Africa, the coaches and referees (if applicable) are also investigated to assess if they had recently attended a BokSmart course prior to the injury or not.

Therefore, the aim of this investigation was to examine the rugby-related catastrophic injury rates in South Africa before and after the implementation of the nationwide injury prevention programme, BokSmart.

METHODS

**Design**
Ecological study.

**Data collection**
Injury data have been prospectively collected by a joint initiative between the Chris Burger Petro Jackson Player’s Fund (CBPJPF) and South African Rugby Union (SARU) since 2008 and has been explained in detail previously.[7] In short, a detailed questionnaire was completed by the BokSmart Serious Injury Case Manager (SICM) for every rugby-related catastrophic injury in South Africa (Appendix VI). There is incentive to report rugby-related catastrophic injuries in South Africa, as the CBPJPF provides financial assistance for these players. The detailed questionnaire gathered information about the player, as well as the event which caused the injury (including preceding events). Data that were analysed for this study were: ethnicity, event causing injury, outcome of injury (permanent or non-permanent), year of injury, site of injury (head or neck) and age group that the injury occurred in (junior or senior).
Permission to analyse the SARU/CBPJPF’s database was granted by the University of Cape Town’s Human Research Ethics Committee, with permission from SARU/CBPJPF to access their data.

Injury Definition and classification
SARU’s catastrophic injury definition was as follows:
“Any head, neck, spine or brain injury that is life-threatening, or has the potential to be permanently debilitating and results in the emergency admission of a rugby player to a hospital or medical care center.”

This definition includes injuries that fall under the current consensus statement for injury surveillance in rugby definition for non-fatal catastrophic injuries [20], as well as injuries that were thought to be catastrophic, but that recovered fully at a later stage (“near misses”), as well as fatal catastrophic injuries. It has previously been contended that “near misses” should be included in such a definition [21] for effective evaluation of prevention strategies. A recent UK study supported this view. [22] Cardiac events were not considered due to their very low incidence rate and the fact that the event might not be specific to the nature of rugby. Catastrophic injuries were classified into two different groups: acute spinal cord injury (‘neck’) and traumatic brain injury (‘head’) and both of groups were comprised of permanent and non-permanent outcomes. These outcomes concern hospital-confirmed diagnoses within one month after the initial injury date as this time frame was thought to be able to provide an accurate diagnosis. For ease of reference, the combination of head and neck injuries will henceforth be referred to as ‘serious injuries’.

Although player participation numbers have been estimated for South Africa and have been used to estimate catastrophic incidence rates previously,[7] player numbers were not available for specific years. Therefore, one had to assume that player numbers had remained the same in all years of evaluation (2008 – 2013): juniors = 529,483 and seniors = 121,663.

Statistical analyses
Owing to the count nature of the data, a Poisson regression was used to assess the time trend effect of the BokSmart programme on catastrophic injuries between 2008
and 2013. During data exploration, a Pearson Goodness of Fit chi-squared test indicated that considering the effect of the intervention as 'pre-' and 'post-BokSmart' would fit the data better (p=0.923) than using the intervention as a linear predictor (p=0.905) as was performed in the RugbySmart evaluation.[15] The years 2008 and 2009 were considered 'pre-BokSmart' (2 years) because some of the 14 rugby unions only received BokSmart education in 2010. Thus, 2010, 2011, 2012 and 2013 (4 years) were considered as 'post-BokSmart'.

With this study design, the assumption is that only the BokSmart intervention could have affected injury rates. While this is not strictly true, as a national federation programme BokSmart has the largest potential influence on nationwide injury rates. Furthermore, BokSmart promulgates any national safety law or legislation in South Africa, such as change in the scrum engagement sequence. [23]

Robust Standard Errors were calculated and presented to illustrate that over-dispersion (mean greater than the variance) was not present in the data [24]. All analyses were performed using Stata version 12.1 (StataCorp. 2014. Stata Statistical Software: Release 12. College Station, TX: StataCorp LP).

RESULTS
Between 2008 and 2013, there were 71 rugby-related serious injuries in South Africa (Table 1) at an average of 12 (± 2) injuries per year. A maximum of 15 injuries occurred in 2009 and minimum of 9 injuries in 2012.

Neck injuries (acute spinal cord injuries) accounted for 87% of all injuries (n = 62 of 71). Of these 62 neck injuries, 57% (n = 35) had permanent outcomes (Table 1).

When examined by age group (junior/senior), the number of serious head/neck injuries was higher in juniors (n = 6) than in seniors (n = 4) in 2008 (Table 1 and Figure 1). After 2008, junior head/neck injury numbers decreased steadily until 2013 (n = 3), while these injury numbers oscillated between five and nine in senior players (Table 1 and Figure 1). One seriously injured player did not have information available on age group at the time of conducting the study.
Chapter 6: The effectiveness of *BokSmart* - a nationwide injury prevention programme on rugby-related catastrophic injury rates

**Table 1. Absolute numbers of serious neck and head injuries (junior injuries are indicated in parentheses).**

<table>
<thead>
<tr>
<th></th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neck/Acute Spinal Cord Injury</td>
<td>8(5)</td>
<td>11(4)</td>
<td>12(4)</td>
<td>14(5)</td>
<td>8(3)</td>
<td>9(2)</td>
</tr>
<tr>
<td>Non-Permanent*</td>
<td>4(3)</td>
<td>5(4)</td>
<td>5(4)</td>
<td>4(2)</td>
<td>4(1)</td>
<td>5(1)</td>
</tr>
<tr>
<td>Permanent</td>
<td>4(2)</td>
<td>6(-)</td>
<td>7(-)</td>
<td>10(3)</td>
<td>4(2)</td>
<td>4(1)</td>
</tr>
<tr>
<td>Head (Traumatic Brain Injury)</td>
<td>2(1)</td>
<td>4(3)</td>
<td>1(-)</td>
<td>0(-)</td>
<td>1(1)</td>
<td>1(1)</td>
</tr>
<tr>
<td>Non-permanent</td>
<td>0(-)</td>
<td>2(2)</td>
<td>0(-)</td>
<td>0(-)</td>
<td>0(-)</td>
<td>1(1)</td>
</tr>
<tr>
<td>Permanent</td>
<td>2(1)</td>
<td>2(1)</td>
<td>1(-)</td>
<td>0(-)</td>
<td>1(1)</td>
<td>0(-)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>10(6)</td>
<td>15(7)</td>
<td>13(4)</td>
<td>14(5)</td>
<td>9(4)</td>
<td>10(3)</td>
</tr>
</tbody>
</table>

*Outcomes for which the hospital was still undecided as to the final diagnosis after one month

Assuming player numbers remained consistent for this time period, incidence rates ranged between 0.57 per 100,000 players (2013) and 1.32 per 100,000 players (2009) in juniors; and between 3.29 per 100,000 players (2008) and 7.40 per 100,000 players (2010). The average incidence rate was 0.91 per 100,000 junior players and 5.62 per 100,000 senior players per year.

Initial analyses indicated that the effect of the intervention (*BokSmart*) was significantly different by age group (junior/senior). Therefore, an age/intervention interaction term was created.

After adjusting for the effects of age and the age/intervention interaction term, *BokSmart* was associated with a reduction of 2.5 serious injuries per year in junior players (IRR: 0.6, 95% CIs: 0.5 – 0.8; p<0.001; S.E: 0.07) (Figure 2). Although *BokSmart* was associated with an increase of 1.3 injuries per year in senior players, this change was not statistically significant (IRR: 1.2, 95% CIs: 0.7 – 2.0, p=0.481; S.E: 0.32). Given the pre-*BokSmart* numbers, the probabilities of observing these serious injury numbers post-*BokSmart* were 0.195 (20%) and 0.283 (28%) in juniors and seniors, respectively.

Examining the effects of ethnicity, outcome (head vs. neck) and event causing injury on serious injury rates produced large standard errors. Thus the study was deemed underpowered to examine these effects.
Chapter 6: The effectiveness of *BokSmart* - a nationwide injury prevention programme on rugby-related catastrophic injury rates

![Graph showing absolute number of head (traumatic brain injuries/TBIs) and neck (acute spinal cord injuries/ASCIs) pre- (2008-9) and post-BokSmart (2010-13) implementation in South Africa. Note that the player that was of unknown age group was not included in these data.]

*Figure 1. Absolute number of head (traumatic brain injuries/TBIs) and neck (acute spinal cord injuries/ASCIs) pre- (2008-9) and post-BokSmart (2010-13) implementation in South Africa. Note that the player that was of unknown age group was not included in these data.*
DISCUSSION

The main finding of the present study was that the implementation of the BokSmart programme was associated with a significant reduction in serious injuries in junior, but not in senior players. This effect was evident after just four years of complete implementation of the programme, which began in mid-2009. Similarly, the evaluation of BokSmart’s parent programme, RugbySmart of New Zealand, also had a positive outcome on serious/catastrophic injury rates. [15]

Furthermore, there were distinct differences between the South African and New Zealand evaluation study designs of serious injuries. For example, the New Zealand evaluation of serious spinal injuries [15] had almost 30 years of historical (pre-intervention) data in comparison with the present study’s two years of pre-intervention data. As a result, the New Zealand study was able to examine the effect of their intervention (RugbySmart) as a linear predictor, whereas it was more
statistically accurate for the present study to investigate the effect of intervention as a dichotomous variable (“pre” vs “post”).

Nonetheless, the absence of an effect of the intervention in senior player in the present study was unexpected and concerning for BokSmart, considering that senior players are at greater risk of suffering a serious injury in South Africa. [7] This finding could simply be an artefact of the greater population of junior players, and hence greater exposure. Catastrophic injuries were not corrected for player numbers and at the last estimate conducted in 2010 juniors outnumbered seniors by 5 to 1 in South Africa. An alternative/further explanation is that the BokSmart intervention could have been less effective in older age groups possibly due to a greater resistance of more experienced coaches, referees and players to adopt a safety programme. While there is no literature to support this assumption, future research should establish if there is evidence for this effect with the BokSmart intervention. It should also be noted that the classifications “junior” and “senior” describe the level at which the injury occurred – there may be cases where the player was too young/old for their particular age group, but this was not considered for the present investigation.

However, it is important to note that rugby coaches and referees, not players are the direct target of the BokSmart/RugbySmart interventions. [17,24] Thus, the assumption that the change in serious injury rates in players is related to BokSmart presumes that the intervention has the ability to influence coaches and referees, and that coaches and referees can influence the behaviour of players and their susceptibility to injury. As it is not feasible to have a control group to truly assess this effect, the authors can’t rule out the possibility that injury rates may have reduced without the introduction of the BokSmart programme, although general injury trends in the sport would indicate otherwise. [26] Additionally, with the ecological design used in the present Chapter, the authors could never infer that the introduction of BokSmart caused a reduction in injury rates, but simply that the programme’s implementation was associated with this described reduction.

Owing to reasons described earlier, this study was underpowered to examine the effects of the intervention on site/outcome- (head vs neck) event- and ethnicity-specific outcomes. Furthermore there are only two years of data available 'pre-
Chapter 6: The effectiveness of BokSmart - a nationwide injury prevention programme on rugby-related catastrophic injury rates

BokSmart and therefore these two years may have a large effect on the results. With more years of data, the BokSmart intervention could be modelled as a linear rather than “pre/post” effect to reduce the influence of these two 'pre-BokSmart' data points. Thus, continued evaluation of the BokSmart programme is justified and critical to the programme.

CONCLUSION
The BokSmart programme was associated in this time trend analysis with a significant improvement in head/neck catastrophic injury rates in junior, but not senior players after four years. The lack of a finding at the senior level may be related to the different effectiveness of the intervention at this older age group, but this assumption needs to be confirmed with further research.

REFERENCES


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Chapter 7: The BokSmart intervention programme is associated with improvements in injury prevention behaviours of rugby union players

THE BOKSMART INTERVENTION PROGRAMME IS ASSOCIATED WITH IMPROVEMENTS IN INJURY PREVENTION BEHAVIOURS OF RUGBY UNION PLAYERS

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Chapter 7: The BokSmart intervention programme is associated with improvements in injury prevention behaviours of rugby union players

ABSTRACT

Introduction and objectives: Participants of rugby union ("rugby") have an above-average risk of injury compared with other popular sports. Thus, BokSmart, a nationwide injury prevention programme for rugby, was introduced in South Africa in 2009. Improvements in injury-preventing behaviour of players is critical to the success of an intervention. The aim of this study was to assess whether BokSmart has been associated with improvements in rugby player behaviour.

Methods: An anonymous knowledge, attitude and self-reported behaviour questionnaire was completed by junior (under-18) and senior (adult) tournament players who attended merit-based tournaments (2008-2012). The questionnaire was completed by 2279 junior players (99% of total estimated population) from 111 teams, and 1642 senior players (96% of population) from 81 teams. A generalised linear model assessed behavioural changes over this time period.

Results: Nine (50%) of the behaviours improved significantly (p<0.005) between 2008-2012 and the remaining behaviours remained unchanged. Improved behaviours included the targeted, catastrophic injury-preventing behaviours of the intervention: practicing of tackling (adjusted overall improvement in odds: 56%) and scrumming, in forwards only (58%), techniques. Other behaviours that improved significantly were: post-injury compression and elevation as well as alcohol avoidance; mouthguard use (training and matches) and; cooling down (training and matches). Practicing of safe rucking techniques; warming-up before training/matches; ice use; heat, massage and alcohol avoidance post-injury; and pre- and off-season conditioning remained unchanged.

Conclusions: BokSmart is associated with improvements in targeted injury-preventing behaviours in players. Future research should ascertain if self-reported behaviours reflect actual behaviour and if the observed improvements translate into changes in injury rates.
Chapter 7: The BokSmart intervention programme is associated with improvements in injury prevention behaviours of rugby union players

INTRODUCTION

Rugby Union (Henceforth “rugby”) is one of the most popular team sports globally. [1] In comparison to other popular team sports, rugby carries a relatively high risk of injury. [2,3] As a result, there are numerous examples of injury prevention efforts that have been evaluated for their effectiveness at reducing this injury risk and include protective equipment trials, [4] law changes [5-6] and nationwide injury-prevention programmes such as RugbySmart of New Zealand.[7]

Player behaviour has been identified as the “key factor” underlying the success of injury prevention in sport.[8] However, there is only one example of an injury prevention programme for rugby where the behaviour of the intervention target has been assessed.[7] In that study, the RugbySmart programme was associated with improvements in self-reported injury-preventing behaviours, concomitant with the reduction in injury rates the same group of players.[7]

Thus, the South African Rugby Union (SARU) adapted and launched BokSmart as a nationwide injury-prevention programme in July 2009. [9] The programme aims to educate all rugby coaches and referees in safe and effective injury prevention methods for rugby. [9] SARU achieve this by teaching BokSmart educators who then disseminate the BokSmart content to all rugby coaches and referees. Through on-going injury surveillance by SARU, the content focuses on high-risk areas for catastrophic injuries. [9] Based on the results of this surveillance, the scrum and tackle (ball carrying and tackling) phases are discussed in depth during the BokSmart course. The other content ranges from hydration and nutrition strategies through to the identification and management of catastrophic injuries (including concussion). Since January 2010, it has been compulsory for all South African coaches and referees to attend a biennial BokSmart course. Coaches and referees are considered key role-players for injury prevention in rugby. [7] By educating these key role-players in South Africa, it was the expectation of BokSmart that the injury prevention behaviour of the players under the control of these coaches and referees would improve, as observed in the New Zealand evaluation. [7]
Chapter 7: The BokSmart intervention programme is associated with improvements in injury prevention behaviours of rugby union players

Therefore, the aim of this study was to assess if player behaviour has improved over a period of five years since the launch of the BokSmart nationwide injury-prevention programme.

METHODS

Study design and population
Data for this ecological study were collected through the BokSmart programme (www.boksmart.com), which is a joint initiative between the South African Rugby Union (SARU) (www.sarugby.co.za) and the Chris Burger/Petro Jackson Player’s Fund (CBPJPF) (www.playersfund.org.za). The CBJPJP is a non-profit public benefit organization (PBO), developed to aid players who have been permanently disabled while playing rugby in South Africa. Permission to analyse the data was obtained, with SARU’s permission, from the UCT Human Research Ethics Committee.

Between 2008 and 2012 SARU administered a ‘knowledge, attitude and behaviour (KAB)’ questionnaire (Appendix II) annually to players at a junior and senior SARU tournament. Both tournaments were attended by teams representing each of the 14 rugby unions in South Africa. As attendance at a BokSmart course has been a mandatory prerequisite for coaching since January 2010, it can be assumed that by 2011 and 2012 all coaches of the surveyed players had attended a course.

The questionnaire was administered at a pre-tournament meeting and completed anonymously by the players. The players were high-level amateur players competing at a provincial tournament in their respective age groups: under-18 (junior) and open/adult (senior). It is important to note that the same group of players was not followed up each year, but rather the players attending these two tournaments between 2008 and 2012 were measured at each time point.

Between 2008 and 2012, a total of 112 junior and 84 senior teams attended these tournaments and were asked to complete the KAB questionnaire. Of these teams, 111 (99%) and 81 (96%) completed them in those age groups respectively. On average, a team squad comprised 22 players, providing an estimated 4 224
Chapter 7: The BokSmart intervention programme is associated with improvements in injury prevention behaviours of rugby union players

players from the 192 compliant teams. In reality there were 2 279 junior and 1 642 senior players that completed the KAB questionnaire between 2008 and 2012, providing a total of 3 921 completed questionnaires (93% of total estimated population). No information was available for those players at the tournament who did not attend the meeting at which the questionnaires were completed.

**KAB Questionnaire (Appendix II)**

Although the KAB questionnaire was not validated prior to use in this study, it was developed through use in the RugbySmart evaluation in New Zealand over a 10-year period which was considered sufficient piloting by SARU for the BokSmart evaluation. [7] The players were not asked to disclose their identity when they completed the questionnaire to improve the integrity of answers by eliminating fear of consequential action based on their answers. Thus, it is possible that some of the same players could be in the dataset more than once if they had competed in the tournament in consecutive years. There is however no way to assess this.

While it is termed a ‘KAB’ questionnaire, the majority of questions actually investigate knowledge, self-reported behaviour (henceforth “behaviour”) and perceptions (not attitude) of injury prevention (primary and secondary) practices of the players. All questions of the KAB questionnaire (appendix I) were grouped into five categories: demographics, behaviour, perceptions, education and knowledge (appendix II). For example, the ‘demographics’ category included questions on age, ethnicity and year of completion; ‘behaviour’ included questions on how players managed their previous injuries; and ‘perceptions/attitudes’ included questions on which injury prevention practices were perceived to be important in reducing injury. The possible answers for each question of the KAB questionnaire (appendix I) are also provided in Appendix II.

The 18 injury preventing behaviours of the KAB questionnaire were subsequently coded as “correct” or “incorrect” behaviours, based on the respondent’s answers and what BokSmart programme implementers (SARU) deemed as “correct”. Besides those who were subsequently coded to have behaved incorrectly, the “Incorrect” category also included respondents who had not answered a particular question (“no answer”). This decision was made in conjunction with SARU prior to the analyses. The rationale for this categorisation was that the current research
Chapter 7: The BokSmart intervention programme is associated with improvements in injury prevention behaviours of rugby union players

question focussed on “correct” (as determined by SARU) answers: thus all other options were deemed “incorrect”. If a particular questionnaire was comprised mainly (> 90%) of “no answer” answers, such a questionnaire was removed from the analyses. The eighteen “specific” behaviours (indicated in parentheses) were grouped based on expert opinion under five “summary” behaviours (Appendix II): injury management (ice, elevation, and compression use; and alcohol, heat, massage and exercise avoidance, post injury), mouthguard use (at training and matches), stretching (warming-up and cooling-down at training and matches), safe techniques (tackling, rucking, scrummaging), and conditioning (pre- and off-season). Besides this grouping, the BokSmart programme also identified two of these eighteen behaviours as “targeted behaviours” due to their potential relationship with catastrophic head, neck and spine injuries: i.e. practicing of safe tackling and scrummaging techniques.

Analyses
Although analyses have been performed on knowledge and perception components of these data, it was not possible to include these results in the current chapter.

As all behaviour questions had either a ‘Correct’ (=1) or ‘Incorrect’ (=0) outcome, they were therefore modelled with a Bernoulli distribution. [10] A logistic regression model was then fitted for each behaviour to assess whether the proportion of correct behaviours had changed over the time period: 2008 – 2012. Although the analyses could have been conducted as ‘before/after’ the launch of the intervention, it was decided that using ‘year’ as a continuous predictor might be more informative for providing feedback on the intervention.

Besides ‘year’ (2008 – 2012), five other potential predictors were considered: age group, ‘age’ (junior, senior); ethnicity, as questioned by SARU (White, Black, Mixed/Coloured, Other); Rugby Provincial Union, ‘Union’ (n=14); position (back, forward, back/forward); perception of whether or not coaches should take a safety course, ‘safety’; and perception of who was important to preventing injuries, ‘role’ (‘Coach’, ‘Referee’, ‘Player’, or a combination of these options). The predictor ‘role’ was a combination of the three questions for coach, referee and player as the answers were virtually identical for these three questions (data not shown).
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A stepwise model selection approach was applied where Akaike’s Information Criterion (AIC) [11] was used to select the predictors to include in each model to obtain the most parsimonious model for each of the 23 behaviours (18 behaviours and their 5 summary behaviours).

Once this behavioural model was established, a chi-squared test was used to assess which of the predictors were contributing statistically significantly (p<0.05) to the behaviour. At this point, any non-significant predictors/confounders (p>0.05) were removed from the model and the model was re-fitted to produce a final parsimonious and statistically robust model. Therefore, whenever a behaviour is stated to be “significantly different” over the 2008 – 2012 time period, this statement is made at the 95% significance level (p<0.05). All “significantly different” findings had lower 95% confidence interval bounds that were not less than 1: these data are also shown for interpretation.

In summary, the proportion change in correct behaviour that is described in the Results has accounted for these other five factors, if they were discovered to be significant confounders of the behaviour’s relationship with year. The specific effects of these other five factors are not described here.

Both the unadjusted and adjusted (taking into account confounders described previously) correct behaviour proportions are reported for the time period (2008 – 2012) of interest. Note that the adjusted change over time is shown as an average annual change as the magnitude of absolute year-to-year proportional change was different depending on the relative proportions of the confounders for each particular behaviour. The overall change for the five years is calculated by extrapolating this average annual change.

RESULTS

Study population
The average age of junior players was 17 ± 1 years (mean ± SD), while senior players were 25 ± 4 years of age (Table 1). At the senior tournament, the majority of players were ‘white’ (64%), while this ethnicity comprised just less than half of
Chapter 7: The BokSmart intervention programme is associated with improvements in injury prevention behaviours of rugby union players.

the respondents at the junior tournament. “Black African” players comprised 34%/15%; ‘coloured/mixed ancestry’ players comprised 19%/21% and ‘other’ comprised 1% at the junior/senior tournaments.

**Table 1. Details of the junior and senior sample, including average age and proportions of white players, forward positions and those who had never had a sprain, previously.**

<table>
<thead>
<tr>
<th></th>
<th>Junior (n = 2279)</th>
<th>Senior (n = 1642)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age in years (mean ± SD)</td>
<td>17 ± 1 (n = 2162)</td>
<td>25 ± 4 (n=1586)</td>
</tr>
<tr>
<td>Ethnicity – white * (%)</td>
<td>46 (n = 2167)</td>
<td>64 (n = 1586)</td>
</tr>
<tr>
<td>Forwards (%)</td>
<td>54 (n = 2167)</td>
<td>55 (n = 1590)</td>
</tr>
<tr>
<td>Never injured b (%)</td>
<td>17 (n = 2161)</td>
<td>11 (n = 1559)</td>
</tr>
<tr>
<td>Coach safety c – yes (%)</td>
<td>87 (n = 2116)</td>
<td>87 (n = 1558)</td>
</tr>
</tbody>
</table>

*a This was the ethnicity classification used by SARU in the KAB questionnaire (Appendix I)

*b Players who answered “Never” to the question “When was your last Rugby ligament sprain or muscle strain?”

*c Players were asked: “Do you think it is important that your coach complete an annual safety course?”

**Player behaviour: 2008-2012**
Overall, nine of the eighteen (50%) specific behaviours and four of the five (80%) of the summary behaviours improved significantly, after adjustment (Table 2 and Figure 1), while the remaining behaviours did not change significantly.

**Injury Management**
Although the unadjusted proportion of correct behaviours deteriorated by -4% (88% to 84%). the adjusted odds ratio improved significantly between 2008 and 2012 (annual change in odds: 1.07 times, [1.04; 1.11]) (Table 2). This was due, in part, to significant improvements in the adjusted odds of compression of an injured limb (annual change of 1.09 times [1.00;1.18]), elevation of an injured limb (annual change of 1.13 [1.03;1.21]) and alcohol avoidance post-injury (annual change of 1.13 [1.03;1.23]) (Figure 1). The alcohol avoidance was very high in juniors. All other adjusted injury management behaviours - ice use on the injured limb and heat and exercise avoidance post-injury - did not change significantly between 2008 and 2012.
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Table 2. Summarised and specific correct behaviour proportions in 2008 and 2012. Average and total odds, accounted for the effect of confounders, are also shown along with corresponding 95% confidence intervals.

<table>
<thead>
<tr>
<th>Behaviour</th>
<th>Unadjusted behaviour (%)</th>
<th>Adjusted odds for behaviour</th>
<th>Average annual change</th>
<th>95% confidence intervals</th>
<th>Overall change (5 years)</th>
<th>95% confidence intervals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Injury management</td>
<td>87.6 83.8</td>
<td></td>
<td>1.07</td>
<td>1.04 1.11</td>
<td>1.42*</td>
<td>1.21 1.67</td>
</tr>
<tr>
<td>Ice use</td>
<td>49.2 45.1</td>
<td></td>
<td>1.07</td>
<td>0.99 1.16</td>
<td>1.41</td>
<td>0.94 2.12</td>
</tr>
<tr>
<td>Compression use</td>
<td>33.1 31.3</td>
<td></td>
<td>1.09</td>
<td>1.00 1.18</td>
<td>1.54*</td>
<td>1.02 2.33</td>
</tr>
<tr>
<td>Elevation use</td>
<td>38.1 45.1</td>
<td></td>
<td>1.13</td>
<td>1.03 1.23</td>
<td>1.73*</td>
<td>1.15 2.61</td>
</tr>
<tr>
<td>Heat avoidance</td>
<td>40.6 35.0</td>
<td></td>
<td>1.04</td>
<td>0.95 1.14</td>
<td>1.13</td>
<td>0.74 1.72</td>
</tr>
<tr>
<td>Alcohol avoidance</td>
<td>62.2 57.5</td>
<td></td>
<td>1.13</td>
<td>1.03 1.23</td>
<td>1.81*</td>
<td>1.15 2.85</td>
</tr>
<tr>
<td>Exercise avoidance</td>
<td>42.3 41.4</td>
<td></td>
<td>1.04</td>
<td>0.95 1.14</td>
<td>1.23</td>
<td>0.78 1.93</td>
</tr>
<tr>
<td>Massage avoidance</td>
<td>20.7 21.2</td>
<td></td>
<td>1.02</td>
<td>0.92 1.13</td>
<td>1.10</td>
<td>0.66 1.83</td>
</tr>
<tr>
<td>Mouthguard use</td>
<td>46.7 49.2</td>
<td></td>
<td>1.08</td>
<td>1.05 1.12</td>
<td>1.50*</td>
<td>1.26 1.79</td>
</tr>
<tr>
<td>Training</td>
<td>29.5 33.4</td>
<td></td>
<td>1.10</td>
<td>1.04 1.16</td>
<td>1.60*</td>
<td>1.23 2.08</td>
</tr>
<tr>
<td>Match</td>
<td>44.4 46.9</td>
<td></td>
<td>1.08</td>
<td>1.03 1.13</td>
<td>1.45*</td>
<td>1.13 1.87</td>
</tr>
<tr>
<td>Stretching</td>
<td>98.9 99.4</td>
<td></td>
<td>1.03</td>
<td>1.00 1.06</td>
<td>1.17*</td>
<td>1.02 1.35</td>
</tr>
<tr>
<td>Warming-up (training)</td>
<td>97.3 95.8</td>
<td></td>
<td>0.92</td>
<td>0.81 1.04</td>
<td>0.66</td>
<td>0.35 1.23</td>
</tr>
<tr>
<td>Warming-up (match)</td>
<td>54.2 51.6</td>
<td></td>
<td>1.07</td>
<td>0.93 1.23</td>
<td>1.39</td>
<td>0.68 2.84</td>
</tr>
<tr>
<td>Cooling-down (training)</td>
<td>96.7 97.0</td>
<td></td>
<td>1.05</td>
<td>1.00 1.11</td>
<td>1.29*</td>
<td>1.00 1.66</td>
</tr>
<tr>
<td>Cooling-down (match)</td>
<td>51.8 49.6</td>
<td></td>
<td>1.08</td>
<td>1.02 1.13</td>
<td>1.45*</td>
<td>1.13 1.86</td>
</tr>
<tr>
<td>Techniques</td>
<td>77.8 79.5</td>
<td></td>
<td>1.06</td>
<td>1.02 1.09</td>
<td>1.31*</td>
<td>1.13 1.53</td>
</tr>
<tr>
<td>Tackle</td>
<td>49.1 52.2</td>
<td></td>
<td>1.09</td>
<td>1.03 1.14</td>
<td>1.50*</td>
<td>1.18 1.92</td>
</tr>
<tr>
<td>Ruck</td>
<td>62.5 62.3</td>
<td></td>
<td>1.05</td>
<td>1.00 1.10</td>
<td>1.26</td>
<td>0.98 1.62</td>
</tr>
<tr>
<td>Scrum (forwards only)</td>
<td>65.4 67.6</td>
<td></td>
<td>1.08</td>
<td>1.00 1.17</td>
<td>1.49*</td>
<td>1.00 2.23</td>
</tr>
<tr>
<td>Physical conditioning</td>
<td>90.2 86.0</td>
<td></td>
<td>0.96</td>
<td>0.91 1.01</td>
<td>0.81</td>
<td>0.63 1.03</td>
</tr>
<tr>
<td>Off-season</td>
<td>82.0 77.9</td>
<td></td>
<td>0.98</td>
<td>0.92 1.04</td>
<td>0.90</td>
<td>0.65 1.24</td>
</tr>
<tr>
<td>Pre-season</td>
<td>85.8 78.7</td>
<td></td>
<td>0.95</td>
<td>0.88 1.02</td>
<td>0.76</td>
<td>0.54 1.08</td>
</tr>
</tbody>
</table>

*Significant increase between 2008 and 2012 (p < 0.05).

Mouthguard use
The unadjusted proportion of correct behaviours for the summary behaviour improved by 2% (47% to 49%), and indicates that mouthguards were being used by less than half of all players at both training and matches between 2008 and 2012 (Table 2 and Figure 1). However, the adjusted odds ratio of the summary behaviour improved significantly (annual change in odds: 1.08 times. [1.05;1.12])
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from 2008 to 2012 (Table 1). This was due to large significant improvements in the adjusted odds ratio of mouthguard use at both training (annual change: 1.10 times [1.04;1.16]) and matches (annual change: 1.08 times [1.03;1.13]).

Stretching
While the unadjusted proportion of correct summary behaviour only improved by 0.5% (98.9 to 99.4%), the adjusted odds ratio improved significantly (annual change in odds: 1.03 times [1.00;1.06]) from 2008 to 2012 (Table 2 and Figure 1). This improvement in the adjusted summary behaviour was due to significant improvements in the adjusted odds of cooling-down after training (annual change: 1.05 times [1.00;1.11]) and matches (annual change: 1.08 [1.02;1.13]. The adjusted odds of warming-up behaviours did not change significantly at training or matches between 2008 and 2012 (Table 2 and Figure 1).

Safe techniques
The unadjusted proportion of correct summary behaviours improved by 2% (78% to 80%) and the adjusted odds improved significantly (annual change in odds: 1.06 [1.02;1.09]) from 2008 to 2012. This was due to significant improvements in adjusted behaviours of practicing of safe tackle techniques in all players (annual change: 1.09 times [1.03;1.14]) and safe scrummaging techniques in forwards (odds ratio 58% larger in 2012 than 2008, annual change: 1.08 [1.00;1.17]). but not safe rucking techniques in all players (not significantly different over the same time period).

Physical conditioning
The unadjusted summary behaviour deteriorated by 14%. between 2008 and 2012, although the adjusted change was not significantly different over this time period. Both off-season and pre-season physical conditioning adjusted odds also decreased, although not significantly, between 2008 and 2012 (Table 2 and Figure 1).

DISCUSSION
The main finding of this study was that the implementation of the BokSmart programme has been associated with improvements in targeted catastrophic injury preventing behaviours (practicing safe tackling and scrummaging techniques) of players between 2008 and 2012. These two behaviours were identified as
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“targeted” by SARU based on the focus of the content included in their *BokSmart* programme. [9] The evaluation of *RugbySmart*, [7] also observed improvements in the proportion of these two correct behaviours (safe tackling and scrummaging) in players over a ten year period: these two behaviours were linked to the concomitant reduction in injury rates observed over the same study period. [7] Subsequent to this evaluation, improvements in behaviour of the intervention target has been identified as critical to the success of any injury-prevention programme, not just rugby. [8]

In total, the New Zealand *RugbySmart* programme evaluated five of the eighteen behaviours from their KAB questionnaire: 1. training of safe rucking techniques, 2. training of safe tackling techniques, 3. training of safe scrummaging techniques (forwards only), 4. warming-up and 5. cooling down. Of these five only warming-up did not improve over the 10 year evaluation (1996 – 2005) in New Zealand. However, this lack of a finding for warming-up was ascribed to the high proportion of players already performing this behaviour correctly at the start of the evaluation.

Importantly, the KAB questionnaire (Appendix I) was designed upon the assumption that 18 behaviours are potentially capable of affecting injury risk in rugby players. While it is well supported in the literature that behaviour does underpin injury-prevention interventions, [8] it is possible that not all eighteen of these 18 behaviours are equally important for injury prevention in rugby. Of the non-targeted behaviours only mouthguard use has evidence for, but not against its relationship with the prevention of injury (dental claims) in rugby. [12] The adjusted odds of mouthguard use for training/matches improved significantly in this evaluation, although the unadjusted proportions were still less than 50% in 2012 (training: 32.1%, matches: 46.7%). This should be a concern for *BokSmart* implementers. Similarly, the finding that just more than half of all players warm-up before matches should also be of concern for implementers, despite this behaviour having equivocal evidence for it’s relationship with injury prevention. [13]

Other adjusted odds of correct behaviour that did not improve in this five year evaluation were: ice use; heat, alcohol, exercise and massage avoidance; warming-up before matches and training; and pre- and off-season conditioning. Of
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these, only pre- and off-season conditioning, and warming-up before training had a possible explanation for a lack of a finding with high proportions of correct behaviour at baseline (2008). It is unclear whether these behaviours are related to injury rates, and thus whether BokSmart should be concerned with this finding. However, future BokSmart content should focus on those that are clearly associated with injury prevention evidence in the most recent literature.

Table 3. Summary of whether adjusted change in odds of correct behaviours improved or remained unchanged in players between 2008 and 2012.

<table>
<thead>
<tr>
<th>IMPROVED</th>
<th>UNCHANGED</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Safe scrummaging*</td>
<td>1. Safe rucking</td>
</tr>
<tr>
<td>2. Safe tackling*</td>
<td>2. Ice use</td>
</tr>
<tr>
<td>3. Compression use</td>
<td>3. Heat avoidance</td>
</tr>
<tr>
<td>4. Elevation use</td>
<td>4. Massage avoidance</td>
</tr>
<tr>
<td>5. Alcohol avoidance</td>
<td>5. Exercise avoidance</td>
</tr>
<tr>
<td>6. Mouthguard use (training + matches)</td>
<td>6. Pre- and off-season conditioning</td>
</tr>
<tr>
<td>7. Cooling-down (training+ matches)</td>
<td>7. Warming up (training and matches)</td>
</tr>
</tbody>
</table>

*targeted behaviours of the BokSmart programme because of a potential relationship with catastrophic injury prevention (according to programme implementers)

The present study has a number of limitations. The behaviour measure was self-reported which means that the measure was not reflective of actual behaviour. This study was also not longitudinal in design – the improvement in behaviour was only at a population, and not individual, level. Also, the improvements may not only be as a result of BokSmart. However, nationwide interventions such as the BokSmart programme are concerned with effectiveness rather than efficacy and thus a population-based improvement is important to the success of the
intervention. [14] Another limitation was the possibility that the same players were included in more than one year of assessment: due to the questionnaires being anonymous (to increase integrity of answers) this factor would be impossible to assess. However, due to the age- and merit-based selection criteria for these tournaments, it is unlikely that this was applicable to a large proportion. Also, due to the unspecific wording of the question (Appendix II), the possible confounding effect of a previous injury on a behavioural outcome could not be accounted for statistically. Possibly the most important limitation of this study is that it is not known whether an improvement in correct behaviour can cause a reduction in injury rates. Although this causal link was implied in the comparable evaluation of RugbySmart, the effect may be different in South Africa. Through the concomitant injury surveillance project that SARU began at these tournaments in 2011, it is hoped that causal link can be investigated by 2015. A particular strength of the present data was the high response rates of the questionnaire: 99 and 96% of the estimated total populations in junior and senior players, respectively. By comparison, the RugbySmart evaluation had response rates between 57 and 83%. [7]

CONCLUSION
The BokSmart programme was found to be associated with improvements in targeted injury prevention behaviour in players: practicing of safe tackling and scrummaging (forwards only) techniques. Future research needs to establish if these behavioural improvements are truly longitudinal and consistent with the players’ coaches and referees. Furthermore, future research should also assess if these improvements in targeted injury-preventing behaviours translate into reductions in injury rates in these players.

REFERENCES
Chapter 7: The BokSmart intervention programme is associated with improvements in injury prevention behaviours of rugby union players


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*Figure 1. Changes in odds of correct behaviour proportions for Injury Management, Mouthguard use, Training of Safe Techniques (Safe Techniques), Stretching and Conditioning.*